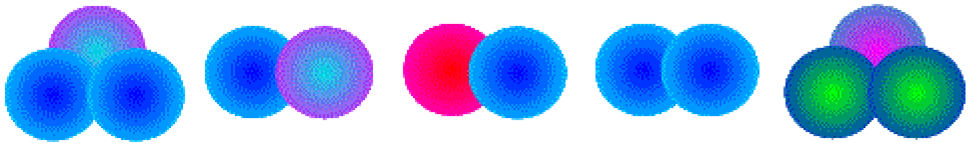
UNDERSTANDING 5 GAS DIAGNOSIS



For a quick determination of high HC look at the CO_2. CO_2 under 12% would indicate a lack of combustion. A CO_2 reading above 12% would indicate that the engine is running efficiently and that the catalytic converter is most likely failing.

COMPONENTS OF EMISSIONS

Hydrocarbons (HC) Is raw gasoline or gasoline that has not burned. Associated with incomplete combustion. Combines with NOx and sunlight to form photochemical smog.

Carbon Monoxide (CO) Is partially burned fuel known as a rich indicator. CO is a highly poisonous and displaces oxygen in the bloodstream.

Oxides of nitrogen (NOX) Is an unnatural combination of oxygen and nitrogen that occurs when combustion temperatures are 2500 degrees or higher. NOX and HC with sunlight form ozone or photochemical smog.

Carbon dioxide (CO_2) A measurement of combustion efficiency a byproduct of good clean combustion. During combustion, O_2 combines with HC and CO to form CO_2 and H20

Oxygen (O_2) Supports combustion, also known as a good **lean** indicator

CAUSES OF EMISSIONS HC

In order for the internal combustion engine to obtain the lowest level of emissions,all elements of combustion have to be in place. Problems such as spark timing, air-fuel mixture, lack of compression, or ignition misfires will cause the HC to increase. The amount of HC increase depends on the severity of the problem. For example, an engine with an ignition misfire will produce the highest level of HC. The air/fuel mixture enters the cylinder and gets compressed but does not burn and exits the engine on the exhaust stroke in its raw form unburned fuel. The HC levels from the exhaust wouldn't be much different than sampling the fuel tank filler neck; it's raw fuel untouched by combustion. This is what occurs during a total loss of combustion usually associated with ignition misfires. Anything that stops the burning process from completing or prevents it from occurring will increase the HC with only 1 exception an injector that is not working.

Electrical misfires: if the spark does not occur, fuel will not burn to create the highest level of HC in the tailpipe. What comes in comes out the same, unconverted raw fuel.

Advanced ignition timing: When spark occurs too early before the air/fuel mixture has been properly compressed, HC will increase due to fuel not burning completely, also when ignitions occur too early the expanding gasses put downward pressure on the top of the piston as it is still moving upward in the compression stroke. This creates a loss of power, and these expanding gasses are being compressed, causing an increase in pressure and temperature that will raise the NOX also. It would be likely that the engine will also ping and detonate.

Lean air-fuel mixtures: When lean, HC molecules are separated by too much oxygen, the combustion flame cannot jump gaps for the entire air/fuel charge to burn. This is called a lean misfire. Lean misfires are not consistent like a loss of ignition and won't cause the HC to raise to the level of an ignition misfire. Keep in mind when a lean misfire occurs, there is still HC in the cylinder even though it is lean, causing the HC to increase.

Rich running condition: Too much fuel and not enough air is considered a rich condition of. During combustion, all the oxygen gets used up before all the fuel is burned resulting in an increase of HC and CO. HC increases when the combustion stops as it runs out of oxygen and there is still raw fuel left in the combustion chamber. CO increases because there was not enough oxygen to complete the oxidation process that would have resulted in the production of more CO_2 and less CO,

EGR valve open at idle: Oxygen is replaced by inert exhaust gas that contains mostly nitrogen that will not burn increasing levels of HC at idle. An engine at idle is only running 50% volumetric efficient. When EGR is open at idle volumetric efficiency is reduced to 40% or lower. An idling engine can only get as much air as the throttle plate will allow into the intake manifold. When the EGR valve is open at idle, it crowds out air that would normally be used for combustion, causing high HC, This isn’t the case when the engine is under a load. Under a load, the throttle plate is open increasing volumetric efficiency to 95%, allowing for complete. EGR opening under a load will not cause combustion problems due to the fact that there is enough air for complete combustion.

Idle speeds too low: This is usually due to insufficient airflow past the throttle plate. This lowers the pressure in the cylinder, reducing combustion efficiency, increasing HC emissions. This problem directly affects volumetric efficiency by restricting airflow resulting in lower pressure and an increase in HC levels.

Leaking piston rings: The air/fuel mixture isn't compressed properly causing low combustion pressures resulting in a lack of combustion efficiency. This causes the HC levels to increase. The HC that escapes past the piston rings enters the crankcase. Over time this will saturate the engine oil with fuel. This fuel is drawn through the PCV valve causing a rich mixture

Burnt intake or exhaust valves: when a cylinder doesn’t seal on its compression stroke the pressures will be too low for complete combustion to occur and HC levels will be elevated. The HC will generally be higher at idle than under a load due to volumetric efficiency. An engine generally will run at 50% efficiency at idle and 95% under a load. This is proven by the fact that running compression at idle is only 50% and close to 100% at WOT., The load on the engine increases and more air fills the combustion chamber the HC level drop, causing the effect of higher HC at Idle than at WOT with the above condition.

Some other causes:

Malfunctioning air injection systems
Malfunctioning catalytic converter

There are many more causes of elevated HC emissions. It can be simplified to one simple phrase (anything that stops the combustion process too soon will cause elevated HC with the exception of an injector circuit malfunction). Think of HC as a measure of poor efficiency. The higher the HC, the worse the efficiency of the engine will be.

CAUSES OF EMISSIONS CO

CO is partially burned fuel that occurs when the air/fuel mixture is too rich. CO will increase when there is not enough air to burn the fuel that enters the cylinders. During a rich running condition, fuel burns until the oxygen are depleted, causing combustion to stop prematurely. What this means is HC was not completely oxidized and comes out of the exhaust as CO, and not CO2. CO is a byproduct of combustion and is incomplete burning of fuel caused by a lack of oxygen. High CO is a rich indicator, and should always result in low O2 readings on the 5 gas analyzer with the exception of misfires, exhaust leaks, and Air injection problems. In these cases the extra air causes the O2 sensor to see a false lean signal, and the computer enriches the mixture to compensate, causing both the CO and O2, to be elevated.

Plugged PCV valve: The engine can receive as much as 30% of its air intake from the PCV system. When the PCV system gets plugged, it starves the engine of needed oxygen to complete the burning process and will create a rich running condition with elevated levels of CO. The wrong size PCV valve, one that is too small restricting airflow will have the same results. the

Dirty air filter: Speed density engines that use a MAP sensor to detect load are very susceptible to this condition. The computer will sense a drop in intake manifold vacuum that equals an increase in manifold pressure. The computer will determine a load is being placed on the engine resulting in a rich command causing high CO. Vehicles that use a MAF sensor for the load will not have a rich air-fuel mixture. MAF sensors measure air directly allowing the MAF to see exactly how much air enter the engine allowing the computer will deliver the correct amount of fuel. ,

Fuel in the crankcase: Fuel that enters the crankcase is drawn through the PCV system this fuel is not metered and causes high CO. This is extra fuel from what the engine receives from its normal source.

Saturated EVAP canister: EVAP canisters job is to store HC fuel vapors from the fuel tank while the vehicle is at rest. The computer will purge these vapors from the canister while the engine is running. The computer activates the canister purge solenoid causing a slight vacuum that pulls the vapor from the canister. This vapor is burned and quickly dissipates. A saturated canister will allow a continual flow of vapor and raw fuel into the engine that is not metered, causing a rich mixture.

Note: Most canister purge systems will not begin purging until the engines computer system has entered the closed-loop and the throttle is off idle.

Some other causes:

The malfunctioning air injection system
Malfunctioning catalytic converter
Malfunctioning in computer controls
High fuel pressure
Sunken float
Leaking injectors

Remember that CO is a **rich** indicator; it will be high when the air-fuel mixture is rich. CO is incomplete burning of the fuel and is by-product combustion.

CAUSES OF EMISSIONS NOX

NOx is formed when combustion temperatures exceed 2500 degrees. Oxygen bonds to nitrogen to form NOx. This is the result of high temperature and or high pressures within the combustion process.

Advanced timing: Spark occurs before the piston has reached the top of its compression stroke. When the air-fuel mixture ignites too early the gasses expand while the piston is still moving up, causing an increase in pressure and temperature. NOX emissions will be extremely high with this problem. The high pressures and temperatures in the cylinder can cause pinging and detonation.

EGR valve malfunction: The purpose of the EGR system is to mix a small amount of exhaust gas with the intake air to take up space in the cylinder reducing combustion and combustion temperatures.Variable valve timing has now replaced the EGR valve on many applications. If the EGR fails or passages are blocked, the combustion temperatures will increase, causing the NOX to increase.

High-performance parts: The purpose of high-performance parts is to increase the volumetric efficiency of the engine. Any time efficiency is increased there is an increase in combustion temperatures. Efficiency can be increased by putting more air into the engine or by shrinking the size of the combustion chamber. Either way it’s done it all has the same results higher cylinder temperature and or pressures and elevated NOx production.

Cooling system problems: The job of the cooling system is to remove heat from the cylinders and the cylinder heads. When the cooling system cannot adequately dissipate the temperature of the engine, the NOX will be ,elevated.

Low octane fuel: Fuel with low octane ratings will burn faster and ignite with lower temperatures. As air and fuel get compressed temperature within the cylinder rises, and if they raise to the flashpoint of fuel, the fuel will self ignite. Once the fuel ignites, the gases expand, and because the combustion was premature, the gases are expanding as the piston is still moving up on the compression stroke while compressing the expanding gases. This creates excessive pressure and temperatures, causing the NOX to go up.

Lean air-fuel mixture: When oxygen is added to the fire, the fire gets hotter. Blacksmiths used bellows to add oxygen to fire so it would be hot enough to mold the metal horseshoes. If we add oxygen to fire within the cylinder it to gets hotter creating excessive temperature and elevating NOx production. Lean air-fuel mixtures will burn slower, allowing it more time to build up heat.

Carbon build-up on pistons: Carbon on the top of the pistons shrinks the size of the combustion chamber allowing higher combustion pressures. This increase in pressure raises the NOX emissions. ,

Carbon on intake valves: Carbon build up on the backside of the intake valves soaks up the fuel entering the cylinder, creating a lean condition. This has been known to create elevated levels of NOx.

Inoperative knock sensor: A knock sensors job is to signal the PCM when pinging occurs so the PCM can retard the timing. When pinging is occurring within a cylinder, the temperature and pressures will rise to cause an increase in ;NOX emissions.

Turbocharger/superchargers: Add on parts such as these are designed to increase volumetric efficiency by pressurizing the intake manifold above atmospheric pressures. Increased airflow into the cylinder increases combustion pressures and temperatures increasing NOX emissions.

Computer inputs: The PCM is responsible for controlling the air/fuel mixture and spark advance. It uses sensor inputs to achieve this goal. When a sensor is out of calibration, the PCM will respond by changing timing and air/fuel mixture to whatever way the sensor is biased. For example, the O2 sensor is biased high this means the voltage output of the sensor is too high for the oxygen content in the exhaust. The PCM will interpret this as a rich condition and will lean out the mixture and advance the timing. The lean mixture and advanced timing will increase NOX emissions.

Cylinder head machining: Often cylinder heads are shaved when performing valve jobs. This is done to create a flat surface for the head gasket to seal. It is not unheard of to take as much as 30 thousand off the cylinder head. When this is done, it creates a smaller combustion chamber. This shrinkage of the combustion chamber increases the cylinder pressure and increases Nox emissions.

CAUSES OF EMISSIONS CO2

Carbon dioxide is the result of proper combustion of HC and O2. Any problems in the engine that affect the combustion process will lower the CO2 levels. You cannot have a misfire and expect to see high CO2 levels. The higher the CO2 level, the more efficient the engine is running. Optimum CO2 is 12% to 15 %.

CO2 can be used as an efficiency meter of the engines combustion efficiency. When there is a problem that affects the combustion process, the CO2 will drop below 12%. that If HC is high and CO2 is normal, you have a catalytic converter problem. Is CO2 is low you have a combustion efficiency problem that could be caused by all the above.

CAUSES OF EMISSIONS O2

O2 readings that show up on your five gases analyzer is extra oxygen that was not converted during the combustion process. This is why O2 is an excellent lean indicator. When the engine is running lean, O2 will increase proportionately with the air/fuel ratio. As the engine goes to the lean misfire conditions, around 16.0 to 1 O2 will rise drastically. There are other causes of high O2 besides lean conditions such as misfires, air injection problems, and exhaust leaks. Good O2 reading at the tailpipe should be under 1%.

Quick Reference Chart

Symptom	HC	CO	CO_2	O_2	NO_x
Ignition misfire	Large increase	Some decrease	Some Decrease	Some-large increase	Some-large decrease
Compression loss	Some-large Increase	Some decrease	Some decrease	Some Increase	Some-large decrease
Rich Mixture	Some-large Increase	Large increase	Some decrease	Some Decrease	Some-large decrease
Lean mixture	Some Increase	Large Decrease	Some Decrease	Some Increase	Some-large increase
Very Lean Mixture	Large Increase	Large Decrease	Some Decrease	Large Increase	Some-large decrease
Slightly retarded timing	Some decrease	No change or Some increase	No change	No change	Large Decrease
Very retarded Timing	Some Increase	No Change	Some-large Decrease	No Change	Large Decrease
Advanced timing	Some Increase	No change or Some-decrease	No change	No Change	Large Increase
EGR Operating	No Change	No Change	Some Decrease	No Change	Large Decrease
EGR Leaking	Some Increase	No Change	No change or Some decrease	No Change	Some decrease or No change
Air injection Operation	Large Decrease	Large Decrease	Some-large Decrease	Large Increase	No Change
Catalytic converter functional	Some Decrease	Some Decrease	Some Increase	Some Decrease	Some Decrease W/3-w cat
Catalytic Converter Not functional	Some-large Increase	Some-large increase	Some Decrease	Some Increase	Some Increased W/3-w cat
Exhaust Leak	Some Decrease	Some Decrease	Some Decrease	Some Increase	No change
Worn Engine	Some Increase	Some Increase	Some Decrease	Some Decrease	No change or Slight decrease
O_2 sensor Biased low	Some Increase	Some-large Increase	Some Decrease	Some Decrease	Some Decrease
O_2 sensor Biased high	Some Increase	Some decrease	Some Decrease	Some increase	Some increase
Flat Camshaft	No change or Some decrease	Some Decrease	Some Decrease	No change or Some decrease	No change or Some decrease