INTRODUCTION TO EMISSIONS SYSTEMS

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.

CONVERTER REPLACEMENT

Original equipment converters are designed for go 100,000 plus miles—which many do provided they aren't poisoned by by lead, silicon or phosphorus. When leaded gasoline was still available, fuel switching to save money caused the premature demise of many a converter. 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 is the engine is burning oil because of worn valve guides or rings.

Converters may also fail if they get too hot. This can be caused by unburned fuel in the exhaust. Contributing factors include a 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 real hot real fast. If the converter's temperature climbs high enough, it can melt the ceramic substrate that supports the catalyst 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. Or, if the converter is 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 repair option. Up to model year 1995, 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 jumped to 8 years and 80,000 miles.

Replacement converters 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.

A new converter will solve a plugged or dead converter problem. But unless the underlying cause is diagnosed and corrected, the replacement converter may suffer the same fate. Other items that should also be inspected include the air pump and related plumbing, oxygen sensor and feedback control system.A sluggish oxygen sensor, for example, 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 to make the vehicle fail and 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 auto makers 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 remind the motorist to have his oxygen sensor checked or replaced.

A leading supplier of oxygen sensors (Bosch) 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 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. And on 1996 and newer OBD II equipped vehicles, the recommended replacement interval is 100,000 miles.

PCV

PCV valves are generally considered a maintenance item like spark plugs, and should be inspected and replaced periodically (typically every 50,000 miles). The PCV valve siphons blowby vapors from the crankcase into the intake manifold so the vapors don’t escape into the atmosphere. One of the beneficial effects of PCV, besides eliminating blowby emissions, is that it pulls moisture out of the crankcase to extend oil life. Moisture can form acids and sludge which can cause major engine damage. So if the PCV valve or hose plugs up, rapid moisture buildup and oil breakdown can result.

EGR

The EGR valve has no recommended replacement or inspection interval, but that doesn’t mean it won’t cause trouble. EGR reduces the formation of oxides of nitrogen by diluting the air/fuel mixture with exhaust. This lowers combustion temperatures to keep it under 2500 degree F so little NOX is formed (the higher the flame temperature, the higher the rate at which oxygen and nitrogen react to form NOX). As an added benefit, EGR also helps prevent detonation.

The heart of the system is the EGR valve. The valve opens a small passage between the intake and exhaust manifolds. When ported vacuum is applied to the EGR valve diaphragm, it opens the valve allowing intake vacuum to siphon exhaust into the intake manifold. This has a same effect as a vacuum leak, so EGR is only used when the engine is warm and running above idle speed.

Some vehicles have "positive backpressure" EGR valves while others have "negative backpressure" EGR valves. Both types rely on exhaust system backpressure to open the valve. But 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 modify 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.

EGR valves do not normally require maintenance, but can become clogged with carbon deposits that cause the valve to stick or prevent it from opening or closing properly. An EGR valve that’s stuck open will act like a vacuum leak and cause a rough idle and stalling. An EGR valve that has failed, refuses to open (or the EGR passageway i the manifold is clogged) will allow elevated NOX emissions and may also cause a detonation (spark knock) problem. Dirty EGR valves can sometimes be cleaned, but if the valve itself is defective it must be replaced.

OTHER EMISSION PARTS

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 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 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.

EVAP

Evaporative emissions from the fuel system (fuel vapors) are trapped and store in a charcoal canister. Later, a purge valve opens allowing the vapors to be sucked into the engine and reburned. 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.

OBD II

Starting as early as 1994, some U.S. vehicles were equipped with a new government mandated onboard diagnostic (OBD II) system. By model year, 1996, OBD II was required on all new cars and light trucks.

OBD II is designed to detect emission problems. When a problem is detected, the Check Engine light comes on and a diagnostic trouble code is stored in the vehicle's powertrain computer. Later, the code can be read using a scan tool to determine the nature of the problem.

With OBD II, the Check Engine light will come on anytime emissions exceed federal limits by 50% on two consecutive trips, or there's a failure of a major emissions control system. With earlier engine control systems, the only way to uncover most emission problems is to give the vehicle an emissions test—which is not required in many rural areas. But OBD II is on every 1996 and newer car and light truck regardless of where it is registered in the U.S. And unlike an emissions test which may only be given once every year or two, OBD II is monitoring emissions performance every time the vehicle is driven.