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Emissions Management

Model: All Equipped with OBD II

Production: 1995 to Present

Manufacturer: Bosch and Siemens Engine Control Modules

OBJECTIVES

After completion of this module you will be able to:

- Describe what is required to illuminate the Malfunction Indicator Lamp
- Access readiness codes using the ISID
- Understand how a oxygen sensor operates
- Understand how the DM-TL system operates
- Test a DM-TL system using a smoke tester
- Understand how misfire monitoring takes place

Introduction

OBD History

As a result of low fuel costs, together with a high standard of living and a dense population, the state of California was affected particularly heavily by air pollution. This spurred the state to pass the most comprehensive and stringent emissions and consumption laws in the world. The automobile manufacturers were reminded of their obligations and this drove them on to comply with the new regulations at enormous expense.

- In continuing efforts to improve air quality, the Environmental Protection Agency (EPA) amended the Clean Air Act in 1990. The Clean Air Act was originally mandated in 1970. The Clean Air Act has a direct impact on automobile manufactures whereby they are responsible to comply with the regulations set forth by the EPA. The 1990 amendment of the Clean Air Act set forth all of the changes currently being introduced on vehicles sold in the United States today.
- In 1967, the State of California formed the California Air Resources Board (CARB) to develop and carryout air quality improvement programs for California's unique air pollution conditions. Through the years, CARB programs have evolved into what we now know as ON Board Diagnostics and the National Low Emission Vehicle Program.
- The EPA has adopted many of the CARB programs as National programs and laws. One of these earlier programs was OBD I and the introduction of the "Check Engine" Light.
- BMW first introduced OBD I and the check engine light in the 1987 model year. This enhanced diagnosis through the display of "flash codes" using the check engine light as well as the BMW 2013 and GT-1. OBD I was only the first step in an ongoing effort to monitor and reduce tailpipe emissions.
- By the 1989 model year all automotive manufactures had to assure that all individual components influencing the composition of exhaust emissions would be electrically monitored and that the driver be informed whenever such a component failed.
- Since the 1996 model year all vehicles must comply with OBD II requirements. OBD II requires the monitoring of virtually every component that can affect the emission performance of a vehicle plus store the associated fault code and condition in memory.

If a problem is detected and then re-detected during a later drive cycle more than one time, the OBD II system must also illuminate the "Check Engine" Light in the instrument cluster to alert the driver that a malfunction has occurred. **However, the flash code function of the Check Engine Light in OBD I vehicles is not a function in OBD II vehicles.**

- This requirement is carried out by the Engine Control Module (ECM/DME) as well as the Automatic Transmission Control Module (EGS/AGS) and the Electronic Throttle Control Module (EML) to monitor and store faults associated with all components/systems that can influence exhaust and evaporative emissions.

OBD I

The essential elements here are that electrical components which affect exhaust emissions are monitored by the motor-electronics system and an optical warning signal (CHECK ENGINE Light) is issued in the event of an OBD I-relevant malfunction. The corresponding fault can be read out via a flashing code without the aid of a testing device.

OBD II

Since January 1996, OBD II has been compulsory on all vehicles in the US market. The main difference from OBD I is that not only are the purely electrical components monitored but also all the systems and processes that affect exhaust emissions and fuel system evaporative emissions.

The operational reliability of the exhaust-treatment system must be guaranteed for 5 years and/or 100,000 miles; this is maintained by emission certification. In this case, the data relevant to exhaust/evaporative emissions are read out via a standardized interface with a universal "diagnosis device". If a violation is identified, the vehicle manufacturer in question is legally bound to eliminate the fault throughout the entire vehicle series.

Objectives of OBD II

- Permanent monitoring of components relevant to exhaust emissions in all vehicles.
- Immediate detection and indication of significant emission increases over the entire service life of each vehicle.
- Permanently low exhaust emissions in the field.



Emissions Overview

Purpose of the System

What is OBD?

Today many of the engine's control systems such as throttle opening, fuel injection, ignition, emissions and performance are controlled by an electronic control module and the related sensors and actuators. The first on-board diagnostic (OBD) systems were developed by the manufacturer as a way to detect problems with the electronic systems.

Beginning with 1994 model year, requirements for OBD systems have been established by the EPA and CARB. The purpose of the OBD system is to assure proper emission control system operation for the vehicle's lifetime by monitoring emission-related components and systems for deterioration and malfunction. This includes also a check of the tank ventilation system for vapor leaks.

The OBD system consists of the engine and transmission control modules, their sensors and actuators along with the diagnostic software. The control modules can detect system problems even before the driver notices a driveability problem because many problems that affect emissions can be electrical or even chemical in nature.

What happens if a problem is detected?

When the OBD system determines that a problem exists, a corresponding "Diagnostic Trouble Code" is stored in the control module's memory.

The control module also illuminates a yellow dashboard Malfunction Indicator Light indicating "Check Engine" or "Service Engine Soon" or displays an engine symbol.

This light informs the driver of the need for service, NOT of the need to stop the vehicle. A blinking or flashing dashboard light indicates a rather severe level of engine misfire.

After fixing the problem the Fault code is deleted to turn off the light. If the conditions that caused a problem are no longer present the vehicle's OBD system can turn off the dashboard light automatically. If the OBD system evaluates the component or system three consecutive times and no longer detects the initial problem, the dashboard light will turn off automatically.



What is the most common problem detected by OBD?

■ Fuel Filler Cap

If the fuel filler cap is not properly closed after refueling, the OBD system will detect the vapor leak that exists from the cap not being completely tightened.

If you tighten the cap subsequently, the dashboard light should be extinguished within a few days or after deleting the Fault code. This is not an indication of a faulty OBD system. The OBD system has properly diagnosed the problem and accordingly alerted the driver by illuminating the dashboard light.

Please check the fuel filler cap first when the dashboard light comes on to avoid unnecessary diagnostic time. To check the fuel filler cap turn the cap to the right until you hear a click or the cap reaches the full stop. Make sure that the retaining strap is not caught between the filler pipe and the fuel filler cap. If the light should stay on further in depth evaporative leak diagnosis is required.

■ Misfire Detection

As part of the CARB/OBD II regulations the Engine Control Module must determine if misfire is occurring and also identify the specific cylinder(s). The ECM will determine severity of the misfire event, and whether it is **emissions relevant** or **catalyst damaging** (more information is available in the Emission Management section). In order to accomplish these tasks the ECM monitors the crankshaft for acceleration losses during firing segments of cylinder specific firing order. If the signal is implausible an erroneous reference mark can be obtained by the ECM which will result in a misfire fault being set.

Possible causes of cylinder misfire faults (actual field findings):

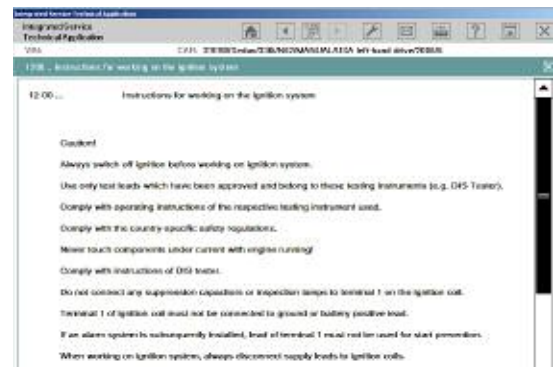
- Vehicle ran low or out of fuel
- Poor fuel quality (ex. water in fuel, customer uses an additive, etc.)
- Low/high fuel pressure
- Ignition coil
- Fouled spark plug(s)
- Restricted / contaminated fuel injector(s)
- Crankshaft position sensor
- Poor combustion due to low compression or high leakage
- Blocked/restricted Catalyst

Engine Misfire Diagnosis

Engine Misfire is the result of inefficient combustion in one or more cylinders. The causes of Engine Misfire are extensive but can be grouped into the following sub-systems. Consider the charts below as an additional diagnostic aid once ISTA is connected, the correct fault symptom has been chosen and the fault memory has been interrogated. Follow the Test Module as displayed by ISTA.

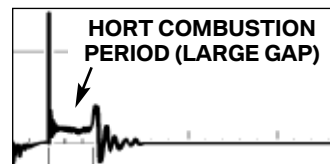
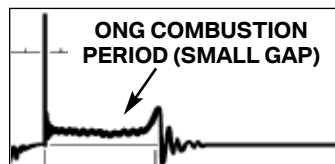
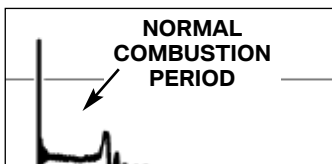
IGNITION SYSTEM			
COMPONENT	POSSIBLE CONDITION	TEST	CORRECTION
Spark Plug:	<ul style="list-style-type: none"> • Incorrect spark plug installed • Electrode gap closed or too small • Electrode(s) missing • Oil or fuel fouled spark plug • Ceramic insulation cracked 	Secondary Ignition	<ul style="list-style-type: none"> • Verify correct spark plug • Replace if necessary • Swap with another cylinder
Secondary circuit: (wiring, M73-cap, rotor)	<ul style="list-style-type: none"> • Wet or moist due to water infiltration. • High resistance due to corrosion. 		<ul style="list-style-type: none"> • Check water ingress, repair, replace • Check resistance value, replace
Ignition Coil(s):	<ul style="list-style-type: none"> • Secondary/Primary Circuits open or shorted. • Housing cracked, damaged. 	Secondary and Primary	<ul style="list-style-type: none"> • Inspect and replace if necessary • Swap with another cylinder
Ignition Coil & Engine Harness Connectors	<ul style="list-style-type: none"> • Power supply, Primary control and ground (shunt signal) circuits impaired. 	Primary Ignition & Term 4A feed-back Preset Measurements	<ul style="list-style-type: none"> • Look for open, loose connector, corrosion, crossed or backed out pins (also consider ignition unloader or ECM relay on MY97 and newer cars). • Determine defective condition, repair or replace.

- A secondary ignition oscilloscope display provides vital information about the ignition system's condition.
- Follow the precautions in group 12 of the Repair Instructions.
- Use the following scope patterns as a guideline for ignition system diagnosis.



Evaluation of secondary signal amplitude at idle speed.

1. Normal Ignition Voltage Peak: **Spark Plug is OK**
2. Low Ignition Voltage Peak: **Gap too small (defective)**
3. High Ignition voltage peak: **Gap too large (defective)**



ENGINE MECHANICAL SYSTEMS

COMPONENT	POSSIBLE CONDITION	TEST	CORRECTION
Pistons, Rings, Valves, Camshaft:	<ul style="list-style-type: none"> Hole in piston crown, ring(s) broken, valve(s) not seating, valve(s) bent, valve spring(s) broken, camshaft lobe cracked, etc. 	<ul style="list-style-type: none"> Idle Quality - Rough Running Preset. Cylinder compression & leakdown tests. 	<ul style="list-style-type: none"> Correct condition as required.
Hydraulic Valve Actuator (HVA):	<ul style="list-style-type: none"> HVA oil bore restricted or blocked. Engine oil pressure builds up too slow. Intermittent Misfire Fault - Not Currently Present. HVA binding/sticking in bore. 	<ul style="list-style-type: none"> Idle Quality - Rough Running Preset. Listen to HVA Check Oil Pressure Cylinder leakdown 	<ul style="list-style-type: none"> Always consider mechanical components when diagnosing misfire. Inspect for scoring.
Vacuum Leaks:	<ul style="list-style-type: none"> Unmetered vacuum leaks causing a “lean” operating condition. Possible “Excessive Mixture Deviation” fault codes. 	<ul style="list-style-type: none"> Idle Quality - Rough Running Preset. Test for vacuum leaks per Repair Instr. and SIB on “Crankcase Ventilation”. Interpret Add. & Multiple adaptation values 	<ul style="list-style-type: none"> Correct condition as required.

FUEL QUALITY, DELIVERY, INJECTION & EVAPORATIVE SYSTEMS

COMPONENT	POSSIBLE CONDITION	TEST	CORRECTION
Fuel (quality):	<ul style="list-style-type: none"> Contaminated fuel. (water, other non combustible). 		<ul style="list-style-type: none"> Clean fuel system, replace fuel.
Fuel Delivery:	<ul style="list-style-type: none"> Fuel pump delivery pressure low, restriction in fuel line to fuel rail or running loss valve. Fuel filter restricted (clogged). Low fuel in tank. 	<ul style="list-style-type: none"> Check fuel pressure & volume. Check fuel pump power and ground 	<ul style="list-style-type: none"> Determine restriction/flow reduction, replace component as necessary. Interpret Additive and Multiplicative adaptation values.
Running Loss Valve:	<ul style="list-style-type: none"> Valve stuck in “small circuit” position. 	<ul style="list-style-type: none"> Check valve 	<ul style="list-style-type: none"> Display “diagnosis requests” in ISTA and test valve for proper function, replace valve as necessary.
Fuel Injectors:	<ul style="list-style-type: none"> Leaking fuel injector pintle seats cause rich engine starts with hot ambient temperatures. Blocked (dirty) injector(s). 	<ul style="list-style-type: none"> Ti Preset & status page. Sec Ign scope pattern. 	<ul style="list-style-type: none"> Check injectors for leakage. Swap suspect injector with another cylinder. Inspect injector, replace if necessary.
Fuel Pressure Regulator:	<ul style="list-style-type: none"> Regulator defective, causes fluctuation in the injected quantity of fuel causing mixture adaptation faults. 	<ul style="list-style-type: none"> Fuel pressure 	<ul style="list-style-type: none"> Check nominal fuel pressure value with engine operating under varied speeds.
Evaporative System:	<ul style="list-style-type: none"> Defective evaporative system vent causing fuel tank collapse and fuel starvation. 	<ul style="list-style-type: none"> ISTA status, Evap test with pressure tool, purge valve func. test. 	<ul style="list-style-type: none"> Check the fuel tank condition and vent line. Check Fresh Air Valve on TLEV E36 vehicles or LDP/ DM-TL and filter on ORVR vehicles for proper system “breathing”.

IMPLAUSIBLE ECM CONTROL FUNCTION OR SENSOR INPUT SIGNALS

COMPONENT	POSSIBLE CONDITION	TEST	CORRECTION
Crankshaft Position Sensor or Increment Wheel:	<ul style="list-style-type: none"> • Implausible signal for misfire detection. • Increment wheel loose or damaged (internal on M44, M52 and M54, external on M62 & M73). • Air gap between sensor and wheel. • Noticeable at higher rpm. 	<ul style="list-style-type: none"> • ISTA preset measurement. 	<ul style="list-style-type: none"> • Determine defective sensor or increment wheel and replace.
Catalyst Damaged:	<ul style="list-style-type: none"> • Excessive exhaust back pressure (bank specific fault present, more noticeable under heavy load and high rpm). 	<ul style="list-style-type: none"> • ISTA preset measurement of oxygen sensor. • Back pressure test per SIB with Special Tool. 	<ul style="list-style-type: none"> • Determine catalyst condition, replace or repair as necessary.
Oxygen Sensor:	<ul style="list-style-type: none"> • Excessive mixture deviation, possible vacuum leaks. 	<ul style="list-style-type: none"> • Monitor oxygen sensor signal via ISTA/IMIB. 	<ul style="list-style-type: none"> • Swap sensor from other bank (if applicable) and see if fault transfers to other bank.
Engine Control Module	<ul style="list-style-type: none"> • Internal control module fault. • Misfire Reprogramming. 	<ul style="list-style-type: none"> • Check fault memory. • Refer to SIB 	<ul style="list-style-type: none"> • Highly unlikely but must be considered. • Check Model/Prod range - reprogram

When diagnosing a Misfire fault code, Remember:

“Misfire” is caused by a defect in the internal combustion engine or a defect in the control of the engine operation.

“Misfire” is the result of improper combustion (variation between cylinders) as measured at the crankshaft due to:

- Engine mechanical defects; breakage, wear, leakage or improper tolerances.
- Excessive mixture deviation; air (vacuum leaks), fuel and all the components that deliver air/fuel into the combustion chambers.
- Faulty ignition; primary, secondary including spark plugs.
- Faulty exhaust flow; affecting back pressure.
- Tolerance parameters; ECM programming.

A Misfire fault code(s) is the “symptom” of a faulty input for proper combustion. When diagnosing a misfire, review the charts to assist you in finding the faulty input.

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.

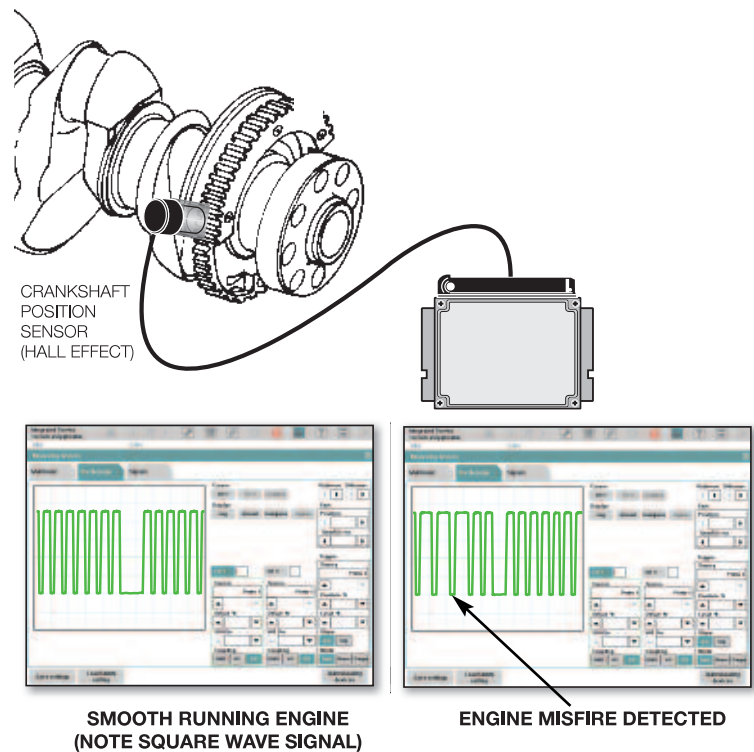
Each segment period consist of an angular range of 90° crank angle that starts 54° before Top Dead Center.

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.

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 ISTA. If the adaptation limit is exceeded a fault will be set.



Overview of the National Low Emission Vehicle Program

Emission Reduction Stages

While OBD II has the function of monitoring for emission related faults and alerting the operator of the vehicle, the National Low Emission Vehicle Program requires a certain number of vehicles produced (specific to manufacturing totals) currently comply with the following emission stages;

TLEV: Transitional Low Emission Vehicle

LEV: Low Emission Vehicle

ULEV: Ultra Low Emission Vehicle.

SULEV Super Ultra Low Emission Vehicle

Prior to the National Low Emission Vehicle Program, the most stringent exhaust reduction compliancy is what is known internally within BMW as HC II. The benefit of exhaust emission reductions that the National Low Emission Vehicle Program provides compared with the HC II standard is as follows;

Grams/Mile @ 50° F - Cold Engine Startup				
Compliance Level	NMHC Non-Methane Hydrocarbon	CO Carbon Monoxide	NOx Oxide(s) of Nitrogen	
TLEV:	50% cleaner			
	TLEV	0.250	3.4	0.4
	LEV	0.131	3.4	0.2
	ULEV	0.040	1.7	0.2
Grams/Mile @ 50,000 miles				
Compliance Level	NMHC Non-Methane Hydrocarbon	CO Carbon Monoxide	NOx Oxide(s) of Nitrogen	
LEV:	70% cleaner			
	TLEV	0.125	3.4	0.4
ULEV:	84% cleaner			
	LEV	0.075	3.4	0.2
	ULEV	0.040	1.7	0.2
Grams/Mile @ 100,000 miles				
Compliance Level	NMHC Non-Methane Hydrocarbon	CO Carbon Monoxide	NOx Oxide(s) of Nitrogen	
SULEV	90% cleaner			
	TLEV	0.156	4.2	0.6
	LEV	0.090	4.2	0.3
	ULEV	0.055	2.1	0.3

PZEV regulations include:

- Vehicles must meet SULEV tailpipe emissions standard (approx. 1/5 of ULEV standards)
- Vehicles conform to Zero Evaporative Emissions
- Vehicles subject to extended OBD regulations.
- Emission relevant components warranted for 15 years or 150,000 miles

BMW SULEV & PZEV Engines

BMW M56 Engine

The following components are used to achieve SULEV (Super Ultra Low Emission Vehicle) and ZEV Zero Evaporative Emission requirements:

- Pistons - Revised to change spark travel path
- Catalytic Converters - Ceramic carriers with high cell density for better “Warm Up” Control
- Oxygen Sensors - Planar wide band O₂ sensors in front of the cats
- Vanos - Positioning changed during start up for improved start up and emissions
- Fuel Pump Control - Revised with raised pressure and more accurate flow control
- Fuel Injectors - New design for improved fuel flow and higher working pressure
- Fuel System - All metal fuel system components made of stainless steel
- Air Intake System - Revised to block HC escape
- Crankcase Ventilation - Revised
- Secondary Air System - Mass air flow sensor to monitor secondary air flow
- Cooling System - Revised to reduce Ozone levels



BMW N51 Engine

In order to comply with SULEV requirements, the **N51** is another variant of the N52 engine. There are various measures to meet the EPA/CARB standards, some of which are familiar from the previous SULEV (M56) engine.

Some of the SULEV measures for the N51 include:

- Near engine catalyst with additional underbody catalyst
- Secondary air system
- Optimized combustion chamber geometry in cylinder head
- Modified piston crown for lower compression
- Plastic valve cover with integrated crankcase vent valve and separator (from N52KP)
- Stainless steel fuel lines with threaded connections
- Radiator with “Prem-air” coating
- Throttle system - EGAS08 carried over from N52KP
- Airbox with Activated carbon filter for EVAP control
- Purge system pipes are made from “optimized” plastic



Catalytic Converters

The catalysis attached in direct proximity to the engine and are equipped with ceramic(s) carriers in high cell density technology. These converters reach operating temperature faster and offer quicker control of exhaust emissions. Vehicles are also equipped with dual downstream converters.

Oxygen Sensors

The M56 engine use for Oxygen sensors, two planar broadband sensors upstream of the converter and two sensors downstream.

The planar broadband sensor reach operating temperature very fast and are able to effect fuel mixtures in approximately 5 seconds.

Fuel Pump System

Fuel system operating pressure is increased to 5 Bar.

The fuel pump is controlled by the Fuel pump control unit, based on engine demand as received from the DME over the Lo-CAN. The fuel pump control unit additionally receives information over the K-Bus, specifically crash information from the MRS.

Fuel Injectors

Nozzle diameter of the fuel injectors has been reduced and the installation angle has been changed. The injectors were also adapted to perform at the higher system operating pressure.

Injectors screw into the rail and a tap to test pressure readings is NOT provided.



Secondary Air System

The secondary air pump has been revised to improve its response time in cold weather starting situations.

A HFM (Hot Film Air Mass Meter) has been added to the secondary air system to monitor air volume pumped into the exhaust for more accurate control of the NOx emissions.



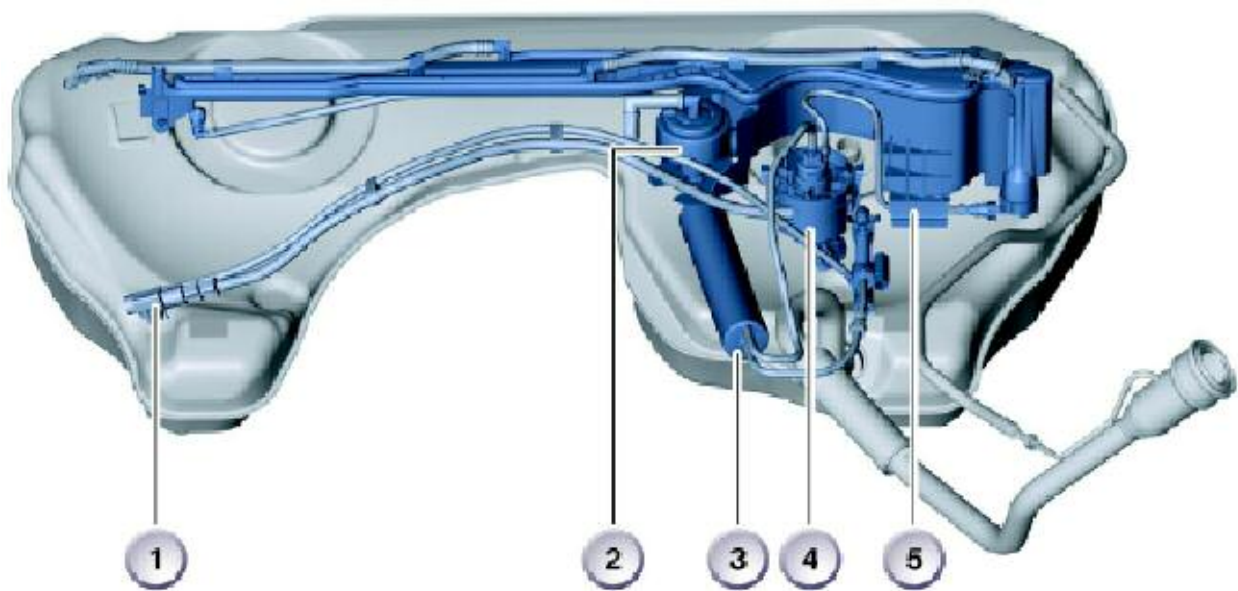
Fuel System

In order to meet the **Zero Evaporative Emission** requirement, the fuel system was completely revised. The fuel tank, tank filler neck, charcoal canister, fuel rail and tank ventilation valve are all made of stainless steel.

When perform repairs on the fuel system, it is imperative that all fitting remain clean and that the proper tightening torques are observed.

The fuel tank is manufactured of high grade steel and completely coated to meet the requirements of a minimum durability of 15 years.

The fuel tank can be exchanged only as a complete unit.



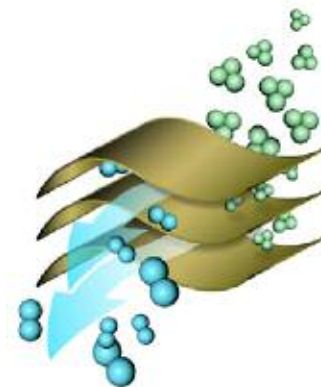
Index	Explanation
1	Syphon Jet
2	Roll over valve
3	Fuel Filter
4	Electric fuel pump
5	Liquid Vapor Separator

Cooling System

The radiator of SULEV looks similar to the standard radiator.

The surface of the cooling fins are coated with a special "PremAir" coating.

The coating consists of multiple porous layers of a catalytic surface. The task of the catalyst coating is to convert Ozone into Oxygen.



System Monitoring

Within the framework of OBD II, certain components/systems must be monitored once per driving cycle while other control systems (e.g. misfire detection) must be monitored permanently. A "driving cycle" consists of engine startup, vehicle operation (exceeding of starting speed), coasting and engine stopping.

Permanent Monitoring

Permanently monitored systems are monitored according to temperature immediately after startup. In the event of malfunctions (e.g. oxygen sensor), the Malfunction Indicator Light will illuminate immediately.

The following are monitored permanently:

- Misfire Detection
- Fuel System (duration of injection)
- All emission related electrical circuits, components and systems of the ECM, TCM and EML (if equipped).

Cyclic Monitoring

Systems monitored once per driving cycle will only result in a fault being registered after the corresponding operating conditions have been completed. Therefore, there is no possibility for checking when the engine is started up briefly and then shut down.

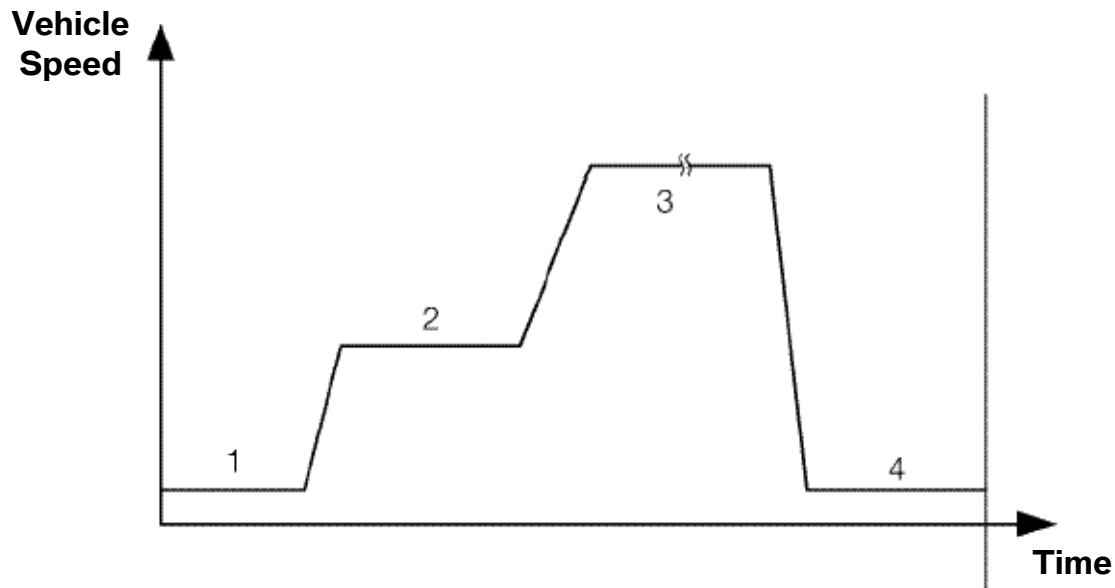
The following are monitored once per driving cycle:

- Oxygen Sensor Function
- Secondary Air Injection System
- Catalytic Converter Function (efficiency)
- Evaporative Vapor Recovery System

Due to the complexity involved in meeting the test criteria within the defined driving cycle, all tests may not be completed within one "customer driving cycle". The test can be successfully completed within the defined criteria, however customer driving styles may differ and therefore may not always monitor all involved components/systems in one "trip".

Drive Cycle

The following diagram shows how a drive cycle is set (test drive) in order for all the systems to be monitored once. The test conditions can be created in any desired order after startup.



Example of a Drive Cycle for Completing all OBD II Relevant Checks:

1. Engine cold start, idling, approximately 3 minutes. Evaluated:
 - Secondary Air System
 - Evaporative Leak Detection (LDP Equipped Vehicles)
2. Constant driving at 20 to 30 MPH, approximately 4 minutes. Evaluated:
 - Oxygen Sensors - Achieved “Closed Loop” Operation
 - Oxygen Sensors - Response Time and Switching Time (Control Frequency)
3. Constant driving at 40 to 60 MPH, approximately 15 minutes (sufficient vehicle coasting phases included). Evaluated:
 - Catalytic Converter Efficiency
 - Oxygen Sensors - Response Time and Switching Time (Control Frequency)
4. Engine idling, approximately 5 minutes. Evaluated:
 - Tank-Leak Diagnosis (DM-TL Equipped Vehicles after KL 15 is switched OFF)

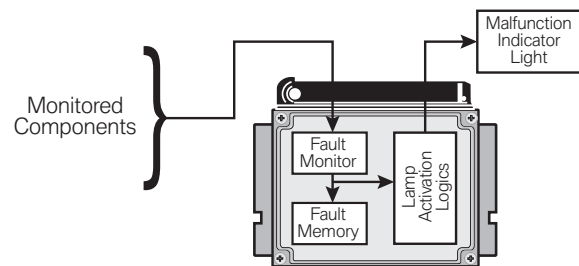


The diagnostic sequence illustrated above will be interrupted if:

- **The engine speed exceeds 3000 RPM**
- **Large fluctuations in the accelerator pedal position.**
- **The driving speed exceeds 60 MPH**

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 (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 SET	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	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 ISTA and IMIB.

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.

With the use of a universal scan tool, connected to the "OBD" DLC an SAE standardized DTC can be obtained, along with the condition associated with the illumination of the "Malfunction Indicator Light". Using the ISTA, a fault code and the conditions associated with its setting can be obtained prior to the illumination of the "Malfunction Indicator Light".

Readiness Code

The readiness code provides status (Yes/No) of the system having completed all the required monitoring functions or not. The readiness code is displayed with an aftermarket Scan Tool or ISTA. The code is a binary (1/0) indicating;

- 0 = Test Not Completed or Not Applicable - six cylinder vehicles (not ready - V8 and V12)
- 1 = Test Completed - six cylinder vehicles (ready - V8 and V12)

A "readiness code" must be stored after any clearing of fault memory or disconnection of the ECM. A readiness code of "0" will be stored (see below) after a complete diagnostic check of all components/systems, that can turn on the "Malfunction Indicator Light" is performed.

The readiness code was established to prevent anyone with an emissions related fault and a "Malfunction Indicator Light" on from disconnecting the battery or clearing the fault memory to manipulate the results of the emissions test procedure (IM 240).

Interpretation of the Readiness Code by the ECM(s) (SAE J1979)

The complete readiness code is equal to "one" byte (eight bits). Every bit represents one complete test and is displayed by the scan tool, as required by CARB/EPA. For example:

0 = EGR Monitoring (=0, N/A with BMW)

1 = Oxygen Sensor Heater Monitoring

1 = Oxygen Sensor Monitoring

0 = Air Condition (=0, N/A with BMW)

1 = Secondary Air Delivery Monitoring

1 = Evaporative System Monitoring

0 = Catalyst Heating

1 = Catalyst Efficiency Monitoring



Drive the car in such a manner that all tests listed above can be completed (refer to the drive cycle). When the complete "readiness code" equals "1" (ready) then all tests have been completed and the system has established its "readiness".

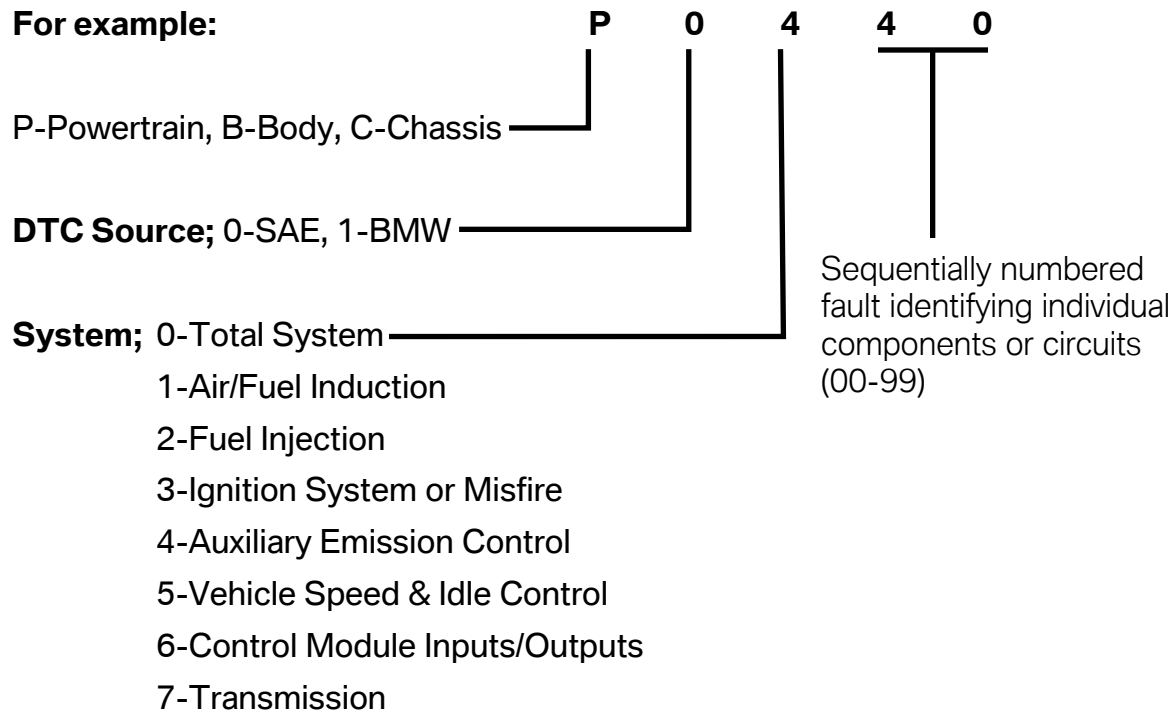
Readiness Code using the ISTA

The readiness code can be checked with the ISTA. This is particularly helpful in verifying that "drive cycle" criteria was achieved. A repair can be confirmed before returning the vehicle to the customer by a successfully completed drive cycle.

OBD II Diagnostic Trouble Codes (DTC)

The Society of Automotive Engineers (SAE) established the Diagnostic Trouble Codes used for OBD II systems (SAE J2012). The DTC's are designed to be identified by their alpha/numeric structure. The SAE has designated the emission related DTC's to start with the letter "P" for Powertrain related systems, hence their nickname "P-code".

For example:



- DTC's are stored whenever the "Malfunction Indicator Light" is illuminated.
- A requirement of CARB/EPA is providing universal diagnostic access to DTC's via a standardized Diagnostic Link Connector (DLC) using a standardized tester (scan tool).
- DTC's only provide one set of environmental operating conditions when a fault is stored. This single "Freeze Frame" or snapshot refers to a block of the vehicles environmental conditions for a specific time when the fault first occurred. The information which is stored is defined by SAE and is limited in scope. This information may not even be specific to the type of fault.

BMW Fault Code

- BMW Codes are stored as soon they occur even before the "Malfunction Indicator Light" comes on.
- BMW Codes are defined by BMW, Bosch and Siemens Engineers to provide greater detail to fault specific information.
- **Siemens systems** - one set from four fault specific environmental conditions is stored with the first fault occurrence. This information can change and is specific to each fault code to aid in diagnosing. A maximum of ten different faults containing four environmental conditions can be stored.
- Bosch systems - a maximum of four sets from three fault specific environmental conditions is stored within each fault code. This information can change and is specific to each fault code to aid in diagnosing. A maximum of ten different faults containing three environmental conditions can be stored.
- BMW Codes also store and displays a "time stamp" when the fault last occurred.
- A fault qualifier gives more specific detailed information about the type of fault (upper limit, lower limit, disconnection, plausibility, etc.).
- BMW Fault Codes will alert the Technician of the current fault status. He/she will be advised if the fault is actually still present, not currently present or intermittent.

The fault specific information is stored and accessible through ISTA.

- BMW Fault Codes determine the diagnostic output for ISTA.

OBD II Fault Memory and Fault Codes

Within the framework of OBD II, a diagnosis of all emission-related components/functions must take place during driving. Faults will be stored and displayed if necessary. For this purpose, the ECM includes OBD II memory. The standardized P codes for malfunctions are stored in this memory. The memory can be read out with the ISTA or a Scantool.

Emission Control Function Monitoring & Comprehensive Component Monitoring

OBD II regulations are based on section 1968.1 of Title 13, California Code of Regulations (CCR), The law set forth in section 1968.1 requires an increased scope of monitoring emission related control functions including:

- Catalyst Monitoring
- Heated Catalyst Monitoring
(currently used on BMW 750iL vehicles)
- Misfire Monitoring
- Evaporative System Monitoring
- Secondary Air System Monitoring
- Air Conditioning System Refrigerant Monitoring
(Not applicable for BMW vehicles)
- Fuel System Monitoring
- Oxygen Sensor Monitoring
- Exhaust Gas Recirculation (EGR) System Monitoring
(Not applicable for BMW vehicles)
- Positive Crankcase Ventilation (PCV) System Monitoring
(Not required at this time)
- Thermostat Monitoring (if equipped)

Monitoring these emission requirements is a function of the ECM which uses “data sets” while monitoring the conditions of the environment and the operation of the engine using existing input sensors and output actuators.

The data sets are programmed reference values the ECM refers to when a specific monitoring procedure is occurring. If the ECM cannot determine the environmental and/or engine operating conditions due to an impaired or missing signal, it will set a fault and illuminate the “Malfunction Indicator Light”.

This input or control signal monitoring falls under another category called “Comprehensive Component Monitoring”. The ECM must recognize the loss or impairment of the signal or component. The ECM determines a faulted signal or sensor via three conditions:

1. Signal or component shorted to ground.
2. Signal or component shorted to B+.
3. Signal or component lost (open circuit). Specific fault codes are used to alert the diagnostician of these conditions.

OBD II System Information on TIS

BMW TIS includes a section with OBD II related information and it is divided into three main categories:

- **Mode \$06 Interface Data;** features a list of current and previous DME's for specific on board monitoring test results.
- **OBD II Overview and Drive Cycle;** features a brief summary of the Emissions Overview contained in this Reference Manual.
- **OBD II Systems;** features a list of current and previous DME's with information on Fault Codes Conditions with possible fault causes and suggested repair procedures as well as specific OBD II Description information as per DME version. This section is an important tool that can help you in your diagnosis process!

To access the information contained in the OBD section, access CenterNet, then go to TIS and select the category you wish to browse.

The screenshot shows the BMW TIS website interface. The main navigation menu on the left includes sections like 'What's New', 'Service Information', 'Operating Fluids', 'Technical Training', and 'Parts Information'. The 'Model Map' section is highlighted, and the 'OBD' link is circled in red. An inset shows a detailed view of the OBD II Systems Information page, which displays a table of engine families, engine/trans types, models, and production dates for the years 2011 and 2010.

Engine Family (See Group/ID)	Engine/Trans Type	Models	Production Dates
MSD07 42 Test File	r5UT	D08 D19 D59	01V 2011
MSD0 17-2 Test File	F45	E06 E19	01V 2011
MSD0 17-2 Test File	855	F07 F10 F26	01V 2011
2010			
MSD0 17-2 Test File	856	F07	01V 2010
MSD08 Test File	900	X5H X6H	01V 2010 01V 2010
MSD09 Test File	F60	F07	01V 2010
MSD06 2 Test File	F60M	E12	01V 2010
05E 7.3	867	D08	01V 1010

16 Pin Diagnostic Socket

Model and Production Date: E46 from 6/00

E39, E52, E53 from 9/00

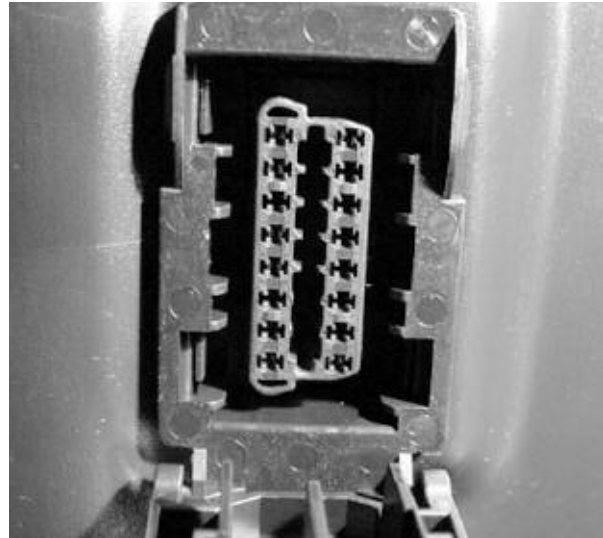
For model year 2001 the E39, E46 and E53 **will eliminate the 20 pin diagnostic connector** from the engine compartment. The 16 pin OBD II connector located inside the vehicle will be the only diagnosis port.

The E38 and Z3 will continue to use the 20 pin connector until the end of production.

The 16 pin OBD II connector has been in all BMWs since 1996 to comply with OBD regulations requiring a standardized diagnostic port.

Previously before 2001, only emissions relevant data could be extracted from the OBD II connector because it did not provide access to TXD (D-bus).

The TXD line is connected to pin 8 of the OBD II connector on vehicles without the 20 pin diagnostic connector.



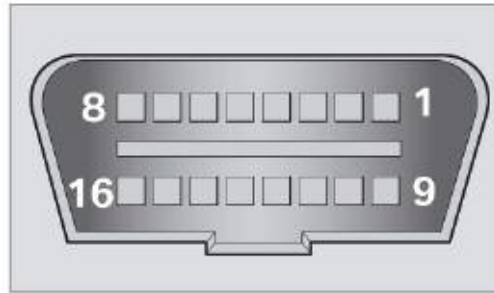
The cap to the OBD II connector contains a bridge that links KL 30 to TXD and TXD II. This is to protect the diagnostic circuit integrity and prevent erroneous faults from being logged.

The OBD II connector is located in the driver's footwell to the left of the steering column for E39, E46 and E53 vehicles.

BoardNet 2020

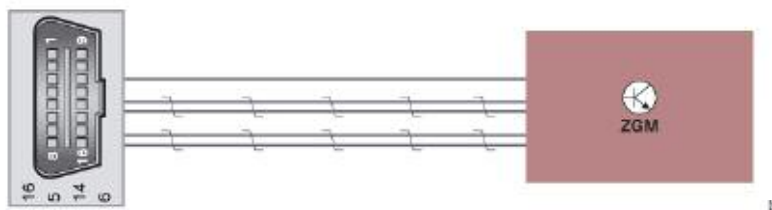
Vehicles equipped with BN2020 have the following configuration in the OBD II Diagnostic Socket:

Diagnostic socket



Index	Explanation	Index	Explanation
1	Not assigned	9	Engine speed
2	Not assigned	10	Not assigned
3	Ethernet Rx+	11	Ethernet Rx-
4	Terminal 31	12	Ethernet Tx+
5	Terminal 31	13	Ethernet Tx-
6	D-CAN High	14	D-CAN Low
7	Not assigned	15	Not assigned
8	Ethernet activation	16	Terminal 30F

Ethernet connection between the diagnostic socket and ZGM



These five lines are routed from the diagnostic socket to the central gateway module (ZGM).

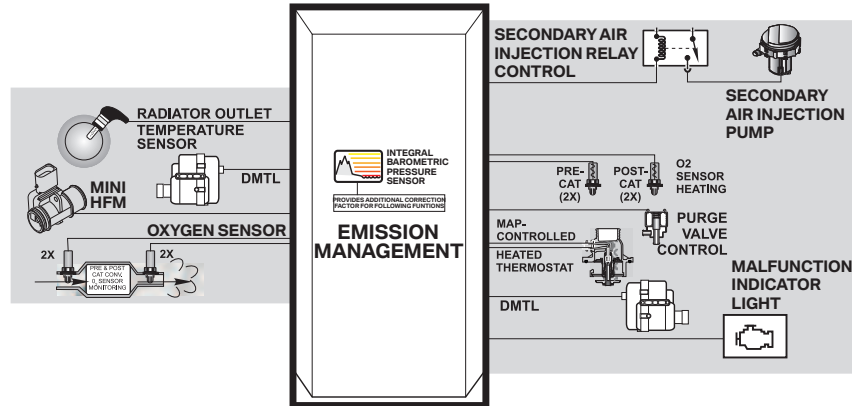
One of the five lines transmits the activation signal. The remaining four lines are twisted pair and are used for data transmission.



For further information please refer to the F01 Reference Manual.

Emission Management

Example of IPO for an Emissions Management System



One of the main purposes of the ECM is Emissions Management which includes the actuation of several components. In the following pages you will find a generic explanation on how this system works. For more detailed information please access BMW Training Reference Manuals found on-line.

The 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 also 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 the remaining combustible exhaust gases and is monitored by the ECM for catalyst efficiency.

Malfunction Indicator Light (MIL)

The 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".

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 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.

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.

Adaptation Values

In order to maintain an “ideal” air/fuel ratio, the engine control module is capable of adapting to various environmental conditions encountered while the vehicle is in operation (i.e. changes in altitude, humidity, ambient temperature, ambient pressure, fuel quality, etc.).

The adaptation system 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 engine control module modifies the injection rate under two areas of engine operation:

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

These values are displayed in the “Diagnosis Query” section of ISTA and are a helpful diagnostic tool that shows how the system is trying to compensate for a less than ideal initial air/fuel ratio.

Note: If the adaptation value is greater than “0.0 ms” the Engine Control Module is trying to en-richen the mixture. If the adaptation value is less than “0.0 ms” the Engine Control Module is trying to lean-out the mixture.

Diagnosis Request Status	Explanation
Additive mixture adaptation (Idle)	<p>If the value is greater than 0.2ms there is an unmeasured air leak or not enough fuel being supplied to the system.</p> <ul style="list-style-type: none"> • The O₂ sensor indicates a LEAN condition • The engine control module tries to RICHEN the mixture. <p>If the value is less than -0.2 ms there is an air restriction or too much fuel is being supplied to the system.</p> <ul style="list-style-type: none"> • The O₂ sensor indicates a RICH condition. • The Engine Control Module tries to LEAN out the mixture.
Multiplicative mixture adaptation (Part load)	<p>If the value is greater than 8% there is an unmeasured air leak or not enough fuel being supplied to the system.</p> <ul style="list-style-type: none"> • The O₂ sensor indicates a LEAN condition • The Engine Control Module tries to RICHEN the mixture <p>If the value is less than -8% there is an air restriction or too much fuel being supplied to the system</p> <ul style="list-style-type: none"> • The O₂ sensor indicates a RICH condition • The Engine Control Module tries to LEAN out the mixture

Oxygen Sensors

The oxygen sensor is an indispensable component for controlling and measuring the composition of exhaust gas with the aim of conforming to legally stipulated emission values. This is achieved by measuring the residual oxygen content in the exhaust gas.

A fuel-air ratio of 1 kg of fuel to 14.7 kg of air is required for optimum combustion.

Oxygen sensor before catalytic converter

■ Bosch LSH25 Oxygen Sensor

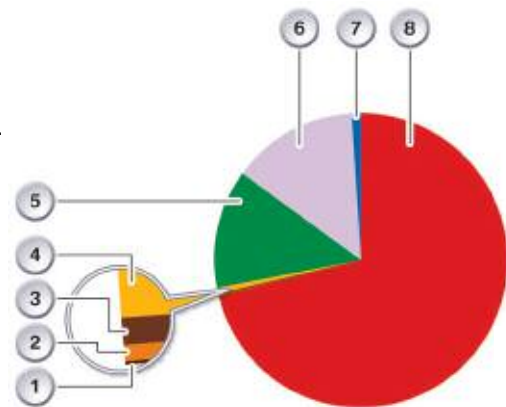
The pre-cat Bosch LSH 25 oxygen sensors measure the residual oxygen content of the exhaust gas. The sensors produce a low voltage (0-1000 mV) proportional to the oxygen content that allows the ECM to monitor the air/fuel ratio.

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

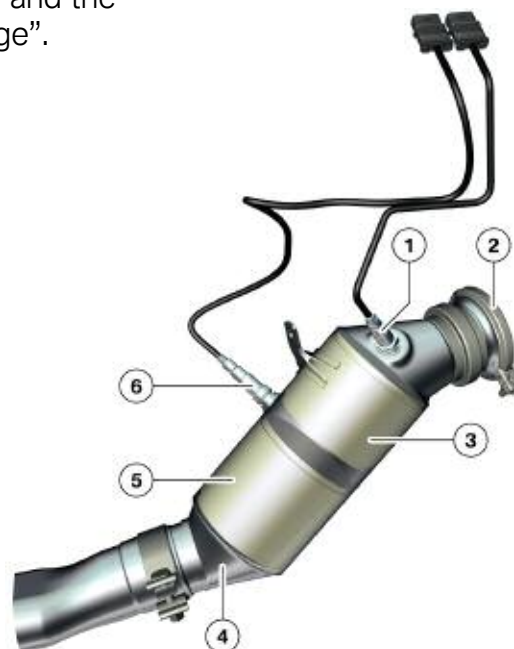
The “tip” of the sensor contains a microporous platinum coating (electrodes) which conduct current. The platinum electrodes are separated by solid electrolyte which conducts oxygen ions. The platinum conductors are covered with a highly porous ceramic coating and the entire tip is encased in a ventilated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

Index	Explanation
1	Oxygen sensor upstream of catalytic converter
2	Connection to the turbocharger
3	Ceramic structure 1
4	Catalytic converter outlet funnel
5	Ceramic structure 2
6	Oxygen sensor after ceramic structure 1

Exhaust gas composition before catalytic converter

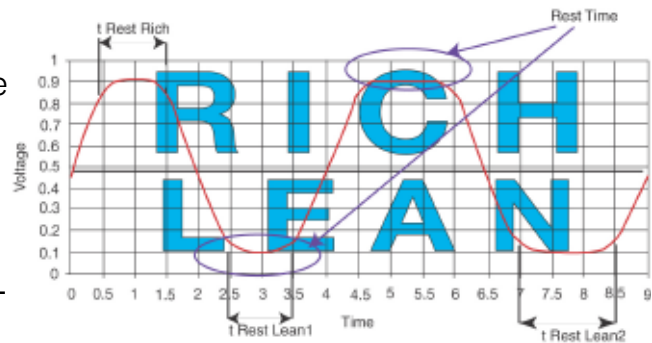


Index	Explanation
1	Solids 0.005%
2	NO _x 0.1%
3	HC 0.2%
4	CO 0.7%
5	CO ₂ 14%
6	H ₂ O 13%
7	Oxygen + others 1%
8	N ₂ 71%



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.



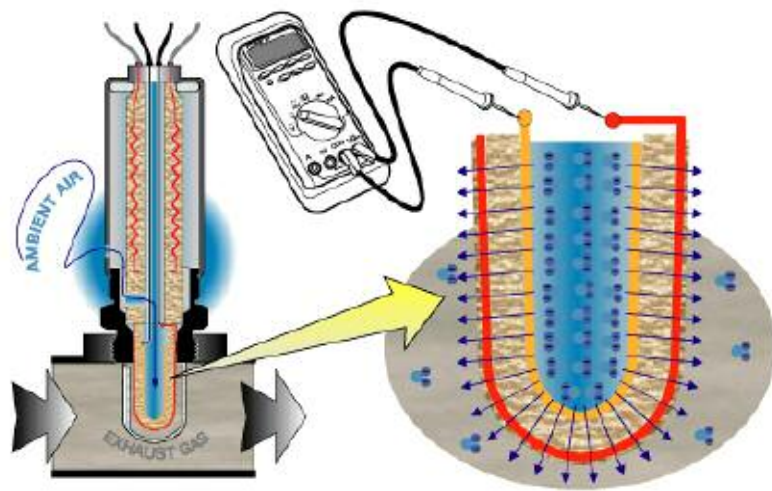
If the exhaust has a lower oxygen content (rich mixture), there will be a large ion “migration” through the sensor generating a higher voltage (950 mV).

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 predefined number of oscillation cycles.

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.



■ Bosch LSU Planar Wideband Oxygen Sensor

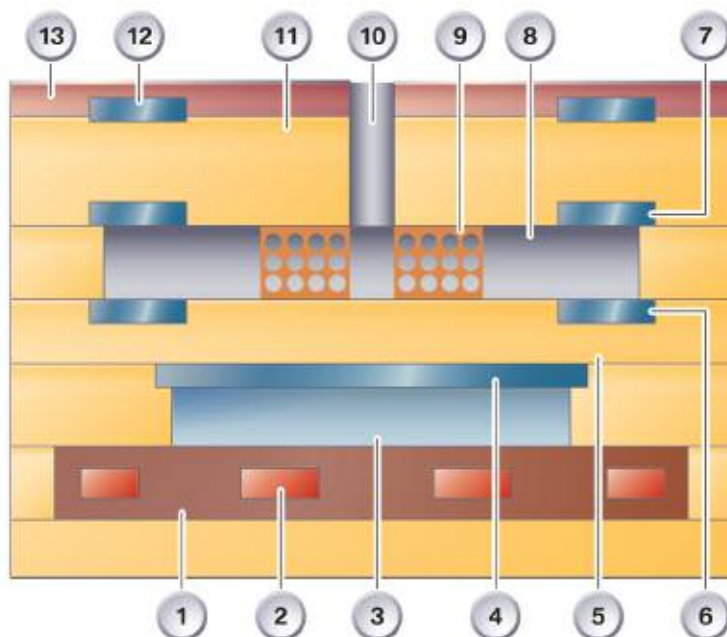
Engines equipped with planar wideband oxygen sensors (pre-catalyst) are identified by its planar shape (type of construction) which is more compact and is made up of thin layers of zirconium dioxide (ZrO_2) ceramic films. This modular lamination structure enables the integration of several functions including the heating element which ensures the minimum operating temperature (750 °C) is reached rapidly.

In contrast to conventional oxygen sensors, the wideband features can measure not only at $\Lambda=1$, but also in the rich and extremely lean range ($\Lambda=0.7$ to complete atmospheric oxygen) very rapidly.

To operate effectively, the oxygen sensor requires ambient air as the “reference gas” inside the sensor. **The ambient air reaches the inside of the sensor through the plug connection and through the harness.** The plug connection socket must therefore be protected from contamination (wax, preservatives, engine degreasers, engine washing, etc.). In the event of the oxygen sensor malfunctioning, the connector should always be checked first with regard to contamination and cleaned if necessary. The plug connection must be disconnected and then reconnected to remove any oxidation from the connector pins.

The pump cell and reference cell are made of zirconium dioxide and each coated with two porous platinum electrodes. They are arranged so that there is a measuring gap of approx. 10 to 50 microns between them. This measuring gap is connected by an inlet opening to the exhaust gas. The pump cell is controlled by the ECM applying voltage to the electrodes to initiate oxygen ion pumping across the porous membrane of the reference cell, providing a quicker response time.

Design of broadband oxygen sensor



Index	Explanation
1	Insulation layer
2	Heating element
3	Reference air channel
4	Inner electrode, reference cell
5	Ceramic layer made of ZrO_2
6	Outer electrode reference cell
7	Inner electrode, O_2 pump cell
8	Diffusion gap
9	Porous diffusion barrier
10	Exhaust inlet hole
11	Ceramic layer made of ZrO_2
12	Outer electrode, O_2 pump cell
13	Protective layer

If the exhaust gas content is lean, the pump cell pumps oxygen away from the measuring gap to the outside. The direction of flow is reversed for rich exhaust gas content, then oxygen is pumped from the exhaust gas into the measuring gap. The pump current flow is proportional to the oxygen concentration (lean) or the oxygen requirement (rich). The pump is constantly working to maintain that the gas composition in the measuring gap is constantly at $\lambda=1$. The required current of the pump cell is evaluated by the ECM as a signal that represents oxygen content in the exhaust gas.

■ **Bosch LSU ADV (Planar Wideband)**

The Bosch oxygen sensor LSU ADV is used as the control sensor before the catalytic converter. The abbreviation LSU stands for “Lambdasonde Universal” and ADV for “Advanced”. The function is similar to that of the LSU 4.9 oxygen sensor and is therefore described in detail in the E71 X6 training material under “N63 engine” available in TIS and ICP.

The oxygen sensor before catalytic converter (LSU ADV) offers the following advantages:

- High signal stability specially during turbocharged operation due to low dynamic pressure dependence.
- Increased durability due to reduced pump voltage.
- Increased accuracy (by a factor of 1.7 compared to LSU 4.9).
- Ready for operation in < 5 seconds.
- Greater temperature compatibility.
- Improved connector with more effective contacting properties.

The LSU ADV has an extended measuring range, making it possible to measure precisely from λ 0.65. The new oxygen sensor is ready for operation faster so that exact measured values are available within 5 seconds of start up.

The higher measuring dynamics of the sensor makes it possible to more effectively determine and control the fuel-air ratio separately for each cylinder. This results in a homogeneous exhaust flow that reduces emissions while also having a favorable effect on long-term emission characteristics.

Oxygen Sensor after Catalytic Converter

The oxygen sensor after catalytic converter is also known as the monitoring sensor. The familiar Bosch LSF 4.2 monitoring sensor are used in most of our NG engines.

The voltage range is 0.10 to 1.0 volts.

Oxygen Sensor Signals

The sensor conductivity is efficient when the oxygen sensor is hot (750° C). For this reason, the sensor contains a heating element. This reduces warm up time, and retains the heat during low engine speed when the exhaust temperature is cooler. The oxygen sensor heating elements receive power from the IVM (12 V) and the ground supply is pulse width modulated by the ECM.

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

- At a value of $\Lambda = 1$, the pump cell requires approx. 3 mA.

The oxygen sensor signal voltage is approx. 1.5V

The reference cell voltage is approx. 450mV

- At a Λ value <1 (rich), the oxygen sensor signal voltage is approx. 0.3V
- At a Λ value >1 (lean), the oxygen sensor signal voltage is approx. 4.3V

If necessary, the ECM will “correct” the air/fuel ratio by regulating the ms injection time. The ECM monitors the length of time the sensors are operating in the lean, rich and rest conditions. The evaluation period of the sensors is over a predefined number of oscillation cycles and pump cell amperage.

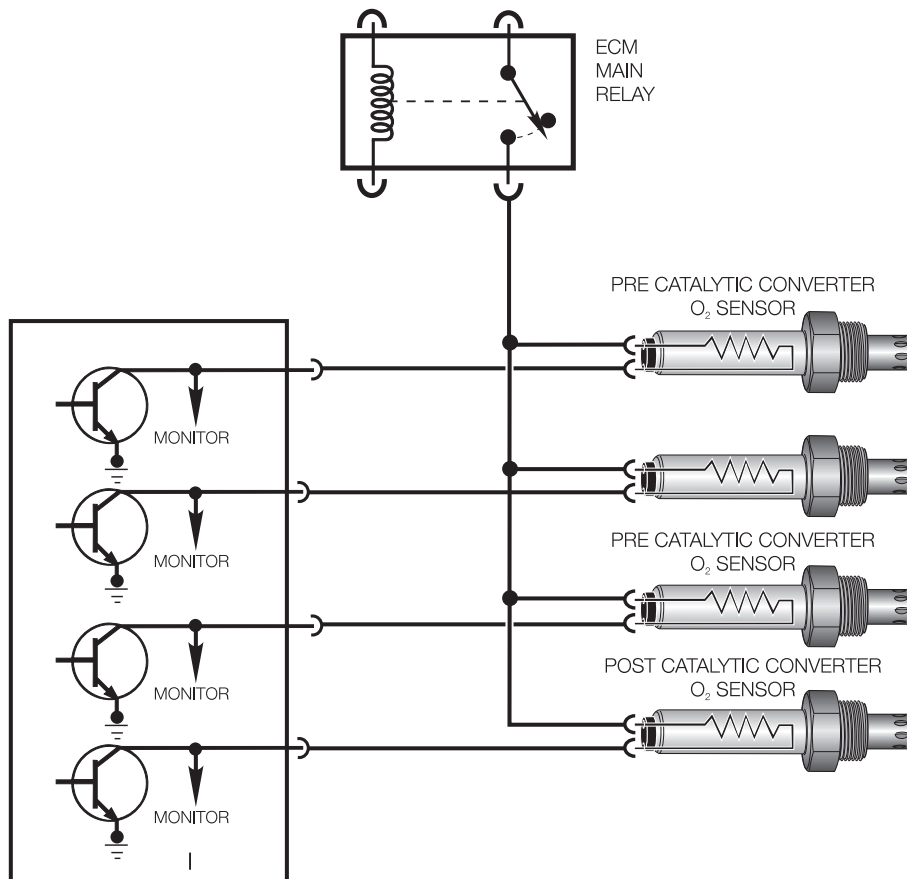
Direct Oxygen Sensor Heating

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.



Testing the Oxygen Sensor

Testing should be performed using ISTA/IMIB Oscilloscope. List. The scope pattern should appear 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



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

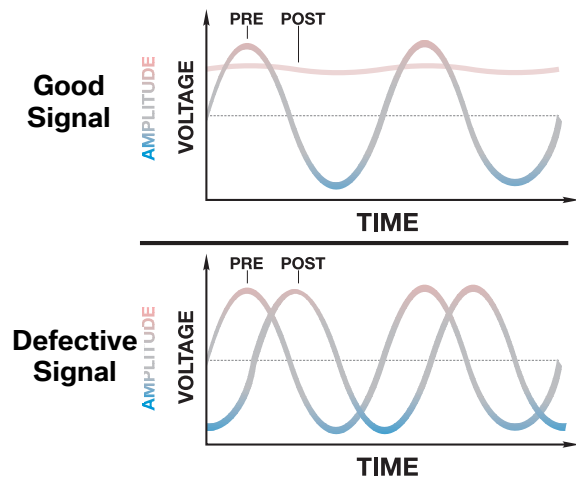
Catalytic Converter Monitoring

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.

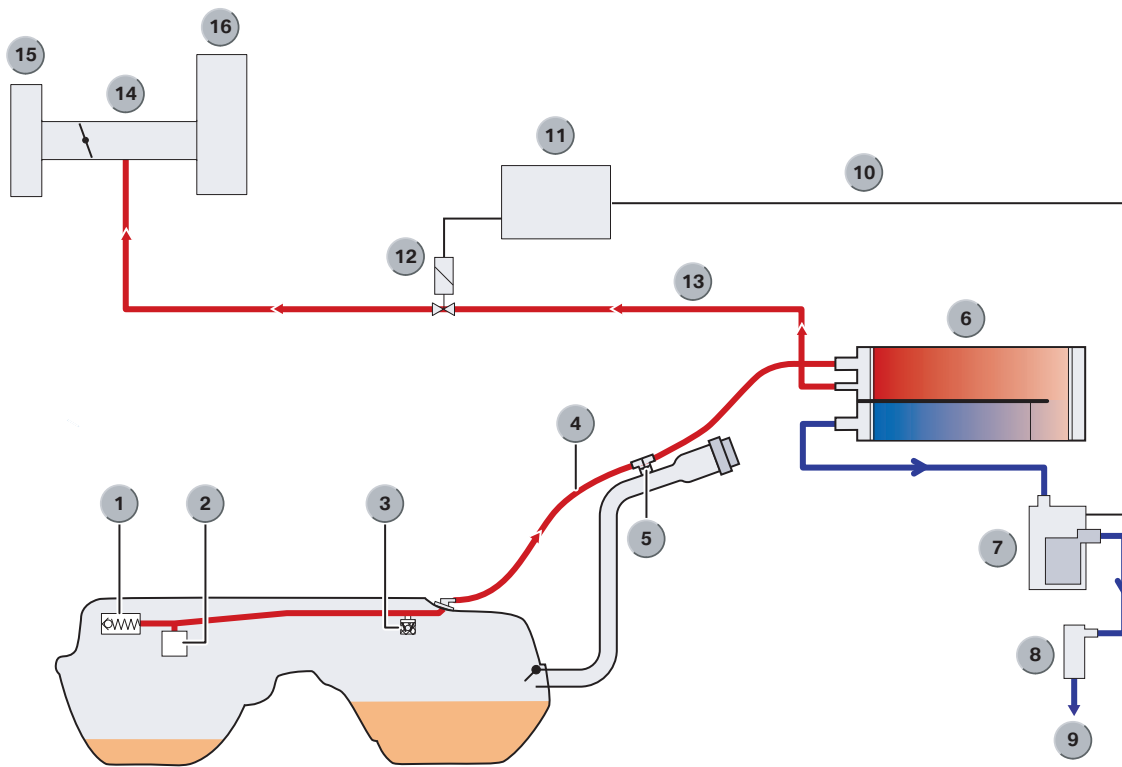
In order to determine if the catalysts are working correctly, post catalyst oxygen sensors are installed to monitor exhaust gas content exiting the catalysts. The signal of the post cat. O₂ sensor is evaluated over the course of several pre cat. O₂ sensor oscillations.

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.



On-Board Refueling Vapor Recovery (ORVR)



Index	Explanation	Index	Explanation
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

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).

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.

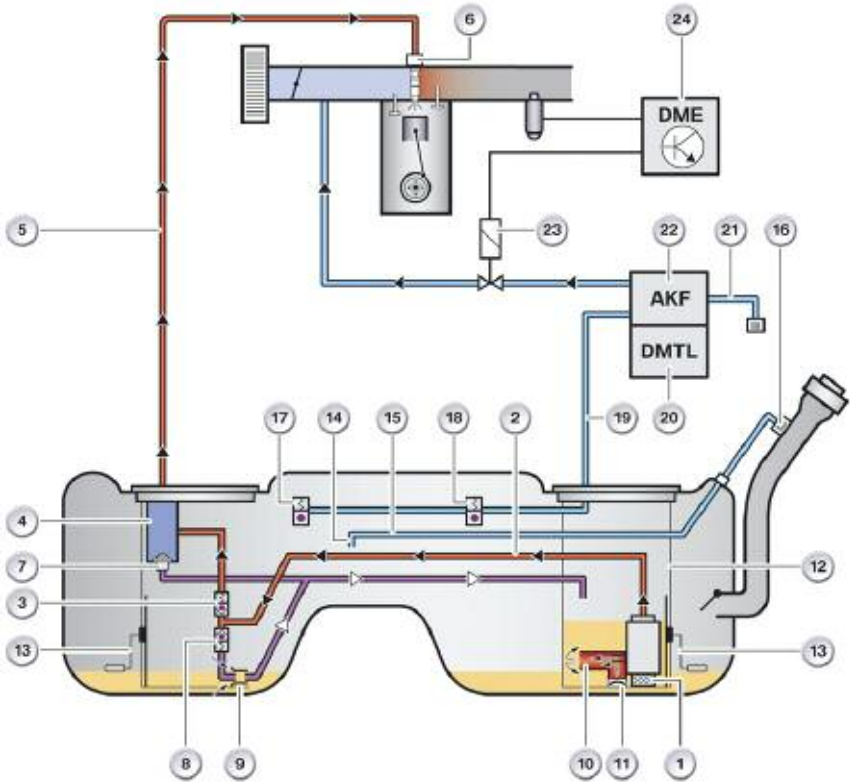
This leaves a vapor area of approximately 6 liters above the fuel level. This area provides integral liquid/vapor separation. The vapor condensates separate and drain back into the fuel. The remaining vapors exit the fuel tank (when sufficient pressure is present) through the Operating Vent Valve (3)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



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 Operating Vent Valve is also equipped with a protection float in the event of an “overflow” situation.

On-Board Refueling Vapor Recovery (ORVR) E9x Vehicles



Index	Explanation	Index	Explanation
1	Electric Fuel Pump	13	Fuel Level Sensor
2	Feed Line	14	Refuelling Line Connection Piece
3	Check Valve	15	Refuelling Ventilation Line
4	Fuel Filter	16	Refuelling Ventilation
5	Feed Line to Engine	17	Left Operation Ventilation Valve
6	Fuel Injector	18	Right Operation Ventilation Valve
7	Pressure Regulator	19	Operation Ventilation Line
8	Check Valve	20	Diagnosis Module for Tank Leakage (DM-TL)
9	Left Suction Jet Pump	21	Atmosphere Line
10	Right Suction Jet Pump	22	Carbon Canister
11	Initial Filling Valve	23	Fuel Tank Vent Valve
12	Fuel Baffle	24	Digital Motor Electronics

The ORVR system recovers and stores hydrocarbon fuel vapors during refueling. When refueling the E90, a downward open adapter (14) is located on the refueling ventilation line (15) in the fuel tank. During the refueling procedure, the air can escape out of the tank via the refueling ventilation line (15) and the fuel filler neck.

When the fuel level rises up to the opening of the refueling ventilation line, it is closed off and the fuel level increases in the fuel filler neck up to the fuel station pump. The fuel station pump then switches off automatically.

After the fuel station pump has switched off, an expansion volume (approx. 10 liters) remains above the refueling ventilation line.

Ventilation During Engine Operation

The fuel vapors produced in the fuel tank pass:

- through the operation ventilation valves (17 + 18)
- through the ventilation line (19),
- into the carbon canister AKF (20),
- through the purge air line and
- through the fuel tank vent valve TEV (22),
- to the engine intake manifold.

The two operation ventilation valves are located above the refueling ventilation adapter (14). They are connected by a line. The left operation ventilation valve (17) only has a ventilation function while the right operation ventilation valve (18) additionally has a pressure holding function (50 mbar).

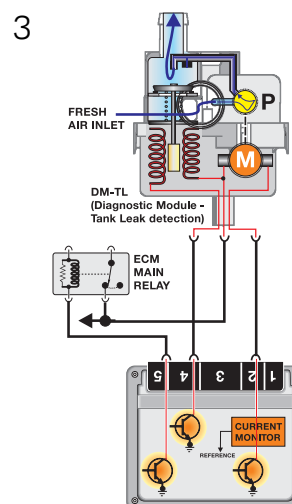
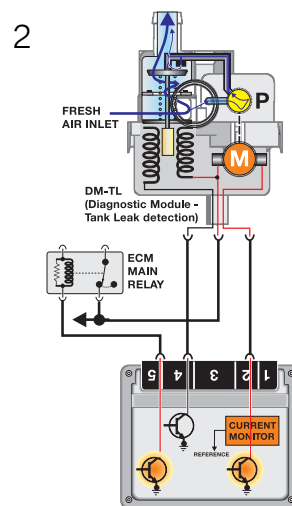
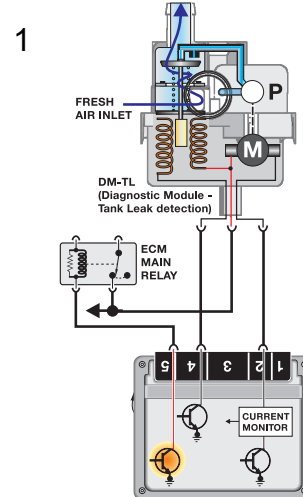
The aim of the pressure holding function is to avoid the remaining air of the expansion volume escaping via the carbon canister while refueling (with refueling ventilation line closed).

Evaporative Leakage Detection (DM-TL)

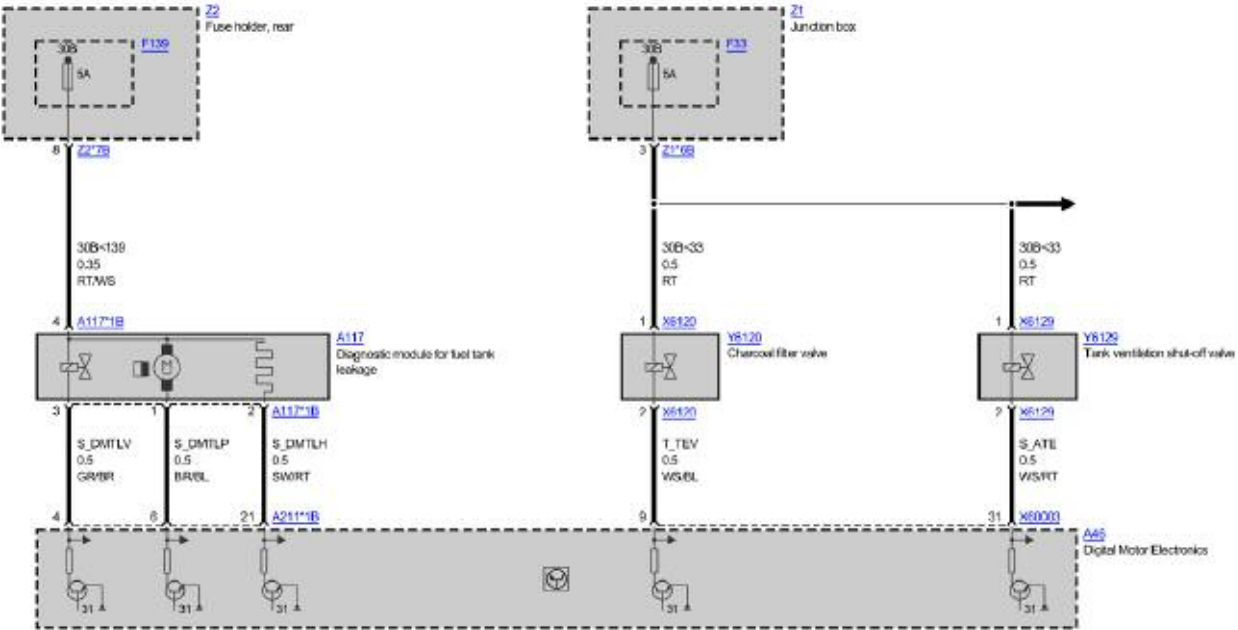
This component ensures accurate fuel system leak detection for leaks as small as 0.5 mm by slightly pressurizing the fuel tank and evaporative components. The DM-TL pump contains an integral DC motor which is activated directly by the ECM. The ECM monitors the pump motor operating current as the measurement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



SSP-SP0000052267 Diagnostic module for fuel tank leakage

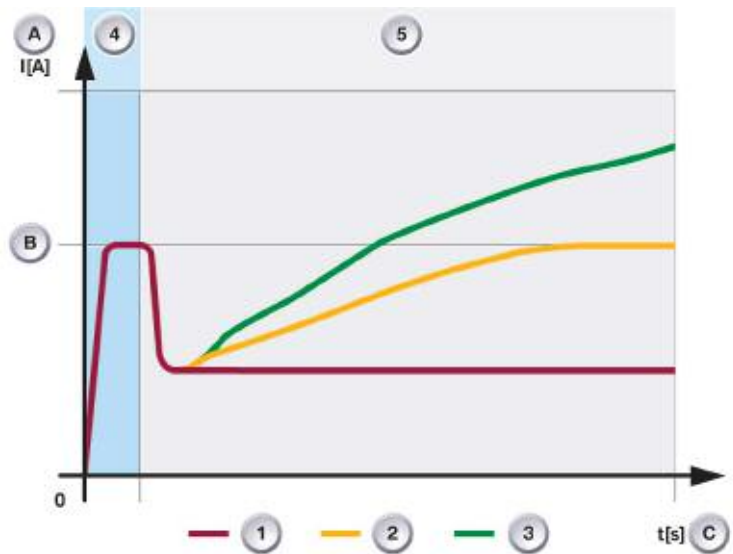


To prevent condensation buildup in the DM-TL pump, a heating element is integrated into the housing of the pump. The heating element is ground controlled by the ECM.

Test Results

The time duration varies between 30 & 360 seconds depending on the resulting leak diagnosis test results (developed tank pressure “amperage” within a specific time period).

When 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”.



Index	Explanation	Index	Explanation
A	Current	2	Leak = 0.5mm
B	Overpressure 25hPa (25mbar)	3	No leak in system (leak <0.5mm)
C	Time	4	Reference measurement (leak 0.5mm)
1	Leak >1mm	5	Leakage measurement

Refuelling While a Leak Diagnosis is Taking Place:

The ECM detects refueling during a leak diagnosis as a result of the pressure drop when the fuel filler cap is opened and the increase pressure while filling the tank is being filled.

In this case, the leakage diagnosis is interrupted. The solenoid valve in the DM-TL is switched off and the tank pressure escapes through the activated carbon canister.

If refueling does not take place immediately after the fuel filler cap has been opened, the system will detect a large leak and the a fault will be stored in the ECM. If refueling is detected in the next driving cycle (increase in fuel level), the fault is cleared.

The ECM detects refueling from a change in the fuel tank sending unit level. If the filler cap was not properly installed, when the leakage test is performed and leakage is detected; the variable indicator lamp (shown to the right) and the “Please Close Filler Cap” Check Control message will be displayed.

If the filler cap is correctly installed and leakage is not present the next time the test is performed, the “Malfunction Indicator Light” will not be illuminated.

Starting with 2002 MY, a heating element was added to the DM TL pump to eliminate condensation.

The heater is provided battery voltage when KL_15 is switched “on” and the ECM provides the ground path (see page 47).



Principle of Operation

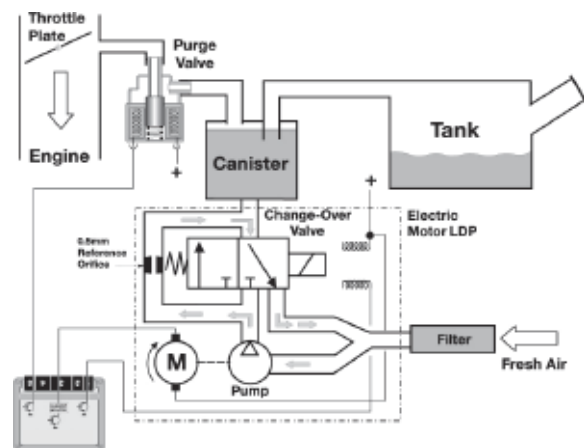
The Evaporative Leakage Detection is performed on the fuel storage system by the DM-TL pump which contains an integral DC motor that is activated by the ECM. The ECM monitors the pump motor operating current as the measurement for detecting leaks.

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

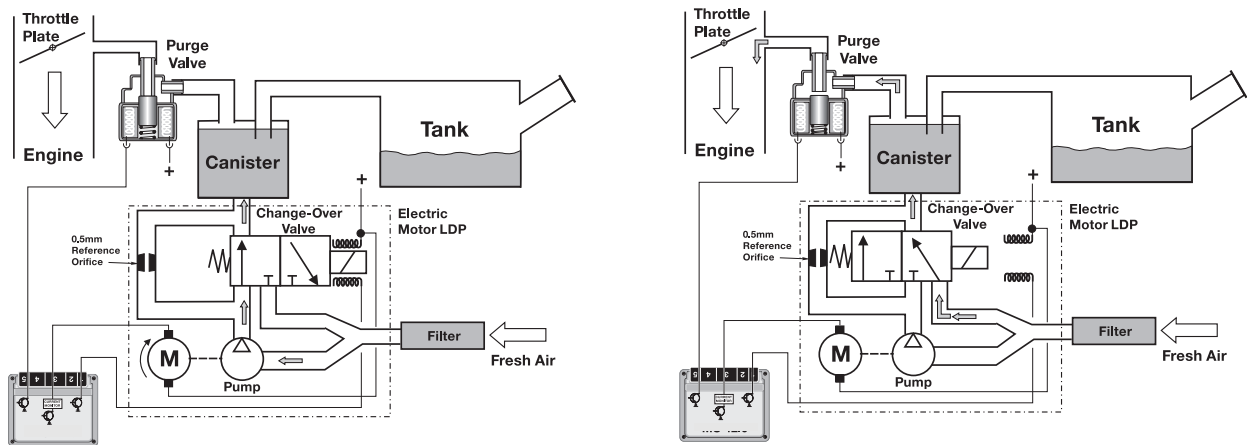
The ECM activates the pump motor. The pump pulls air from the filtered air inlet and passes it through a precise 0.5 mm reference orifice in the pump assembly. The ECM simultaneously monitors the pump motor current flow. The motor current raises quickly and levels off (stabilizes) due to the orifice 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.



■ 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 through the charcoal canister trapping hydrocarbon vapor and venting air to atmosphere through the filter.



Evaporative Emission Purging

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:

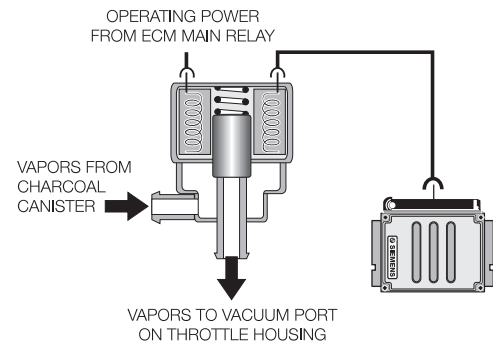
- Oxygen Sensor Control is active
- Engine Coolant Temperature is $> 67^{\circ}\text{C}$
- Engine Load is present

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.



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.

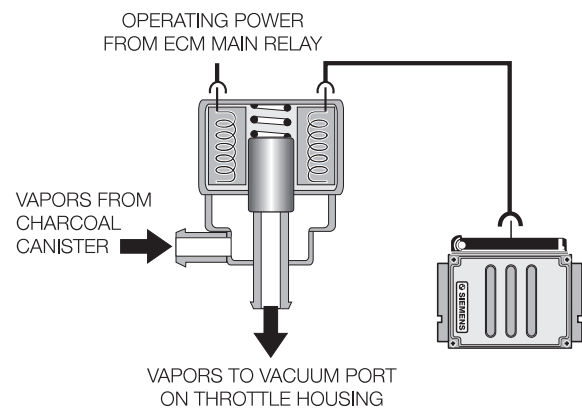


Evaporative Emission Valve

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 drive-ability complaint could be encountered and a mixture related fault code will be set.



Secondary Air Injection

This system 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.

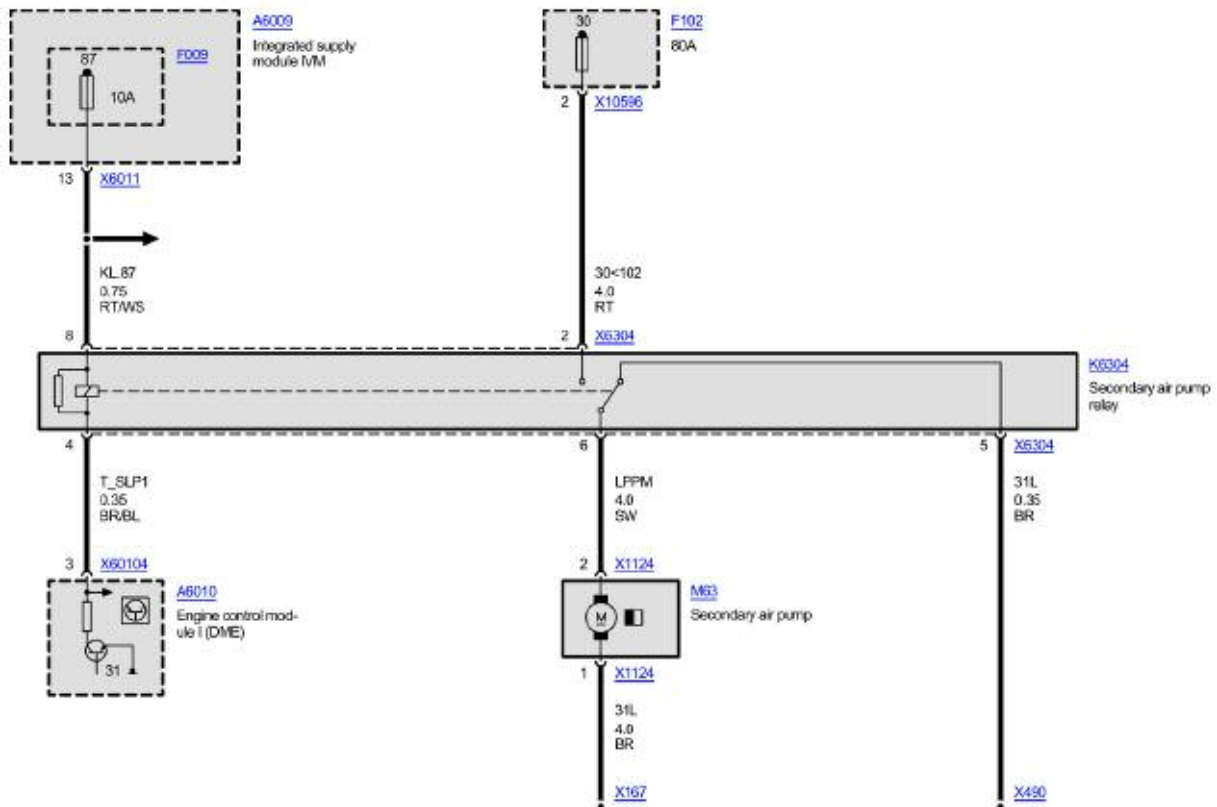
The ECM provides a ground circuit to activate the Secondary Air Injection Pump Relay. The relay supplies voltage to the Secondary Air Injection Pump.

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.

SSP-SP0000017943 Secondary air pump

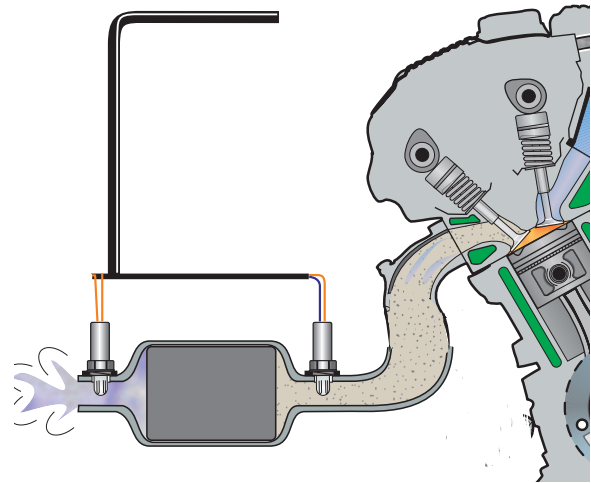


Secondary Air Injection Monitoring

The monitoring of Secondary Air is performed by the ECM via the use of the pre-catalyst oxygen sensors. Once the air pump is active and air is 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.



Secondary Air System

As on **N73** engine, the **N74** is equipped with a secondary air system. Blowing additional air (secondary air) into the exhaust gas duct in the cylinder head during the warm-up phase initiates thermal post-combustion that leads to a reduction in the unburned hydrocarbons (HC) and carbon monoxide (CO) contained in the exhaust gas. The energy generated here heats up the catalytic converter faster in the warm-up phase and increases its conversion rate. The catalytic converter response temperature (light-off temperature) of 300°C is reached only a few seconds after the engine is started.

What is new is that there is one pressure sensor before each secondary air valve. The function of the secondary air system is monitored by registering the pressure conditions.

■ Secondary air pump

The electrically operated secondary air pump is attached to the cylinder head of cylinder bank 1.

During the warm-up phase, the pump draws in fresh air from the engine compartment. This is cleaned by the filter integrated in the pump and delivered across the pressure line to the two secondary air valves.



After the engine start, the secondary air pump is supplied with vehicle voltage by the DME via the secondary air pump relay. The switched-on period is about 20 seconds and it depends essentially on the coolant temperature at engine start. It is activated from a coolant temperature of +5°C to +50°C (40°F to 120°F).

■ Secondary air valve

A secondary air valve is bolted onto the rear of each cylinder head. The secondary air valve opens as soon as the system pressure generated by the secondary air pump exceeds the opening pressure of the valve. Secondary air is fed via the secondary air line into the elongated passage of the cylinder head. From the elongated passage, 24 tap holes lead to the 12 exhaust ducts where the thermal post-combustion takes place.

The secondary air valve closes as soon as the secondary air pump switches off, thus preventing exhaust gas from flowing back to the secondary air pump.



**Secondary Air Valve
and Pressure Sensor**

■ On-board diagnosis of secondary air system

Monitoring takes place with the help of the pressure sensors that are fitted before each of the secondary air valves. The exhaust gas oxygen sensors are also used.

The overall diagnosis is divided into a rough diagnosis that begins immediately after the secondary air pump starts up and the fine diagnosis that begins around 12 to 14 seconds after the secondary air injection starts.

The rough diagnosis uses only the pressure signals. Every fault in the secondary air system is detected if there is a drop below a minimum pressure in the event of a leakage or if a maximum pressure is exceeded when a valve is clogged or jammed closed. However, under certain circumstances, it might not be possible to assign the fault correctly, because the pressure sensors indicate the same pressure due to the connecting line.

The fine diagnosis uses the exhaust gas oxygen sensor signals in addition to the pressure signals. The combination of exceeding or falling short of fault thresholds for the pressure and exhaust gas oxygen sensor values means the fault can be precisely assigned to the relevant cylinder bank. The fine diagnosis relies on the oxygen sensor readiness, this is available much later than in naturally aspirated engines due to the heat loss through the turbocharger.

There is also an electrical diagnosis for the secondary air pump relay and for the pressure sensors. These indicate the usual electrical faults (line disconnection, short circuit to ground, short circuit to supply voltage). There is an additional mutual plausibility check of the pressure sensors on initialization with ambient pressure.

Misfire Detection

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

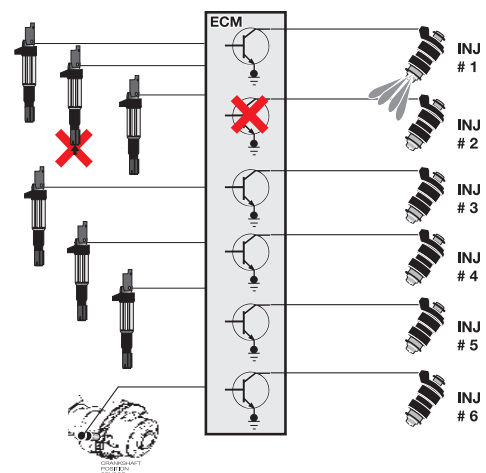
- Within an interval of 1000 crankshaft revolutions, the ECM adds the detected misfire events for each cylinder. If the sum of all cylinder misfire incidents exceeds the predetermined value, a fault code will be stored and the “Malfunction Indicator Light” will be illuminated.
- If more than one cylinder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

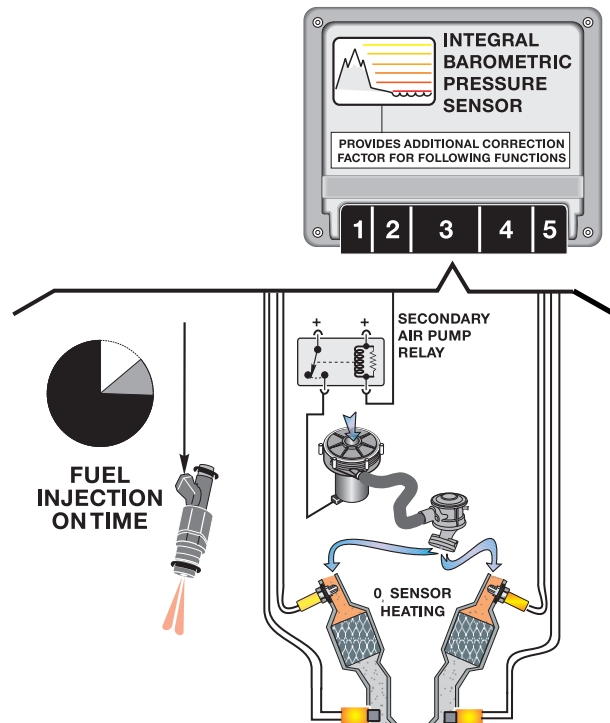


Ambient Barometric Pressure

The Integrated Ambient Barometric Pressure Sensor is part of the ECM and is not serviceable. The internal sensor is supplied with 5 volts. In return it provides a linear voltage of approx. 2.4 to 4.5 volts representative of barometric pressure (altitude).

The ECM monitors barometric pressure for the following reasons:

- The barometric pressure signal along with calculated air mass provides an additional correction factor to further refine injection “on” time.
- Provides a base value to calculate the air mass being injected into the exhaust system by the Secondary Air Injection System. This correction factor alters the secondary air injection “on” time, optimizing the necessary air flow into the exhaust system.



Crankcase Ventilation

One of the major changes on the new NG6 engines is that the crankcase ventilation system has been upgraded and improved. This applies to all of the new NG6 versions (N52KP, N51 and N54).

There are two distinct versions of crankcase ventilation. One type is unique to the N54 and the other applies to N51 and N52KP.

The N52, which is still in production continues to use the “external” crankcase ventilation system with the electrically heated crankcase ventilation valve/cyclone separator.

Crankcase Ventilation System on N52



Crankcase Ventilation (N51 and N52KP)

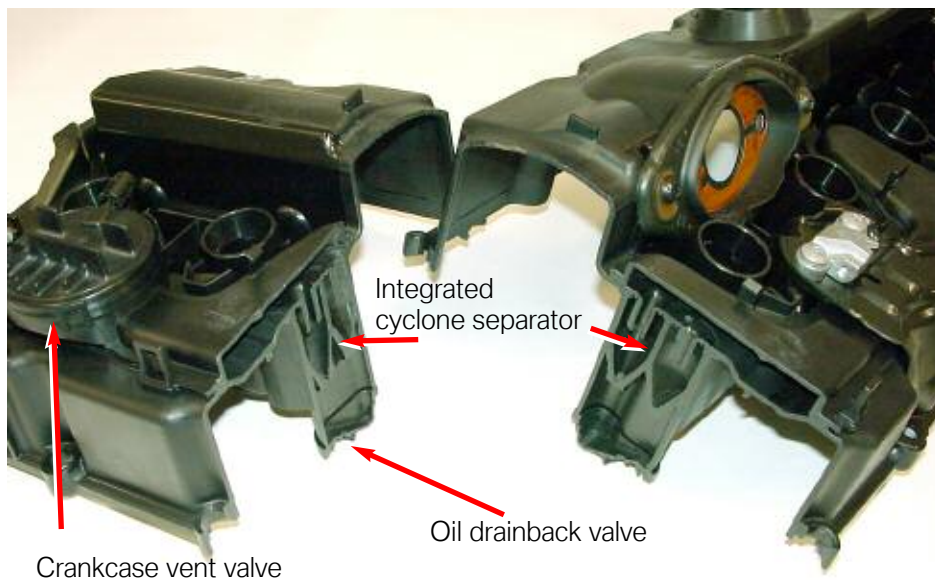
The crankcase ventilation system on the N51 and N52KP has been modified as compared to the N52. The system is integrated into the plastic cylinder head cover.

The crankcase gases are regulated by a crankcase ventilation valve similar to the design used on the N62. The crankcase vent valve is currently part of the cylinder head cover and is not replaceable as a separate component.

Oil separation is carried out via a “labyrinth” system and two cyclone separators which are incorporated into the cylinder head cover. By having the system components integrated into the cylinder head cover, the crankcase gases are heated by the engine rather than an electric heater as on the N52. However, there is still one electric heating element at the manifold inlet.

Once the liquid oil is separated from the crankcase vapors, the oil is allowed to drain back through check valves back into the engine.

N52KP Cylinder Head Cover (cutaway view)

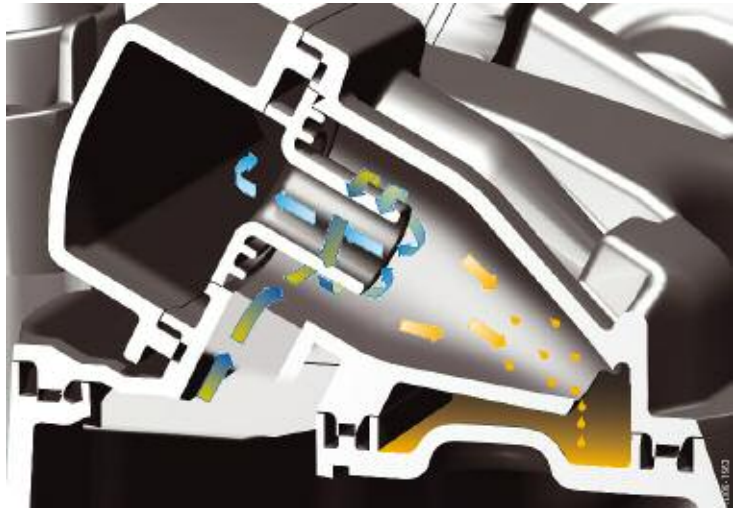


Crankcase Ventilation (N54)

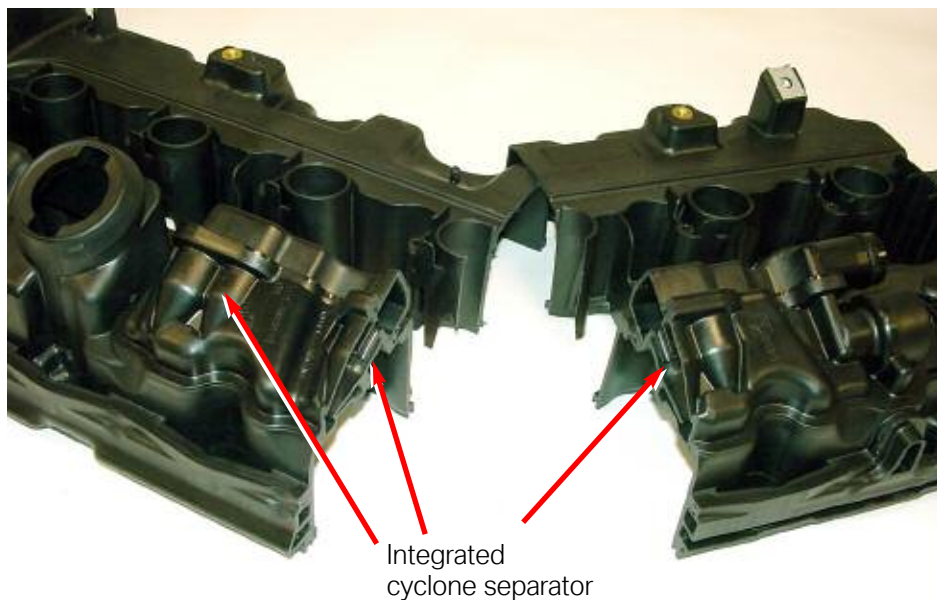
Since the N54 is a turbocharged engine, the crankcase ventilation system has to meet certain design requirements. For example, when the engine is in turbocharged mode, the increased manifold pressure should not have an adverse effect on the crankcase venting. This is why, there is no crankcase ventilation valve in the system.

The system consists of four small cyclone separators which are integrated into the plastic cylinder head cover. The flow of crankcase gases is metered through a series of restrictions which control the ultimate crankcase pressure.

One of the main operating principles behind the crankcase venting system on the N54 is that there are two strategies - one for the turbocharged mode and one for “non-turbocharged” operation such as decel. These strategies are dependent upon the intake manifold pressure.



N54 Cylinder Head Cover (cutaway view)



NOTES

PAGE

Crankcase Ventilation System Overview (N55)

The blow-by gasses flow into the settling chamber of the cylinder head cover through an opening located in the rear of the cover. Here, the blow-by gasses are directed through holes on to an impact plate, against which the oil impacts at high speed, and drains off. The blow-by gasses, cleaned of oil, flow via the pressure control valve (depending on the operating mode) through the non-return valves into the inlet pipe upstream of the turbocharger, or via passages in the cylinder head ahead of the intake valves. The separated oil is drained via a return flow duct into the oil pan.

■ **Naturally Aspirated Mode (N55)**

The standard function can only be used as long as a vacuum prevails in the intake air manifold, i.e. in naturally-aspirated engine mode.

With the engine operating in naturally-aspirated mode, the vacuum in the intake air manifold opens the non-return valve (15) in the blow-by duct within the cylinder head cover. This draws off blow-by gasses via the pressure control valve. At the same time, the vacuum also closes the second non-return valve (12) in the duct to the charge air intake pipe.

The blow-by gasses flow via a distribution rail integrated in the cylinder head cover, through the intake passages (16) in the cylinder head, which lead directly into the intake ports, ahead of the valves.

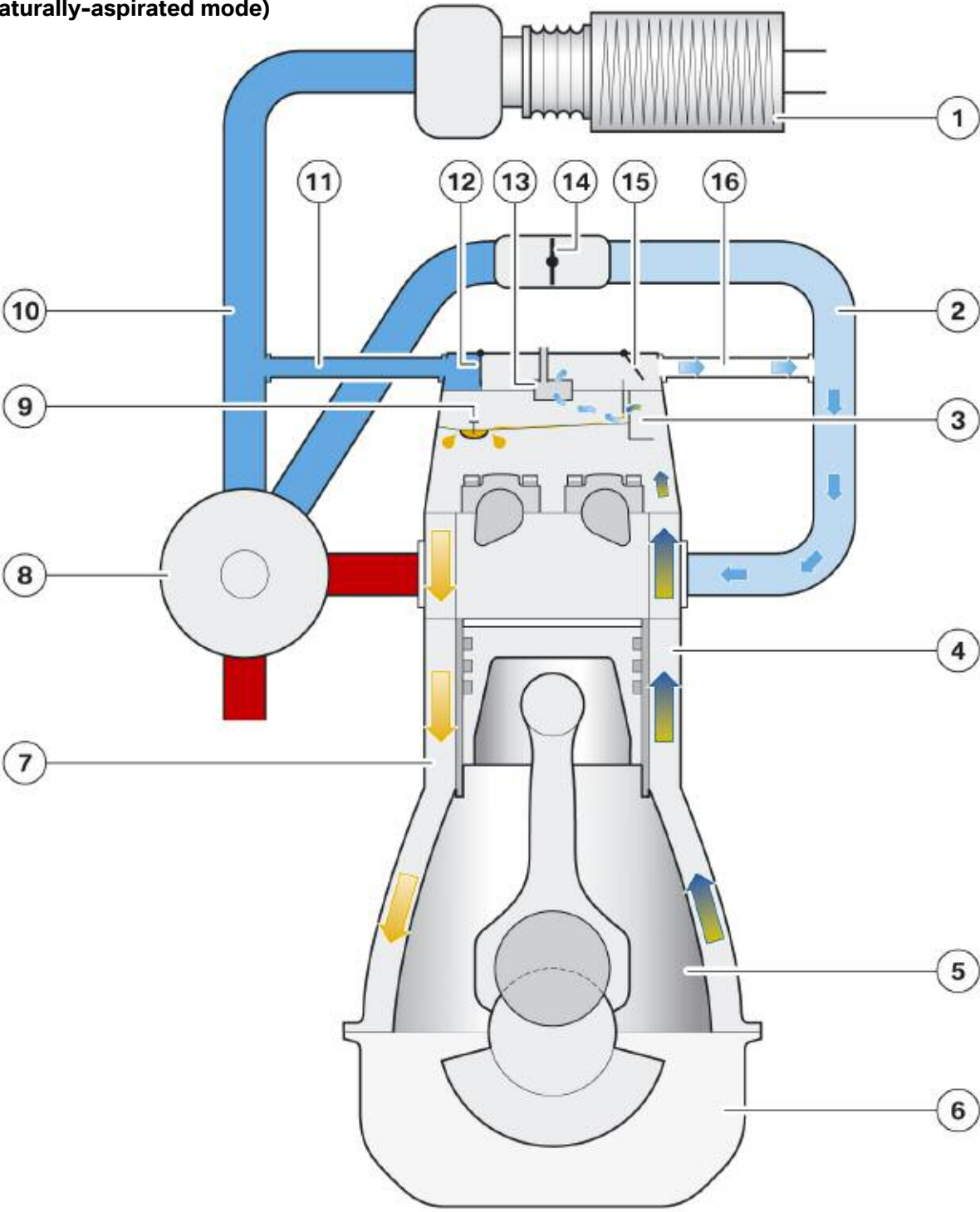
■ **Boost Mode (N55)**

As the pressure in the intake air manifold increases in boost mode, blow-by gasses can no longer be introduced via the passages in the cylinder head, otherwise, the boost pressure could enter the crankcase. A non-return valve (15) in the blow-by channel within the cylinder head cover closes the connection (16) to the intake air manifold. This protects the crankcase from excess pressure.

The increased demand for fresh air creates a vacuum in the clean air pipe between the turbocharger and intake silencer. This vacuum is sufficient to open the non-return valve (12) and draw the blow-by gasses via the pressure control valve.

Crankcase Ventilation Overview (N55)

Crankcase ventilation system in "decel mode"
(naturally-aspirated mode)

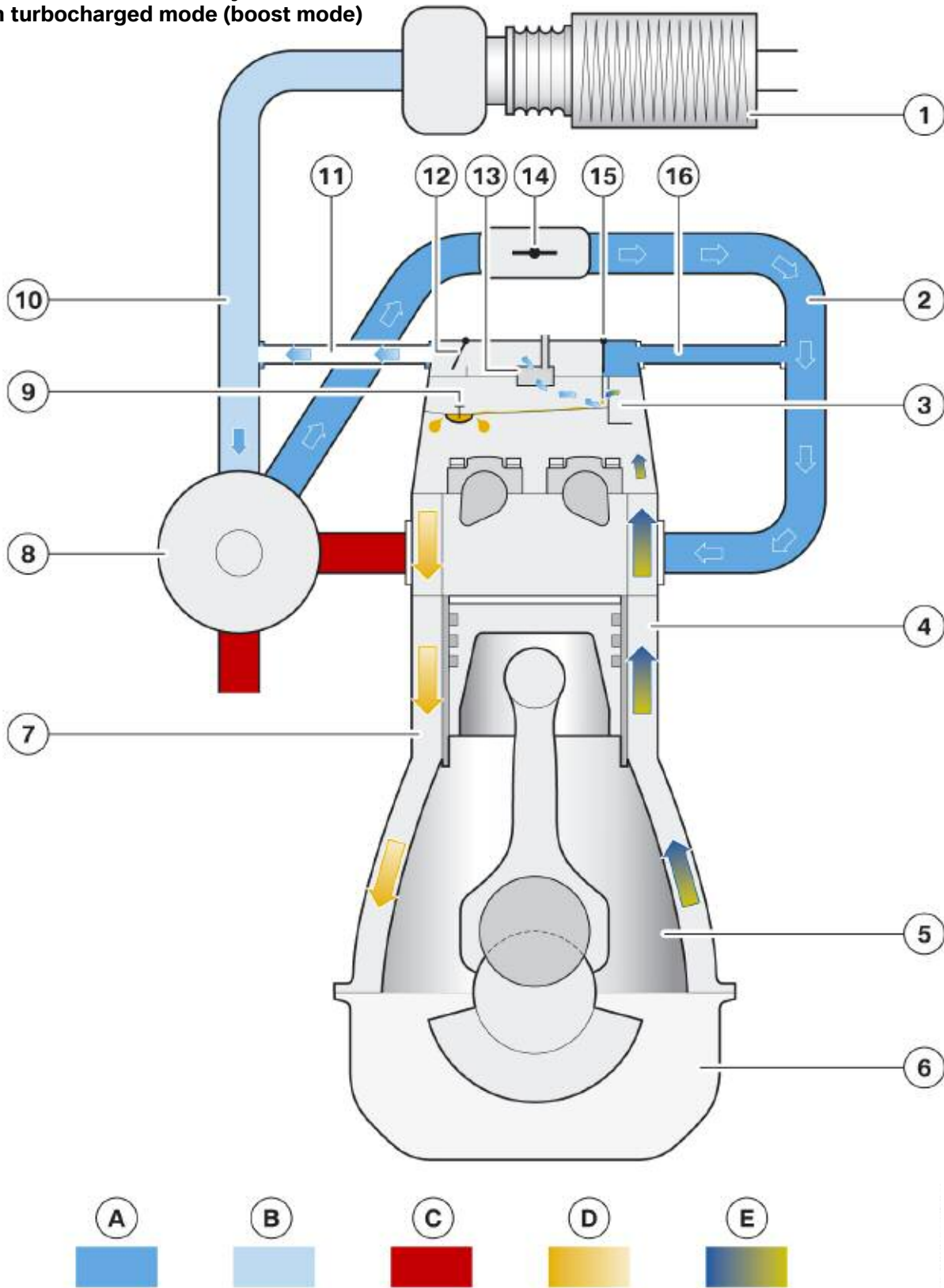


- A
- B
- C
- D
- E

Index	Explanation
A	Ambient pressure
B	Vacuum
C	Exhaust gas
D	Oil
E	Blow-by gas
1	Air cleaner
2	Intake manifold
3	Impact plates
4	Oil return channel
5	Crankcase
6	Oil sump
7	Oil return channel
8	Exhaust turbocharger
9	Oil drain valve
10	Charge air intake line
11	Hose to charge air intake line
12	Non-return valve
13	Pressure regulating valve
14	Throttle valve
15	Non-return valve
16	Passages in cylinder head and cylinder head cover

Crankcase Ventilation System Overview (N55)

Crankcase ventilation system
in turbocharged mode (boost mode)





If a customer complains about high oil consumption and oil is discovered in the turbocharger, it should not be immediately assumed that the turbocharger is defective. If the oil is present in the fresh air pipe (before the turbocharger) then the entire engine should be checked.

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NOTES

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Crankcase Ventilation System Overview (N54)

■ Naturally Aspirated Mode (N54)

When the engine has low manifold pressure such as in decel, the crankcase vapors are routed through a channel (15) between the cylinder head cover and intake manifold. The liquid oil is separated before the channel in the cyclonic separators (3) in the cylinder head cover. The liquid oil returns to the engine via the oil discharge valve (4).

The channel contains a pressure restrictor (16) which regulates the flow of crankcase vapors. During deceleration, the crankcase vapors (E) are directed via a check valve (14) which is located in the cylinder head cover. The check valve is opened when low pressure is present in the intake manifold (throttle closed).

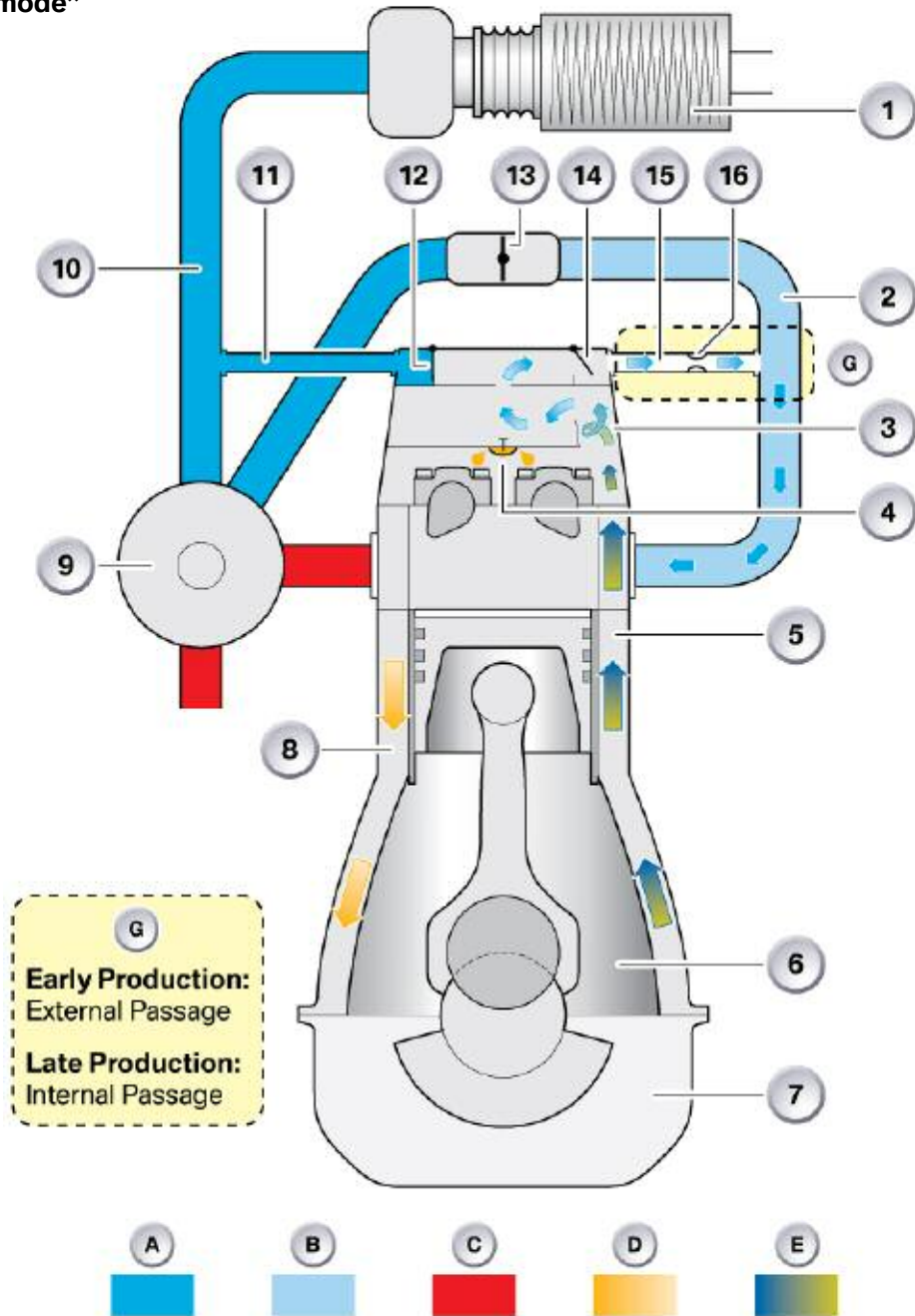
Also, a PTC heater has been integrated into the intake manifold inlet. The inlet pipe is connected to the channel (15) and prevent any moisture from freezing at the inlet.

■ Boost Mode (N54)

When in turbocharged mode, the pressure in the intake manifold increases and then closes the check valve (14). Now, a low pressure is present in the charge air suction line (10). This causes a low pressure in the hose (11) leading to the manifold check valve (12). The crankcase vapors (after separation) are directed through the check valve (12) into the charge air suction line (10) and ultimately back into the engine. The check valve (12) also prevent boost pressure from entering the crankcase when the intake manifold pressure is high.

Crankcase Ventilation System Overview (N54)

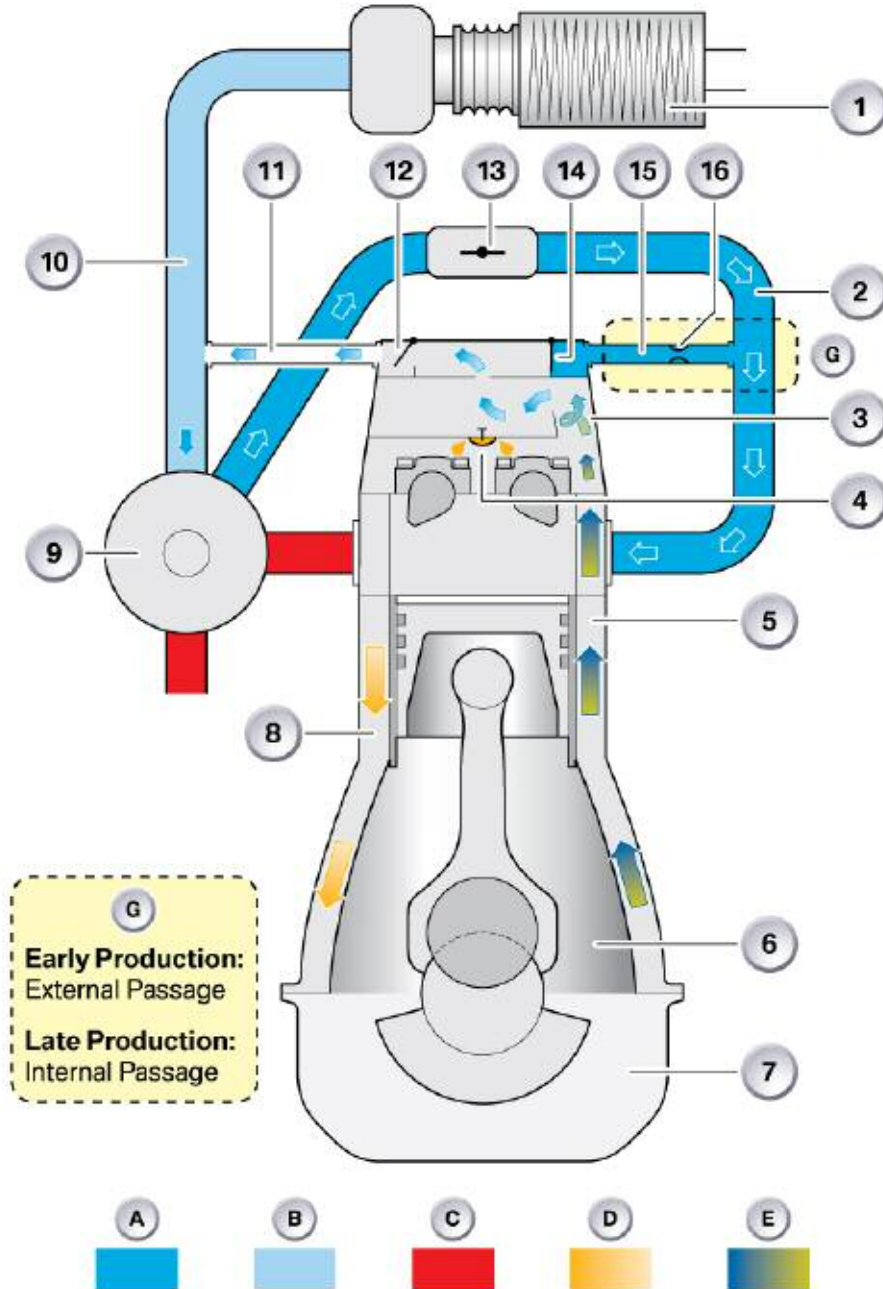
Crankcase ventilation system
in “decel mode”



Index	Explanation	Index	Explanation
A	Overpressure	7	Oil sump
B	Low Pressure (Vacuum)	8	Oil return channel
C	Exhaust gas	9	Turbocharger
D	Liquid oil	10	Charge air suction line, bank 2
E	Blow-by gases (Crankcase vapors)	11	Hose to charge air suction line, bank 2
1	Air cleaner	12	Check valve, manifold
2	Intake manifold	13	Throttle valve
3	Cyclone separators	14	Check valve, charge air suction line
4	Oil discharge valve	15	Channel to intake manifold
5	Venting channel	16	Pressure restrictor
6	Crankshaft cavity		

Crankcase Ventilation System Overview (N54)

Crankcase ventilation system in “turbocharged mode”



If a customer complains about high oil consumption and oil is discovered in the turbocharger, it should not be immediately assumed that the turbocharger is defective. If the oil is present in the fresh air pipe (before the turbocharger) then the entire engine should be checked.

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5	Venting channel	16	Pressure restrictor
6	Crankshaft cavity		



Be aware that any check valve failure could cause excessive oil consumption possibly accompanied by blue smoke from the exhaust. This should not be mistaken for a failed turbocharger. Always perform a complete diagnosis of the crankcase ventilation system, before replacing any turbocharger or associated components.

Crankcase Ventilation Heating

Also integrated into the design of the crankcase ventilation is an electric heating system designed to prevent moisture buildup. Moisture buildup can eventually lead to ice at low ambient temperatures leading to malfunctions of the crankcase ventilation.

The crankcase vent valve and cyclonic separator are also insulated by a protective foam covering to provide additional shelter from low ambient temperatures.

The PTC heating elements are integrated into the crankcase ventilation valve and hose assemblies. There is a junction point on the intake manifold which provides a connection point for the individual heating elements.

There is also a heating element located on the centrally located port on the intake manifold. This port is also provided with a separate heating circuit controlled by a PTC thermistor.

The ECM receives the ambient temperature information from the outside temperature sensor.

SSP-SP0000052251 Oil Supply (Engine Breather Heater)

