

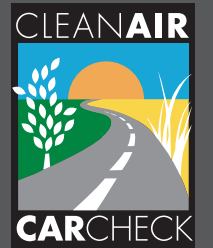


Clean Air Car Check
 Envirotest Systems
 1171 Breuckman Dr.
 Suite B
 Crown Point, IN 46307

Gas analyzer measurements in relation to engine conditions

ENGINE PROBLEM	HC	CO	CO2	O2	NOx
RICH MIXTURE	Moderate Increase	Large Increase	Some Decrease	Some Decrease	Moderate Decrease
LEAN MIXTURE	Moderate Increase	Large Decrease	Some Decrease	Some Increase	Moderate Increase
VERY LEAN MIXTURE	Large Increase	Large Decrease	Some Decrease	Large Increase	Large Increase
IGNITION MISFIRE	Large Increase	Some Decrease	Some Decrease	Moderate Increase	Moderate Decrease
ADVANCED TIMING	Some Increase	No Change or Slight Decrease	No Change	No Change	Large Increase
RETARDED TIMING	Some Decrease	No Change or Slight Increase	No Change	No Change	Large Decrease
VERY RETARDED TIMING	Some Increase	No Change	Moderate Decrease	No Change	Some Increase
LOW COMPRESSION	Moderate Increase	Some Decrease	Some Decrease	Some Increase	Moderate Decrease
EXHAUST LEAK	Some Decrease	Some Decrease	Some Decrease	Some Increase	No Change
WORN CAM LOBES	No Change	Some Decrease	Some Decrease	No Change or Some Decrease	No Change or Some Decrease
GENERAL ENGINE WEAR	Some Increase	Some Increase	Some Decrease	Some Decrease	No Change or Some Decrease
AIR INJECTION FAILURE	Some Increase	Large Increase	Moderate Decrease	Moderate Decrease	No Change
EGR LEAKING	Some Increase	No Change	No Change or Some Decrease	No Change	No Change or Some Decrease
CATALYST INACTIVE	Large Increase	Large Increase	Large Decrease	Large Increase	Large Increase

technicallyspeaking.



SEPTEMBER / OCTOBER 2009

A PUBLICATION FOR THE
 PROFESSIONAL AUTOMOTIVE TECHNICIAN

Exhaust Gases Explained

It can be difficult at times to understand exhaust gases in relation to certain engine conditions. Repairing a condition that lowers emissions of one pollutant can cause an increase in other pollutants. This article explains the exhaust gases, how they are formed, and possible causes of emission test failures.

The combustion cycle

A combustion cycle requires three elements: fuel, oxygen and heat. When one of these three elements is reduced, increased or missing, incomplete combustion will occur resulting in an emissions failure.

Gasoline, as you know, is a hydrocarbon fuel (HC). In a perfect combustion cycle the carbon atoms (C) from the gasoline combine with atmospheric oxygen (O₂) to form carbon dioxide. (C+O₂=CO₂) Likewise, the hydrogen (H) atoms from the gasoline will combine with atmospheric oxygen (O₂) to produce water vapor. (H+O₂=H₂O)

If combustion was perfect, there would be no remaining fuel or oxygen. That is, there is exactly the right amount of oxygen to burn the fuel and exactly the right amount of fuel to consume all the oxygen. The only by-product produced from perfect combustion would be; heat, carbon dioxide (CO₂), and water vapor (H₂O).

Unfortunately, perfect combustion seldom occurs in a gasoline engine. Emission controls are installed on the engine so the air/fuel mixture can be controlled more precisely. Making the control even more difficult is the reality that atmospheric air drawn into the combustion chamber is only about 21% percent oxygen and 78% nitrogen. This establishes the need to control the amount of heat in the combustion chamber to avoid production of Oxides of Nitrogen (NO_x). At the same time, cylinder temperature can be reduced to the point where "quenched" can occur, producing a high HC condition.

>> Continued on the inside

Hydrocarbons (HC)

Hydrocarbons are composed of hydrogen and carbon atoms that exist in varying combinations. Gasoline is a hydrocarbon fuel, so when hydrocarbon (HC) emissions are high, unburned gasoline is being expelled out the tailpipe. Hydrocarbons are an environmental hazard because they combine with other compounds and react with sunlight to cause ground level ozone.

A major misunderstanding with high HC output is that this condition only occurs with a rich fuel mixture. High HC emission output can also occur when the air/fuel mixture is too lean. An air/fuel mixture that is too lean to sustain combustion will cause one or more cylinders to pass unburned fuel into the exhaust system causing an increase in hydrocarbon (HC) emissions. Lean conditions also may cause a simultaneous increase in NOx production when the vehicle is put under a load. On the other hand, technicians will notice a major decrease in CO production due to the availability of oxygen in the combustion cycle.

There is also a cause of an HC failure that is not as common, but needs to be taken into consideration when diagnosing HC failures. The Constant Volume Sampler (CVS) hoses in the test lanes operate with negative pressure or simply stated, a slight vacuum. If there is a leak in the evaporative emissions or fuel system in the vehicle, the CVS hose will draw in the gasoline vapor and fail the vehicle for excessive HC emissions.

Carbon Monoxide (CO)

Carbon Monoxide molecules consist of one atom of carbon and one atom of oxygen. In a case of perfect combustion, one atom of carbon (C) will combine with atmospheric oxygen (O₂) to form carbon dioxide (CO₂). When there is a lack of available oxygen in the combustion chamber, one atom of carbon (C) is combined with one oxygen molecule (O) creating carbon monoxide (CO).

Carbon Monoxide (CO) is produced when there is insufficient oxygen available. When all the oxygen is used up, the burning of the air/fuel mixture is stopped prematurely and CO is created. Carbon Monoxide is a good indicator of a fuel mixture that is too rich, especially if accompanied by a high HC reading. NOx levels are usually low in a rich condition since there isn't enough available oxygen and cylinder temperatures will

drop, a rich condition could easily conceal a high NOx condition.

Since partial combustion is needed to produce CO, a cylinder misfire can most certainly be ruled out. In fact, a slight decrease in CO production may occur while the engine is misfiring. Remember, CO is a very poisonous gas that is colorless and odorless. Caution must be exercised when dealing with vehicles that have failed an emissions test due to high CO.

Common Causes of Emission Failures

(HC) Hydrocarbon failure

- **Ignition System** (Cap, rotor, wires, plugs, secondary KV)
- **Ignition Timing** (Advanced)
- **Vacuum Leaks**
- **Fuel Pressure** (Too high or low)
- **EGR** (Stuck partially open, stem leaks, advanced opening)
- **Engine Mechanical** (Low compression, timing, crankcase pressure)
- **Fuel Injectors** (Leaking or plugged)
- **ECM Inputs** (ECT, MAF, MAP, O₂, etc.)
- **Catalytic Converter** (Oxidation brick)
- **Fuel Vapor Leaks**

(CO) Carbon Monoxide failure

- **Ignition System** (Cap, rotor, wires, plugs, secondary KV)
- **Air Injection System**
- **Vacuum Leaks**
- **Engine Mechanical**
- **Fuel Pressure Regulator** (Ruptured diaphragm)
- **ECM Inputs** (ECT, MAF, MAP, O₂, etc.)
- **Fuel Pressure**
- **PCV System**

(NOx) Oxides of Nitrogen

- **EGR System** (Valve, solenoid, vacuum lines, back pressure)
- **Intake Manifold Gasket**
- **Ignition Timing**
- **Cooling System** (Engine temperature too high)
- **Fuel Trim** (Too lean)
- **Oxygen Sensor** (Indicating Rich Mixture)
- **Intake Valve Carbon Deposits**
- **Catalytic Converter** (Reduction brick)

Oxides of Nitrogen (NOx)

Oxides of nitrogen are gases composed of one nitrogen atom combined with a varying number of oxygen atoms. The "x" in NOx represents the unknown number of oxygen atoms. For example; one nitrogen atom (N) combined with one oxygen atom (O) creates nitrous oxide (NO). Combining one nitrogen atom (N) with two oxygen atoms (O₂) creates nitrous dioxide (NO₂). NOx is an environmental hazard because ultraviolet radiation from the sun acts upon the combination of NOx and hydrocarbons to produce photochemical smog. Smog is a brownish haze that causes severe respiratory problems and the formation of acid rain.

NOx is formed differently than HC or CO. Nitrogen is an inert gas that doesn't easily combine with other gases. It makes up approximately 78% of atmospheric gases and has no role in producing power during the combustion process. Nitrogen gas is just sort of "along for the ride" when introduced through the combustion cycle. NOx formation is entirely dependent on the cylinder combustion temperature. It is formed when combustion temperatures exceed approximately 2500 degrees Fahrenheit. When combustion temperatures reach this level, the nitrogen combines with the oxygen to form the various oxides, with the most common being nitrous oxide (NO).

Carbon Dioxide (CO₂)

Carbon Dioxide is essentially a harmless gas that is created during perfect combustion. The levels of this gas are used as a reference as to how efficient the engine is during combustion. The level of carbon dioxide (CO₂) is directly related to air/fuel ratio and will be at their peak as the mixture reaches stoichiometric. The levels will decrease as the mixture becomes richer or leaner. Carbon dioxide is also produced as the carbon monoxide (CO) is oxidized (O₂ is added) by the catalytic converter.

Oxygen (O₂)

Oxygen content is another gas used in determining combustion efficiency. When air/ fuel mixtures are either rich or lean, the levels of carbon monoxide (CO) and oxygen (O₂) will be opposite of each other. When the engine reaches the stoichiometric air/ fuel ratio, the levels of oxygen and carbon monoxide are just about equal.

For more information contact Steve Popovich, Clean Air Car Check's Diagnostic Technician at 219-661-5456 or steven.popovich@esph.com.

Gas Analyzer Readings for Passing Tests

Listed below are gas analyzer readings that should be typical of a vehicle that will pass an emission test. The emission test facility uses measurements of Grams per Mile (GPM). The test measurements listed below are expressed as Parts per Million (PPM) since most shop analyzers use this scale.

Good Gas Analyzer Readings (PPM)

HC – Less than 100 PPM

CO – Less than 0.5%

CO₂ – between 12% - 15%

O₂ – between 0.3% - 1.3%

NOx – less than 1000 PPM

It is important to note that technicians will not get a NOx reading at idle. NOx is created when the vehicle is under a load. A good test is to put the vehicle in reverse and raise RPM to approximately 1500-2000 to get a NOx reading.

See chart on Page 4 for more gas analyzer information.

REMINDER

Free Tech Night with Al Santini

This four-hour class will address HC and CO failures with case studies on I/M 93 tests. The class will cover fuel control with both O₂S and A/F sensors. Specific fuel problems and compression/ignition problems will be displayed. There will be emphasis on the use of the Digital Storage Oscilloscope and current probe in the diagnosis of fuel and ignition problems.

Wednesday, October 14, 2009

6:00 – 10:00 p.m.

Envirotest Systems Training Room

1171 Breuckman Dr., Suite B (*enter at rear of building, door marked Training Entrance*)

Dinner will be provided. Limited seating. Call 1-888-240-1684 or 219-661-8269 by October 12 to reserve your seat.