Vehicle Emissions Systems

Operation, Diagnosis, and Repair

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1 Emissions Systems Components

1.1 Introduction

When the first emission controls were first introduced back in the late 1960s, they were primarily "add-on" components that solved a particular emission need. When positive crankcase ventilation (PCV) became standard in 1968, the recycling of crankcase vapors eliminated blowby emissions as a major source of automotive pollution. When evaporative emission controls were added in 1971, charcoal canisters and sealed fuel systems eliminated fuel vapors as another factor that contributed to air pollution. Exhaust gas recirculation (EGR) was added in 1973, which lowered harmful oxides of nitrogen (NOX) emissions. But the most significant add-on came in 1975 when the auto makers were required to install catalytic converters on all new cars.

The catalytic converter proved to be a real breakthrough in controlling emissions because it reduced both unburned hydrocarbons (HC), a primary factor in the formation of urban smog, and carbon monoxide (CO), the most dangerous pollutant because it can be deadly even in small concentrations. The converter slashed the levels of these two pollutants nearly 90%!

The early "two-way" converters (so-called because they eliminated the two pollutants HC and CO) acted like an afterburner to reburn the pollutants in the exhaust. An air pump or an aspirator system provided the extra oxygen in the exhaust to get the job done. Two-way converters were used up until 1981 when three-way" converters were introduced. Three-way converters also reduced NOX concentrations in the exhaust, but required the addition of a computerized feedback fuel control system to do so.

Unlike the earlier two-way converters that could perform their job relatively efficiently with a lean fuel mixture, the catalyst inside a three-way converter that reduces NOX requires a rich fuel mixture. But a rich fuel mixture increases CO levels in the exhaust. So to reduce all three pollutants (HC, CO and NOX), a three-way converter requires a fuel mixture that constantly changes or flip-flops back and forth from rich to lean. This, in turn, requires feedback carburetion or electronic fuel injection, plus an oxygen sensor in the exhaust to keep tabs on what’s happening with the fuel mixture.

Like the earlier two-way converters, three-way converters also require extra oxygen from an air pump or aspirator system, and some "three-way plus oxygen" converters are designed so air is routed right to the converter itself for more efficient operation.

1.2 Catalytic Converter

Original equipment converters are designed for go 100,000+ miles—which many do provided they aren’t poisoned by lead, silicon or phosphorus. When leaded gasoline was still available, fuel switching to save money caused the premature failures of many converters. Lead coats the catalyst rendering it useless. Silicon, which is used in antifreeze and certain types of RTV sealer, has the same effect. Coolant leaks in the combustion chamber can allow silicon to enter the exhaust and ruin the converter. Phosphorus, which is found in motor oil, can foul the converter if the engine is burning oil because of worn valve guides or rings.

Converters may also fail if they become overheated, which can be caused by unburned fuel in the exhaust. Contributing factors include an overly rich fuel mixture, ignition misfire (a fouled spark plug or bad plug wire) or a burned exhaust valve that leaks compression. Fuel in the exhaust has the same effect as dumping gasoline on a bed of glowing embers. Things get very hot very fast. If the converter's temperature climbs high enough, the ceramic substrate that supports the catalyst can melt, causing a partial or complete blockage inside. This increases backpressure, preventing the engine from exhaling and robbing it of power. Fuel consumption may shoot up and the engine may feel sluggish at higher speeds. If the converter becomes completely plugged, the engine may stall after starting and not restart.

There's no way to rejuvenate a dead converter or to unclog or clean out a plugged converter, so replacement is the only option. Up until the 1995 model year, converters were covered by a 5-year/50,000 mile federal emissions warranty (7 years or 70,000 miles in California). In 1995, the warranty was extended to 8 years or 80,000 miles.

According to federal regulations, any replacement converter must be the same type as the original (two-way, three-way or three-way plus oxygen), EPA-approved, and installed in the same location as the original.

Bear in mind that, although a fresh converter will solve the problem of a plugged or dead converter, the replacement converter may suffer the same fate if the underlying cause isn't diagnosed and corrected. Other items that should also be inspected include the air pump and related plumbing, oxygen sensors, and feedback control system. For example, a sluggish oxygen sensor may not allow the fuel mixture to change back and forth quickly enough to keep the converter working at peak efficiency. Though this might not lead to a meltdown, it could cause enough of an increase in pollution for the vehicle to fail an emissions test. If the oxygen sensor has died altogether, the fuel mixture will remain fixed and the engine will probably run too rich causing an increase in fuel consumption as well as emissions.

Many automakers recommend inspecting the oxygen sensor at specific mileage intervals to prevent this kind of trouble. Some vehicles (primarily imports) have a reminder light that illuminates every 30,000 miles or so to alert the motorist to have his oxygen sensor checked or replaced.

Bosch, a leading supplier of oxygen sensors, recommends replacing oxygen sensors for preventative maintenance at roughly the same interval as the spark plugs, depending on the application. Unheated 1 or 2 wire O2 sensors on 1976 through early 1990s applications should be replaced every 30,000 to 50,000 miles. Heated 3 and 4-wire O2 sensors on mid-1980s through mid-1990s applications should be changed every 60,000 miles. On 1996 and newer OBDII equipped vehicles, the recommended replacement interval is every 100,000 miles.

1.3 PCV Valve

The PCV valve is generally considered a maintenance item like spark plugs, and should be inspected and replaced periodically (typically every 50,000 miles). The PCV valve siphons combustion blowby vapors from the crankcase into the intake manifold to prevent them from escaping into the atmosphere. One of the benefits of PCV, aside eliminating blowby emissions, is that it extends oil life by drawing moisture out of the crankcase. If the PCV valve or hose becomes plugged, rapid moisture buildup and oil breakdown can result. Additionally, crankcase moisture leads to the formation of acids and sludge, which can cause major engine damage.

1.4 EGR Components

The EGR system reduces the formation of nitrogen oxides by diluting the air/fuel mixture with exhaust gases, which lowers combustion temperatures below 2500 degrees F. Less NOx is formed at reduced temperatures, because the higher the flame temperature, the higher the rate at which oxygen and nitrogen react to form NOx. Lowering the combustion temperature with EGR also helps prevent detonation.

The heart of the EGR system is the EGR valve, which opens a small passage between the intake and exhaust manifolds. When ported vacuum is applied to the EGR valve diaphragm, the valve opens, allowing intake vacuum to siphon exhaust gas into the intake manifold. This creates an effect similar to a vacuum leak, so EGR is activated only after the engine is warm and is running above idle speed.

Some vehicles are equipped with "positive backpressure" EGR valves while others have "negative backpressure" EGR valves. Both types rely on exhaust system backpressure to open the valve. However, the two types are not interchangeable. The vacuum control plumbing to the EGR valve usually includes a temperature vacuum switch (TVS) or solenoid to block or bleed vacuum until the engine warms up. On newer vehicles with computerized engine controls, the computer usually regulates the solenoid to further control the opening of the EGR valve. Some vehicles even have an EGR valve that is driven by a small electric motor, rather than being vacuum actuated, for even more precise control of this emission function.

Although the EGR system has no recommended maintenance or replacement interval, it can malfunction. The valve can become clogged with carbon deposits that cause it to stick or prevent it from opening or closing properly. An EGR valve that is stuck open will act like a vacuum leak and cause a rough idle and stalling. An EGR valve that has failed or is stuck closed (or a clogged EGR passageway in the manifold) will allow elevated NOx emissions and may also cause a detonation (spark knock) problem. Dirty EGR valves can usually be cleaned, but if the valve itself becomes defective it must be replaced.

1.5 EVAP System Components

Evaporative emissions from the fuel system (fuel vapors) are trapped and stored in a charcoal canister. Later, a purge valve opens allowing the vapors to be sucked into the engine and burned. The EVAP system usually requires no maintenance. The fuel filler cap is also part of the EVAP system, and is designed to keep fuel vapors from escaping into the atmosphere. A leaky or missing fuel filler cap may cause a vehicle to fail an emissions test.

1.6 Older Emissions Equipment

On older, carbureted engines, one of several emission control devices may be used to reduce emissions during warm-up. Fuel vaporizes slowly when it is cold, so heating the air before it enters the carburetor or throttle body improved fuel vaporization and allows the engine to more easily maintain a balanced air/fuel mixture. Most such engines have a "heated air intake" system that draws warm air from a "stove" around the exhaust manifold into the air cleaner.

A thermostat inside the air cleaner controls vacuum to a valve in the air cleaner inlet. When the engine is cold, the thermostat passes vacuum to the control valve, which closes a flap to outside air allowing heated air to be drawn into the air cleaner. As the engine warms up, the thermostat begins to bleed air, allowing the control door to open to outside air. Thus the thermostat and airflow control door are able to maintain a more consistent incoming air temperature.

One part that's often needed here is the flexible tubing that connects the air cleaner to the exhaust stove. If it is damaged or missing, the engine may hesitate and stumble when cold.

Another early fuel evaporation aid on older V6 and V8 engines is a "heat riser valve." The valve is located on one exhaust manifold. When the engine is cold, the valve closes to blocks the flow of exhaust so it will be forced back through a crossover passage in the intake manifold directly under the carburetor. The hot exhaust heats the manifold to speed fuel vaporization and engine warm-up. Once the engine warms up, the heat riser valve opens. The heat riser valve needs to be replaced if it is sticking or inoperative.

On some older engines, an electrically heated "EFE grid" is used under the carburetor or throttle body to aid fuel vaporization when the engine is cold. A timer turns the grid off after a fixed period of time. If the grid fails to heat (bad relay, electrical connection, etc.), the engine may hesitate and stumble when cold.

2 OBDII Systems

The origins of OBDII date back to 1982 in California, when the California Air Resources Board (ARB) began developing regulations that would require all vehicles sold in that state beginning in 1988 to have an onboard diagnostic system to detect emission failures. The original onboard diagnostic system (which has since become known as OBDI) was relatively simple and only monitored the oxygen sensor, EGR system, fuel delivery system and engine control module.

OBDI was a step in the right direction, but lacked any requirement for standardization between different makes and models of vehicles. You still had to have different adapters to work on different vehicles, and some systems could only be accessed with costly "dealer" scan tools. So when ARB set about to develop standards for the current OBDII system, standardization was a priority: a standardized 16-pin data link connector (DLC) with specific pins assigned specific functions, standardized electronic protocols, standardized diagnostic trouble codes (DTCs), and standardized terminology.

Another limitation of OBDI was that it couldn't detect certain kinds of problems such as a dead catalytic converter or one that had been removed. Nor could it detect ignition misfires or evaporative emission problems.

Furthermore, OBDI systems would only illuminate their Check Engine lights after failures had occurred. They had no way of monitoring progressive deterioration of emissions-related components. To provide these capabilities, a more sophisticated system was required. The California Air Resources Board eventually developed standards for the next generation OBD system, which were proposed in 1989 and became known as OBDII. The new standards required a phase-in beginning in 1994. The automakers were given until the 1996 model year to complete the phase-in for their California vehicles.

Similar standards were incorporated into the federal Clean Air Act in 1990, which also required all 49-state vehicles to be OBDII equipped by 1996, and some U.S. vehicles were equipped with the new government-mandated OBDII system as early as 1994.

1994 vehicles equipped with the early OBDII systems include the Buick Regal 3800 V6, Corvette, Lexus ES3000, Toyota Camry (1MZ-FE 3.0L V6) and T100 pickup (3RZ-FE 2.7L four), Ford Thunderbird & Cougar 4.6L V8, and Mustang 3.8L V6.1995 vehicles with OBDII include Chevy/GMC S, T-Series pickups, Blazer and Jimmy 4.3L V6, Ford Contour & Mercury Mystique 2.0L four & 2.6L V6, Chrysler Neon, Cirrus and Dodge Stratus, Eagle Talon 2.0L DOHC (nonturbo), and Nissan Maxima and 240 SX.

By the 1996 model year, OBDII was installed on all new cars and light trucks. However, OBDII systems were not required to be fully compliant until 1999, so some earlier OBDII systems may lack one or more of the features normally required to meet all OBDII specifications, such as an evaporative emissions purge test.

OBDII is designed to detect emission problems. If a problem is detected, the system illuminates a Check Engine light and stores a diagnostic trouble code in the vehicle's powertrain computer. Later, the code can be retrieved with a scan tool to determine the nature of the problem.

What makes OBDII different from all the self-diagnostic systems that preceded it is that OBDII is specifically emissions oriented. In other words, it will illuminate a Malfunction Indicator Lamp (MIL) anytime a vehicle's emissions exceed the federal test procedure (FTP) standards for that model year of vehicle by 50% on two consecutive trips. This includes any time random misfires cause an overall rise in HC emissions, any time the operating efficiency of the catalytic converter drops below a certain threshold, any time the system detects air leakage in the sealed fuel system, any time a fault in the EGR system causes NOx emissions to go up, and any time a key sensor or other emission control device fails. In other words, the MIL may illuminate even though the vehicle seems to be running normally and there are no real drivability problems.

2.1 OBDII Emissions Component Upgrades

In addition to sophisticated self-diagnostic software, OBDII incorporates a number of hardware component upgrades over OBDI systems. OBDII-equipped vehicles are typically equipped with:

- Additional oxygen sensors (most of which are now heated) located downstream of the catalytic converter

- More powerful powertrain control modules, with either16-bit (Chrysler) or 32-bit (Ford & GM) processors designed to handle up to 15,000 new calibration constants that were added by OBDII

- Electronically Erasable Programmable Read Only Memory (EEPROM) chips that allow the PCM to be reprogrammed with revised software using a terminal link or external computer

- A modified evaporative emission control system with a diagnostic switch for purge testing or an enhanced EVAP system with a vent solenoid, fuel tank pressure sensor and diagnostic test fitting

- More EGR system components, including a linear EGR valve that is electronically operated and has a position sensor

- Sequential fuel injection, rather than multi-port or throttle body injection, with both a MAP sensor and MAF sensor for monitoring engine load and airflow

2.2 OBDII Engine Management

The performance and emissions that today's engines deliver would be impossible without the electronics that manage everything from ignition and fuel delivery to every aspect of emissions control. Electronics make possible V8 engines that deliver excellent performance, good fuel economy and produce almost no pollution. But there's a price to be paid for today's technology, and that price is complexity.

2.2.1 Powertrain Control Module

The latest powertrain control modules (PCM’s) contain 16-bit or 32-bit processors. Although not as powerful as the latest desktop personal computers, PCM’s can still quickly crunch a lot of information. It's been said that today's automotive PCM’s possess more computing power than the Space Shuttle's main processors.

Today’s PCM can detect all sorts of problems, including fuel vapor leaks in the charcoal canister, evaporative plumbing, or fuel tank by pressurizing or pulling a vacuum on the fuel system. It can even detect a loose or missing gas cap. The system can even detect various air conditioning problems, such as a compressor failure. It doesn’t take a rocket scientist to troubleshoot and repair drivability problems in today's cars, but it does take some knowledge, experience, and diagnostic equipment capable of accessing the onboard electronics.

The PCM is typically housed in a metal box with one or more multi-pin connectors. The PCM's job is to manage the powertrain. This includes the engine's ignition system, fuel delivery system and emission controls. Toward this end, the PCM receives inputs from a wide variety of sensors and switches, some of which are detailed in subsequent sections.

On many automatic transmission vehicles, the PCM also controls transmission operation. On other vehicles, a separate transmission control module (TCM) is used to oversee gear changes and torque converter operation. Even if there's a separate module for the transmission, the PCM and TCM communicate with each other and share data, so each is aware of what the other is doing.

On many newer vehicles, the PCM also regulates charging system voltage, cycles the engine cooling fan, interacts with the antilock brake system (ABS) module to reduce power if the vehicle has traction control, and may even interact with the automatic temperature control (ATC) module to operate the cycling of the air conditioning compressor clutch. The PCM may also be assigned vehicle security tasks.

The PCM's most important tasks include verifying that all the engine's sensors are working properly and that the engine isn't polluting. Since the earliest days of the onboard computer, a certain amount of self-diagnostic capability has been required to detect problems that might upset the smooth operation of the system. On older vehicles, the diagnostics were relatively crude. If a sensor circuit went open (no signal) or shorted, the gross failure would set a trouble code and activate the Check Engine light. However, many conditions that didn't cause complete failures could also upset engine performance and drivability. Furthermore, earlier systems had no way of monitoring many conditions that could increase pollution. Consequently, the Environmental Protection Agency (EPA) required every city and state that didn't meet Federal clean air standards to implement some type of vehicle emissions inspection program.

In first generation onboard diagnostic systems, prior to OBDII, disconnecting the computer's power source or disconnecting a battery cable would erase any fault codes. The loss of voltage wiped out the computer's temporary memory causing the Check Engine light to magically go out. But as soon as the original problem reoccurred, the code(s) would be reset and the light would come back on. However, in most newer computer systems, fault codes are stored in a "nonvolatile" memory that is not lost if the battery is disconnected. The codes remain intact until they are cleared using a scan tool. What's more, disconnecting the battery or computer's power supply can have undesirable consequences because it causes the loss of electronic presets in the radio and climate control system, as well as the engine computer's "learned" memory - the adjustments that are made over time to compensate for engine wear and driving habits. On vehicles where the computer also electronically regulates the transmission, the computer may even require a special training procedure to relearn the proper operation of the transmission if power has been lost!

2.2.2 Oxygen Sensors

The first O2 sensor was introduced in 1976 on a Volvo 240. California vehicles were equipped with them next in 1980, when California's emission rules required lower emissions. Federal emission laws made O2 sensors virtually mandatory on all cars and light trucks built since 1981. With the advent of OBDII regulations (1996 and newer vehicles), many vehicles are now equipped with multiple O2 sensors, some as many as four.

Each primary O2 sensor is mounted in the exhaust system, ahead of the catalytic converter to monitor the amount of unburned oxygen that remains in the exhaust gas mixture as it exits the engine. Monitoring the oxygen level at this point enables the vehicle's computer to determine if the fuel mixture is burning rich (less oxygen) or lean (more oxygen).

Many factors affect the relative richness or leanness of the fuel mixture, including air and coolant temperatures, barometric pressure, throttle position, airflow and engine load. Other sensors are installed to monitor these factors, but the primary O2 sensor operates as the master monitor for the fuel mixture. The PCM uses information from the primary O2 sensor to continuously re-adjust and fine-tune the air/fuel ratio in order to minimize both fuel consumption and emissions, which causes a subsequent change in the O2 sensor's signal. This control mechanism is often referred to as the "fuel feedback loop."

The O2 sensor acts as a miniature generator, producing its own voltage when it gets hot. The sensor contains a zirconium ceramic bulb inside the vented cover on the end of the sensor that is inserted in the exhaust manifold. The outside of this bulb is coated with a porous layer of platinum. Inside the bulb are two strips of platinum that serve as electrodes or contacts.

The outside of the bulb is exposed to the hot gases in the exhaust while the inside of the bulb is vented internally through the sensor body to the outside atmosphere. Older style oxygen sensors actually have small holes in their body shells, so air can enter the sensor. Newer style O2 sensors vent through their wire connectors and have no separate vent holes. The minute space between the insulation and the conductor in the wire provides enough room for air to seep into the sensor. (Grease should never be used on O2 sensor connectors, because the grease can block the flow of air). Venting the sensor through the wires rather than through a hole in the body reduces the risk of dirt or water contamination that could foul the sensor from the inside, causing failure. The difference in oxygen levels between the exhaust and outside air within the sensor causes a voltage to flow through the ceramic bulb. The greater the difference, the higher the voltage.

An oxygen sensor will typically generate up to about 0.9 volts when the fuel mixture is rich and there is little unburned oxygen in the exhaust, but the sensor's output voltage will drop to about 0.1 volts when the mixture is lean. The sensor's voltage is approximately .045 volts when the air/fuel mixture is balanced at its stoichiometric point approximately 14.7 to 1.

The oxygen sensor must be heated to 600 degrees or higher before it will begin to generate a voltage signal, so many oxygen sensors on newer vehicles, have small heating elements inside to enable them to reach operating temperature quickly. The heating elements also prevent the sensors from cooling off too much during prolonged idle, which would cause the PCM to revert to open loop operation.

On 1996 and newer vehicles, secondary O2 sensors are installed on the tailpipe side of each catalytic converter to monitor converter efficiency. By comparing the primary (upstream) and secondary (downstream) O2 sensor readings, the PCM can determine how well the converter is doing its job. If the converter ceases to function properly, as indicated by little or no difference between the primary and secondary O2 sensor voltages, the PCM will set a code and energize the Check Engine light.

2.2.2.1 Oxygen Sensor Replacement

Although they are extremely rugged, O2 sensors do deteriorate with age and may become contaminated if the engine burns oil or develops a coolant leak. Although O2 sensors generally have no recommended replacement interval, replacing sluggish O2 sensors can restore lost performance. To ensure peak performance, unheated one- or two-wire O2 sensors on 1976 through early 1990s applications should be replaced every 30,000 to 50,000 miles. Heated three- and four-wire O2 sensors on mid-1980s through mid-1990s applications should be changed every 60,000 miles, and the sensors should be replaced after 100,000 miles of service on OBDII-equipped vehicles.

Replacing O2 sensors at the above intervals can provide numerous benefits. A good oxygen sensor is essential for good fuel economy, emissions, and performance. A bad primary O2 sensor will typically cause an engine to run rich, burn more fuel, and pollute the atmosphere. Furthermore, bad O2 sensors are a leading cause of catalytic converter failures. Replacing aging O2 sensors is recommended not only to restore peak fuel efficiency and to minimize exhaust emissions, but also to prolong and protect the life of the converter.

2.2.2.2 Oxygen Sensor Failure Modes

The O2 sensor is a component that can often cause drivability issues. This sensor is the master switch in the fuel control feedback loop. The primary O2 sensor monitors the amount of unburned oxygen in the exhaust and produces a voltage signal that varies from about 0.1 volts (extremely lean) to 0.9 volts (extremely rich). The computer uses this signal to constantly fine-tune and flip-flop the fuel mixture, so that the catalytic converter can most efficiently perform its job of cleaning the exhaust. On an OBDII-equipped vehicle, the PCM uses a secondary O2 sensor, installed downstream of the catalytic converter, to monitor converter efficiency.

If an O2 sensor circuit opens, shorts, or drifts out of range, the PCM will usually generate a fault code and illuminate the MIL (malfunction indicator lamp). However, an O2 sensor that is badly degraded may continue to function well enough to avoid triggering a fault code — but not well enough to prevent an increase in vehicle fuel consumption and emissions. The absence of a fault code or warning lamp, therefore, doesn’t ensure that the O2 sensor is operating within specification.

The performance of any O2 sensor will degrade with age, as contaminants accumulate on the sensor tip and gradually reduce its ability to produce the correct voltage. This type of deterioration is caused by a variety of substances that may find their way into the exhaust such as lead, silicone, sulfur, oil ash and even some fuel additives. The sensor can also be damaged by environmental factors such as water, splashed road salt, oil, and dirt.

As an O2 sensor ages, it becomes sluggish in its response. This may prevent the vehicle’s computer from toggling the fuel mixture quickly enough to maintain emissions within prescribed limits. If the sensor fails altogether, it will cause the feedback control system to revert to open loop mode, with a fixed, rich fuel mixture. Consequently, fuel consumption and emissions will rise, and the converter may suffer damage from overheating.

A recent study conducted by Sierra Research concluded that a high percentage of vehicles failing emissions tests did so because of bad oxygen sensors. Failure rates were highest on older vehicles with unheated O2 sensors (60 percent to 72 percent). The second highest failure rate was among vehicles with first generation heated O2 sensors (19 percent to 27 percent), and the lowest failures were found on the newest vehicles with second generation heated O2 sensors (2 percent to 14 percent).

2.2.2.3 Oxygen Sensor Diagnostics

It’s important to periodically check the primary oxygen sensor’s operation when performing routine maintenance (such as changing the spark plugs) and whenever diagnosing a vehicle for an emissions or converter failure.

On 1996 and newer OBDII vehicles, use your scan tool's graphing feature to verify primary O2 sensor performance. A good primary oxygen sensor should produce an oscillating waveform that ranges from near minimum (0.1 to 0.2v) to near maximum (0.8 to 0.9v). At 2,500 rpm, O2 sensors in throttle body injection systems should toggle two to three times per second at 2,500 rpm, and O2 sensors in multi-port injected applications should toggle five to seven times per second.

When the mixture is artificially richened, the sensor should respond almost immediately (within 100 to 300 milliseconds) and produce its maximum (0.9v) output. Likewise, artificially leaning the mixture by opening a vacuum line should cause the sensor’s output to drop immediately to its minimum (0.1v) output. The sensor should be replaced if it fails to respond or is sluggish.

2.2.2.4 Using the Primary Oxygen Sensor to Diagnose Other Problems

A misfires allow unburned fuel into the exhaust. When this unburned fuel enters the converter, it temporarily overwhelms it, causing a momentary spike in hydrocarbon (HC) emissions until the converter begins to oxidize the unburned fuel. At the same time, the unburned oxygen that accompanies the fuel causes a momentary spike in the oxygen content of the exhaust.

As it passes the primary O2 sensor, the excess oxygen causes a sudden dip in the sensor’s output voltage, which shows up as high frequency oscillations or "hash" on the sensor’s output signal. If you’re observing the O2 sensor’s output voltage when the misfire occurs, you’ll see the normal up and down signal pattern suddenly go berserk. Misfire hash is extreme, but some hash in the O2 sensor signal is normal. As a rule, oscillation or noise, between 300 and 600 millivolts in amplitude, is considered normal. Bosch and General Motors O2 sensors tend to produce more of this kind of hash than Japanese O2 sensors because of their increased sensitivity to minute changes in exhaust oxygen levels.

Vacuum leaks that cause misfire can be pinpointed using a propane enrichment tool to check the intake manifold gaskets, throttle body, and hoses. If the misfire hash on the O2 sensor signal subsides when you feed propane to a particular point, you’ve found the leak.

Diagnosing lean misfire caused by bad or dirty injectors requires a more experienced eye. Most O2 sensors are sensitive enough to detect a single misfire in an individual cylinder at low rpm. If the hash appears as one or two spikes in an otherwise normal pattern, the engine may have only one or two bad injectors. On the other hand, if the hash is severe (numerous spikes), all the injectors may need cleaning or replacing.

2.2.3 Coolant Sensor

The system's coolant sensor monitors engine temperature. The PCM uses this information to regulate a wide variety of ignition, fuel and emission control functions. For example, the fuel mixture needs to be richer to improve drivability when the engine is cold. After the engine reaches operating temperature, the PCM begins using the signal from the O2 sensor to vary the fuel mixture. This is called "closed loop" operation, and it is necessary to keep emissions to a minimum.

2.2.4 Throttle Position Sensor

The signal from throttle position sensor (TPS) informs the PCM about throttle position. The PCM uses this input to alter spark timing and fuel mixture as engine load changes. A problem here can cause a flat spot during acceleration (like a bad accelerator pump in a carburetor) as well as other drivability complaints.

2.2.5 Airflow Sensor

The vehicle's airflow sensor may be any of several different types. The PCM uses the signal from this sensor to determine how much air the engine is drawing in as it runs, and varies fuel delivery accordingly.

Problems with an airflow sensor can upset the fuel mixture and result in various drivability problems, such as hard starting, hesitation, stalling, and rough idle. All airflow sensor types including hot-wire mass airflow sensors and older flap-style vane airflow sensors, are expensive to replace.

Some engines are not equipped with airflow sensors, and only estimate the amount of air the engine is taking in by monitoring engine rpm and using the inputs from the throttle position sensor (TPS), manifold absolute pressure (MAP) sensor, and manifold air temperature (MAT) sensor.

2.2.6 Crankshaft Position Sensor

The crankshaft position sensor serves the same function as the pickup assembly in an engine equipped with a distributor. It monitors engine rpm and enables the vehicle's computer to determine relative position of the crankshaft, so the PCM can control spark timing and fuel delivery in the correct sequence. The PCM also uses the crank sensor's input to regulate idle speed, which it does by sending a signal to an idle speed control motor or idle air bypass motor. On some engines, the PCM uses an additional camshaft position sensor to provide additional input to about valve timing.

2.2.7 Additional Sensors

The manifold absolute pressure (MAP) sensor measures intake vacuum, which the PCM uses to determine engine load. The MAP sensor's input primarily affects ignition timing, but also fuel delivery.

Knock sensors are used to detect vibrations produced by detonation. When the PCM receives a signal from a knock sensor, it momentarily retards timing while the engine is under load in order to protect the engine against spark knock.

The EGR position sensor tells the PCM when the exhaust gas recirculation (EGR) valve opens (and how much). This allows the PCM to detect problems with the EGR system that would increase pollution.

The vehicle speed sensor (VSS) keeps the PCM informed about how fast the vehicle is traveling. This information is needed to control other functions such as torque converter lockup. The VSS signal is also used by other control modules, including the antilock brake system (ABS).

2.2.8 Replacement Sensors

A couple of things to bear in mind whenever replacing sensors:

Physically interchangeable parts may not be calibrated identically, so they won't work properly if installed in the wrong application. To make sure you get the correct replacement part, it may be necessary to reference the vehicle’s VIN in addition to the OEM number on the original part.

Some aftermarket parts may not look identical to the original. A "universal" O2 sensor, for example, may fit a large number of applications but usually requires cutting and splicing wires to install.

2.3 OBDII Check Engine Light

Unlike older OBD systems that set a DTC when a sensor circuit shorts, opens, or the sensor signal is out of the prescribed range, OBDII is primarily emissions-driven and will set a diagnostic code whenever a vehicle’s emissions exceed the federal limit by 50%. OBDII will also set a code if there is a gross sensor failure, but certain types of sensor problems may not always trigger a code.

The determining factor of whether or not a problem triggers the Check Engine light is the problem’s effect on emissions. As long as emissions can be kept below a prescribed limit, the OBDII system may not energize the light. In many instances, emissions can be held in check, despite a faulty sensor, by adjusting fuel trim. Consequently, the Check Engine light on an OBDII-equipped vehicle may become illuminated in the absence of any drivability issue, or the light may not be illuminated even though the vehicle is experiencing a pronounced drivability problem.

The malfunction indicator lamp (MIL), which may be labeled with "Check Engine" or "Service Engine Soon" or a symbol of an engine with the word "Check" in the middle, is installed in the dash to alert the driver when a problem occurs. Depending on how the system is configured and the nature of the problem, the lamp may cycle on and off, remain on continuously or flash - all of which can be very confusing to the motorist because he has no way of knowing what the light indicates, i.e. whether or not it a serious problem. If the engine seems to be running okay, the motorist may simply ignore the light. On an OBDII vehicle, the Check Engine light is illuminated only for emissions-related failures. Separate warning lights must be used for non-emissions problems such as low oil pressure, charging system problems, etc.

If the Check Engine light illuminates because of a misfire or a fuel delivery problem, and the problem does not recur after three drive cycles (under the same driving conditions), the light may go out. With a few exceptions, the OBDII warning lamp will also go out if a problem other than fuel delivery or misfire does not recur after 40 drive cycles. (A drive cycle involves starting a cold engine and driving it long enough to reach operating temperature.)

Although the driver may believe that the problem has corrected itself, an intermittent problem may remain and trigger the light again when conditions are right. Regardless of whether or not the light remains on, the PCM will log a diagnostic code that will remain in the computer's memory to aid in fault diagnosis.

2.4 Diagnostic Codes

There are two different levels of diagnostic codes. "Generic" OBDII codes are generic in the sense that all vehicle manufacturers must use the same code numbers to indicate the same type of problem. Generic code compliance is federally mandated.

Beyond the Generic OBDII codes, vehicle manufacturers have implemented their own proprietary "Enhanced" codes to cover problems not included in the standard OBDII code list. Enhanced codes include many problems that are outside the engine management system, such as ABS codes, climate control codes, body codes, and air bag codes, as well as engine management problems not covered by the generic codes.

Generic OBDII codes all begin with "P0" while the OEM enhanced codes all start with "P1." Enhanced codes are often vehicle-specific and require a high-quality scan tool to decipher. Diagnosing computerized engine control systems and sensors isn't an easy task, but that's the price we pay for drastically reduced emissions and the feature-laden vehicles we drive today. Do your diagnostic homework before you replace critical engine management system parts. It will save you a lot of frustration and needless returns.

To minimize the occurrence of false MIL illumination, the OBDII system is programmed to energize the MIL lamp only if some faults have been detected twice under the same driving conditions. With other faults (those that typically cause an immediate and significant jump in emissions), the MIL will be energized after only a single occurrence. Actually, four different types of diagnostic trouble codes have been defined, only two of which are emissions related. To correctly diagnose a problem, it's important to know which type of code you're dealing with.

- **Type A** diagnostic trouble codes are assigned to the most serious malfunctions and will trigger the MIL lamp with only one occurrence. Whenever a Type A code is set, the OBDII system also stores a history code, failure record, and freeze frame data to help diagnose the problem.

- **Type B** codes are assigned to less serious emission problems. These must occur at least once on two consecutive trips before the MIL lamp will be illuminated. If a fault occurs on one trip but doesn't happen again on the next trip, the code won't "mature" and the light will remain off. When the conditions are met to turn on the MIL lamp, a history code, failure record, and freeze frame data are stored in the same manner as with Type A codes.

- **Type C** and **Type D** codes are non-emissions related. Depending on the manufacturer's programming, Type C codes may or may not energize the MIL lamp (or illuminate another warning lamp), but Type D codes, by definition, will not energize the MIL lamp.

Note that a drive cycle or "trip" is not just an ignition cycle, but includes a warm-up cycle as well. It is defined as starting the engine and driving the vehicle long enough to raise the coolant temperature at least 40 degrees F (if the startup temperature is less than 160 degrees F).

Once a Type A or Type B code has been set, the system will illuminate the MIL, and the lamp will remain on until the component that failed passes a self-test on three consecutive trips. If the fault involved something like a P0300 random misfire or a fuel balance problem, the light won't go out until the system passes a self-test under similar operating conditions (within 375 rpm and within 10% of the load that triggered the DTC). That's why the MIL lamp won't go out until the emissions problem has been repaired.

Clearing the codes with your scan tool or disconnecting the powertrain control module's power supply won't prevent the lamp from being illuminated again if the problem hasn't been fixed. It may take one or more driving cycles to reset the trouble code, but sooner or later the system will energize the MIL lamp if the problem is still there. Likewise, the MIL won't necessarily illuminate if you disconnect a sensor. Whether or not it does, will depend on the priority ranking of the sensor (how it affects emissions), and how many driving cycles it takes for the OBDII diagnostics to pick up the fault and set a code.

2.4.1 Generic Diagnostic Codes

The diagnostic codes that are required by law on all OBDII systems are "generic" in the sense that all vehicle manufacturers must use the same common code list and the same 16-pin diagnostic connector. Thus, a P0302 misfire code on a Nissan means the same thing on a Honda, Toyota or Mercedes-Benz. But vehicle manufacturers are permitted to add their own "enhanced" codes to provide even more detailed information about various faults.

2.4.2 Enhanced Diagnostic Codes

Enhanced codes may cover non-emission related failures that occur outside the engine control system. These include ABS codes, HVAC codes, air bag codes and other body and electrical codes.

An enhanced OBDII code may be distinguished from a generic code by its second character. The second character will be a 0 (zero) for any a generic code. The character will be a 1 (one) for a manufacturer's enhanced code (specific to that particular vehicle application). The third character in the code identifies the system where the fault occurred. Numbers 1 and 2 indicate fuel or air metering problems, 3 specifies an ignition problem or engine misfire, 4 is used for auxiliary emission controls, 5 relates to idle speed control problems, 6 is reserved for computer or output circuit faults, and 7 and 8 refer to transmission problems. Diagnostic codes can be read and cleared using an OBDII scan tool.

2.4.3 Suppressed Diagnostic Codes

On OBDII-equipped vehicles, adaptive strategies can sometimes prevent a fault code from being set as long as the complete failure of a sensor or other component has not occurred — provided that the system can compensate well enough to keep tailpipe emissions from exceeding 1.5 times the legal limit. For example, you might have a vehicle with a faulty coolant sensor that always reads low. Normally, this would prevent the computer from entering closed loop operation. But in many instances, the OBDII system will still go into closed loop and no code will be set. To diagnose this kind of problem, you may have to use a scan tool with real-time sensor readings to look at individual sensor inputs and verify that they make sense.

One problem that's often overlooked during the diagnostic process that can cause a variety of drivability issues is a low battery or charging voltage. The vehicle's electronics, as well as electric fuel pump, must be supplied with the correct voltage in order to function properly, so if the battery or charging system voltage is low, a variety of drivability ills, including hard starting, hesitation, and ignition misfire may result. Furthermore, if voltage isn't up to specification, the fuel pump may not deliver enough pressure or volume to meet the demands of the engine. Similarly, low voltage can interfere with the operation of the injectors, sensors, actuators and ignition system.

2.4.4 False Diagnostic Codes

Today's OBDII systems are so sensitive to misfires that as few as five misfires in 200 engine revolutions will trigger a misfire code. Unfortunately, this high level of sensitivity can sometimes generate false misfire readings under certain operating conditions. Driving on an extremely rough road, for example, can produce the same kind of variations in crank speed that appear to be misfires to the OBDII monitor. Some newer OBDII systems compensate for rough road operation by automatically reducing misfire sensitivity. Others use a different method to detect misfires. Instead of monitoring crankshaft speed, these systems monitor the firing voltage of each spark plug to detect problems (a lean misfire typically causes a large jump in the firing voltage, while a shorted or fouled plug causes a drop in the firing voltage). Random misfires that are not isolated to a particular cylinder will also set a misfire code. In these situations, a scan tool that enables you to view the vehicle's real-time sensor data is invaluable in distinguishing a real misfire problem from a false code.

GM has had problems with certain 3.8L engines setting false P1406 codes. This code indicates an EGR valve fault. However, replacing the EGR valve won't fix the problem, because the OBDII system is overly sensitive to the speed at which the EGR valve opens when it is commanded to do so. The solution is not to replace the EGR valve but to "reflash" (reprogram) the computer to be less sensitive to EGR valve response speed. Referring to vehicle manufacturer technical service bulletins (TSB's) will save a lot of time and frustration for these kinds of problems.

On '96 General Motors J-, N- and H-body cars, several rental fleets have encountered problems with MIL lamp illumination because of the failure of motorists and fleet personnel to use the correct refueling procedure when filling the fuel tank with gas. On these cars, the OBDII system applies vacuum to the evaporative emissions control system to check for air leakage. If the gas cap isn't tight or the tank is filled while the key is on or the engine is idling, a false P0440 code can be triggered, causing the MIL light to be illuminated. GM has not issued a technical service bulletin on the problem, but is advising its dealers and fleet customers to reflash the EEPROM with revised OBDII programming that waits to check the evaporative emissions system until the vehicle is in motion.

Bad gas has also caused false MIL lights. When the vehicle is diagnosed, the technician finds a P0300 random misfire code which would normally be set by a lean misfire condition due to a vacuum leak, low fuel pressure, dirty injectors, or an ignition problem such as fouled plugs, bad plug wires, weak coil, etc. The OBDII system tracks misfires by individual cylinder, and considers up to a 2% misfire rate as normal. But water in the gas or variations in the additive package in reformulated gasoline in some areas of the country can increase the misfire rate to the point where it triggers a code.

2.5 OBDII Misfire Detection

The most powerful (and controversial) feature of OBDII is its ability to detect engine misfire. First generation OBD systems couldn't do that directly so there was no way to know if the engine was performing properly or not.

OBDII misfire detection strategies vary somewhat from one vehicle manufacturer to another, but most currently use the input from the crankshaft position sensor to monitor changes in crankshaft speed. A single misfire will cause a slight variation in the rotational velocity of the crank. By knowing the position of the crank and which cylinder is supposed to be firing, the OBDII system can correlate each misfire that occurs with a specific cylinder. The misfires are tracked and tabulated, and if a pattern arises, the PCM will set a misfire code and energize the Check Engine light.

If an emissions problem is being triggered by engine misfire, the OBDII light will flash as the misfire is occurring. But the MIL will not be energized the first time a misfire problem is detected. It will come on only if the misfire continues during a second drive cycle and will set a P030x series code, where the value of "x" indicates the number of the cylinder that is misfiring. The code does not indicate the reason why the cylinder is misfiring. You must determine that by performing other diagnostic tests. The misfire might be due to a fouled spark plug, a bad plug wire, a defective ignition coil in a DIS system, a clogged or dead fuel injector or a loss of compression due to a leaky exhaust valve, leaky head gasket or worn cam lobe.

A P0300 code indicates a random misfire (probably due to a vacuum leak, open EGR valve, etc.). If the last digit is nonzero, it specifies the number of the cylinder that is misfiring. A P0302 code, for example, indicates that cylinder number two is misfiring. Causes here might be anything that will affect only a single cylinder, such as a fouled spark plug, a bad coil in a coil-on-plug ignition system or distributorless ignition system with individual coils, a clogged or dead fuel injector, a leaky valve, or head gasket.

The OBDII system tracks every misfire, counting them up and averaging them over time to determine if the rate of misfire is abnormally high enough to cause the vehicle to exceed the federal emissions limit. If this happens on two consecutive trips, the Check Engine light will illuminate and flash to alert the driver when the misfire problem is occurring.

On some vehicles, the PCM will disable a cylinder if it detects a high enough rate of misfire. This is done to protect the catalytic converter. By shutting off the cylinder's fuel injector, the OBDII system prevents unburned fuel from passing through the cylinder and into the exhaust, because raw fuel in the exhaust would cause the converter overheat, which could cause damage.

2.6 Continuous vs. Non-continuous Monitors

Misfire detection is a continuous monitor, meaning it is enabled whenever the engine is running. As are the fuel system monitor that detects problems in fuel delivery and the air/fuel mixture, and another monitor called the "comprehensive monitor" that detects gross faults in the sensors and engine control systems. These monitors are always active and do not require enabling by any special operating conditions.

Other OBDII monitors are only active at certain times. These are the "non-continuous" monitors, which include the catalytic converter efficiency monitor, the evaporative system monitor that detects fuel vapor leaks in the fuel system, the EGR system monitors, the secondary air system monitor (if the vehicle has such a system), and the oxygen sensor monitors. On some 2000 and newer vehicles, OBDII also has a thermostat monitor to track the operation of this key component. Thermostat monitors are required on all 2002 and newer vehicles. On some 2002 model-year vehicles, there also is a new PCV system monitor, which will be required on all vehicles by 2004.

2.6.1 Catalytic Converter Monitor

The catalytic converter monitor tracks converter efficiency by comparing the vehicle's upstream and downstream oxygen sensor outputs. If the converter is functioning properly, there will be little unburned oxygen in the downstream exhaust gas. This should cause the downstream O2 sensor to remain relatively stable near its maximum output voltage. If the downstream O2 sensor reading fluctuates from high to low in the same manner as the front sensor, the converter is not functioning.

Converter efficiency will drop from 99 percent when new to around 96 percent after a few thousand miles. Any further drop in efficiency may be enough to trigger the Check Engine light. The OBDII system will illuminate the Check Engine light if the difference between the front and rear O2 sensor readings indicates hydrocarbon (HC) readings have increased to a level in excess of 1.5 times the allowable limit. For 1996 and newer vehicles that meet federal Low Emission Vehicles (LEV) requirements, the limit is 0.225 grams per mile (gpm) of HC.

2.6.2 EVAP System Monitor

The EVAP system monitor checks for fuel vapor leaks by performing either a pressure or vacuum test on the fuel system. For 1996 through 1999 vehicles, the federal standard allows leaks up to the equivalent of a hole .040 inches in diameter in a fuel vapor hose or filler cap. For 2000 and newer vehicles, the maximum allowable leakage rate has been reduced to the equivalent of a .020 in. diameter hole, which is almost invisible to the naked eye but can be detected by the OBDII system. Locating leaks this small can be very challenging.

2.7 OBDII Monitor Readiness Flags

An essential design aspect of the OBDII system is the use of "readiness flags" that indicate when particular monitors are active and have observed the systems they are assigned to oversee. The misfire detection, fuel system, and comprehensive system monitors are active and ready all the time, each non-continuous monitor requires a specific sequence of operating conditions before it will set its readiness flag. You cannot perform a complete OBDII test until all of the system's monitors are ready. To set the converter monitor, for example, the vehicle may need to be driven a minimum distance at different speeds.

The conditions for a monitor's readiness may vary considerably from one vehicle manufacturer to another, so there is no "universal" drive cycle that will guarantee all the monitors will be set and ready. As a general rule, performing some stop-and-go driving around town at speeds up to about 30 mph followed by five to seven minutes of 55+ mph highway driving will usually set most or all of the monitors (the converter and EVAP system readiness monitors are the hardest to set). If you find that a particular monitor is not ready when checking the OBDII system, it may be necessary to test-drive the vehicle to set the monitor.

The Environmental Protection Agency (EPA) realized this shortcoming in current generation OBDII systems, so it created the rules for states that want to implement OBDII testing in place of tailpipe dyno testing. The rules allow up to two readiness flags to not be set when performing an OBDII test on 1996 through 2000 vehicles, and one readiness flag not to be set on 2001 and newer vehicles. You can use an OBDII scan tool to confirm that your readiness flags are all set just prior to having your vehicle emissions tested. This will save you the aggravation of being sent off to drive around in order to set the system's readiness flags.

2.7.1 Vehicles with Monitor Readiness Issues

Some import vehicles have known readiness issues. Many 1996-'98 Mitsubishi vehicles have monitors that read "not ready" because setting the monitors requires very specific drive cycles (which can be found in their service information). Even so, these vehicles can be scanned for codes and the MIL light without regard to readiness status. On 1996 Subarus and 1996 Volvo 850 Turbos, turning the key off will clear all the readiness flags and these vehicles must be driven to again set all the readiness flags. On 1997 Toyota Tercel and Paseo models, the EVAP monitor readiness flag will never set, and no fix is yet available. Other vehicles that often exhibit "not ready" conditions for their EVAP and catalytic converter monitors include 1996-'98 Volvos, 1996-'98 Saabs, and 1996-'97 Nissan 2.0L 200SX models.

2.8 OBDII Drive Cycle

The purpose of the OBDII drive cycle is to run all of a vehicle's onboard diagnostics. The drive cycle should be performed after clearing any trouble codes from the PCM's memory, or after the battery has been disconnected. Running through the drive cycle sets all the system status "flags" so that subsequent faults can be detected.

The drive cycle begins with a cold start (coolant temperature below 122 degrees F and the coolant and air temperature sensors within 11 degrees of one another).

NOTE: The ignition key must not be ON prior to the cold start otherwise the heated oxygen sensor diagnostic may not run.

1. As soon as the engine starts, idle in drive for two and a half minutes with the A/C and rear defrost on. OBDII checks oxygen sensor heater circuits, air pump and EVAP purge.

2. Turn the A/C and rear defrost off, and accelerate to 55 mph at half throttle. OBDII checks for ignition misfire, fuel trim and canister purge.

3. Hold at a steady state speed of 55 mph for three minutes. OBDII monitors EGR, air pump, O2 sensors and canister purge.

4. Decelerate (coast down) to 20 mph without braking or depressing the clutch. OBDII checks EGR and purge functions.

5. Accelerate back to 55 to 60 mph at ¾ throttle. OBDII checks misfire, fuel trim and purge again.

6. Hold at a steady speed of 55 to 60 mph for five minutes. OBDII monitors catalytic converter efficiency, misfire, EGR, fuel trim, oxygen sensors and purge functions.

7. Decelerate (coast down) to a stop without braking. OBDII makes a final check of EGR and canister purge.

2.9 OBDII Emissions Testing

The problem with most vehicle inspection programs is that they were developed back in the 1980s to identify "gross polluters." The tests were designed primarily to measure idle emissions on carbureted engines (which are dirtiest at idle), and to check for only two pollutants: unburned hydrocarbons (HC) and carbon monoxide (CO). The pass/fail cut points established for the various model years were also made rather lenient to minimize the number of failures. Consequently, a lot of late model vehicles that shouldn't be passing emissions tests are slipping through.

The I/M 240 vehicle inspection program required "loaded-mode" emissions testing on a dyno while the vehicle was driven at various speeds following a carefully prescribed driving trace. While this was going on, the tailpipe gases were analyzed to check emissions. The total emissions for the entire 240-second driving cycle would then be averaged for a composite emission score that determined whether or not the vehicle passed the test. Also included were an evaporative purge flow test to measure the flow rate of the canister purge valve, and an engine off pressure test of the evaporative emission control system to check the fuel tank, lines and cap for leaks.

Efforts to upgrade emission-testing programs to the new I/M 240 standards stalled because of a lack of public and political support. The I/M 240 program was to have been required in most areas of the country that didn't meet national ambient air quality (NAAQ) standards. But after the program faltered in Maine, most states balked and only a few went ahead with the program. The cost and complexity of the I/M 240 program combined with less than enthusiastic public acceptance doomed it from the start. So it's now up to the individual states to come up with alternative plans for improving their air quality. An key element in many of those plans is OBDII.

OBDII self-diagnostic emissions software has been required on all new vehicles sold in this country since model year 1996, including all imports. OBDII is a powerful diagnostic tool that can give insight into what's actually happening within the engine control system. In 2002, a number of states announced plans to change their emissions testing programs over to OBDII. An OBDII check is a simple plug-in test that takes only seconds instead of the several minutes required for conducting a tailpipe emissions check on a dynamometer. Furthermore, OBDII will detect emissions problems that might not cause a vehicle to fail a tailpipe test – which means emissions test failures under the OBDII test programs are expected to be significantly higher.

2.9.1 The OBDII Emissions Test Procedure

An official OBDII emissions test consists of three parts:

1. An inspector checks to see if the MIL light is illuminated when the ignition is rotated from OFF to the ON position. If the light does not energize, the vehicle fails the bulb check.

2. An OBDII scanner is connected into the vehicle's diagnostic link connector (DLC), and system monitor readiness is verified. The vehicle fails if the DLC is missing, has been tampered with or fails to provide any data. If more than the allowable number of monitors are not ready, the vehicle is temporarily rejected and asked to return later, after it has been driven sufficiently to set the readiness flags.

   The scanner is also used to verify the status of the Check Engine light (commanded ON or OFF), and to download any diagnostic trouble codes that may be present. If the MIL is on and there are any OBDII codes present, the vehicle fails the test and must be repaired.

3. As a final system check, the scanner is used to command the MIL lamp on to confirm that it is responding to commands from the onboard computer. If the lamp does not energize, the vehicle fails the test.

If a vehicle has failed the OBDII emissions test, you must determine the problem by plugging into the OBDII system, pulling any stored codes and observing any other system data that may be relevant to determining the source of the problem. Long-term fuel trim data can provide some useful insight into what's going on with the fuel mixture. If long-term fuel trim is at maximum, or you see a big difference in the numbers for the right and left banks of a V-type engine, it would tell you the engine control system is trying to compensate for a fuel mixture problem (possibly an air leak, dirty injectors, leaky EGR valve, etc.).

OBDII also provides "snap shot" or "freeze frame" data, which can help identify and diagnose intermittent problems. When a fault occurs, OBDII logs a code and records all related sensor values at that moment for later analysis.

Once you've pinpointed the problem and replaced the faulty component, your final step is to confirm that your repair has solved the problem and that the OBDII light remains off. This will usually require a short test drive to reset all the readiness monitors and run the OBDII diagnostic checks.

3 OBDIII Systems

OBDII is a very sophisticated and capable system for detecting emissions problems. However, it's no more effective than OBDI with regard to ensuring that motorists fix emission problems. In the absence of some means of enforcement, such as checking the MIL light during a mandatory inspection, OBDII is just another idiot light. However, plans for OBDIII, which would take emissions monitoring a step further by adding telemetry, are currently under consideration.

Using miniature radio transponder technology similar to that which is being used for automatic electronic toll collection systems, an OBDIII-equipped vehicle would be able to report emissions problems directly to a regulatory agency. The transponder would communicate the vehicle VIN number and any diagnostic codes that are present. The system could be set up to automatically report an emissions problem via a cellular or satellite link the instant the MIL light comes on, or to answer a query from a cellular, satellite or roadside signal as to its current emissions performance status.

Another change that OBDIII may bring is even closer scrutiny of vehicle emissions. The originally mandated OBDII misfire detection algorithms were required to watch for misfires only during the driving conditions that occur in the federal driving cycle, which covers only idle to 55 mph and moderate acceleration. Monitoring of misfires during wide-open throttle acceleration was not required. Although recent revisions require full range misfire detection for all 1997 and newer models, OBDIII could go even further by requiring "fly-by-wire" throttle controls to reduce the possibility of misfires on the coming generation of low emission and ultra low emission vehicles.

What makes OBDIII so attractive to regulators is its effectiveness and cost savings. Additionally, if an emissions problem were detected, it would be much more difficult to avoid having it repaired—which is the goal of all clean air programs anyway. Under the current system, the entire vehicle fleet in an area or state has to be inspected once every year or two to identify the 30% or so vehicles that have emissions problems. By zeroing in on the vehicles that are actually causing the most pollution, significant gains could be made in improving our nation's air quality. But as it is now, polluters may escape detection and repair for up to two years in areas that have biennial inspections. And in areas that have no inspection programs, there's no way to identify such vehicles. OBDIII would change all that. With remote monitoring via the onboard telemetry on an OBDIII-equipped vehicle, the need for periodic inspections could be eliminated because only those vehicles that reported problems would have to be tested.

On one hand, OBDIII with its telemetry reporting of emission problems would save consumers the inconvenience and expense of having to subject their vehicles to annual or biennial emissions tests. As long as their vehicles reported no emission problems, there'd be no need to test them. On the other hand, the specter of having Big Brother in every engine compartment and driving a vehicle that reports itself anytime it pollutes is not one that appeals to many motorists.

In the end, the public would have to be convinced of the merits of OBDIII based on its cost savings, convenience, and ability to make a significant improvement in air quality. Even so, any serious attempt to require OBDIII in the near future is likely to run afoul of Fourth Amendment issues over rights of privacy and protection from government search and seizure. These issues would have to be resolved before OBDIII stood any chance of acceptance. However, most people simply do not believe the government has the right to monitor the whereabouts of their vehicles or to snoop under their hoods anytime it chooses to do so, and acceptance of such a drastic solution seems unlikely.