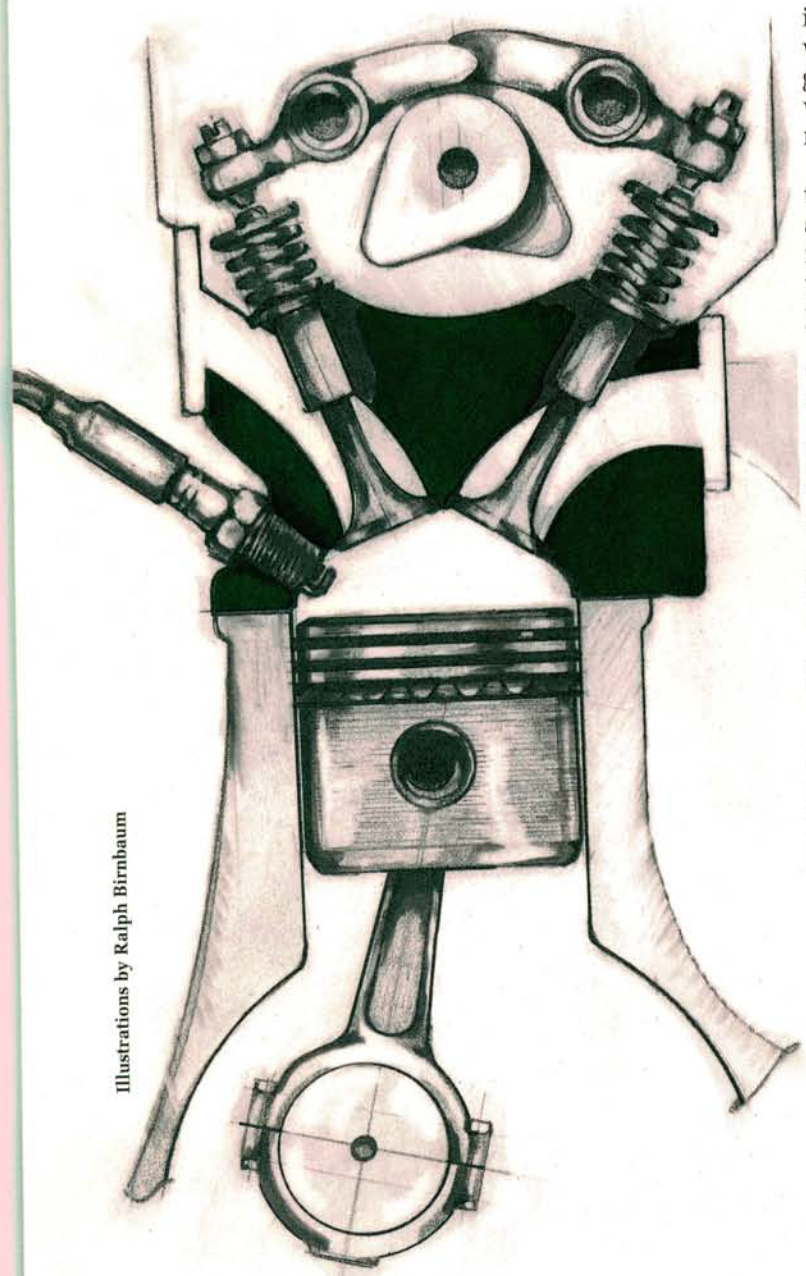
Driveability Clinic

Four Gas Fundamentals

Part One



Illustrations by Ralph Birnbaum

Over the past few months we've been emphasizing the importance of checking the basics as we've worked on several problem cars. If any of us is going to repair emission and driveability problems, we need to start thinking in terms of basic components and how they interact as parts of a system.

One diagnostic tool which enables us to look at the big picture when problems occur is the four gas analyzer. Why? Because the product of combustion is exhaust. And the content of the exhaust gas gets worse when any part of the system stops doing its job properly.

Exhaust gas analysis offers many benefits you won't get from other types of testing. Here are some examples of the benefits of using our super sniffer.

- **Exhaust gas analysis is a dynamic test.** It samples the by-products of combustion in a running engine.
- **Exhaust gas analysis helps speed up troubleshooting.** Each part of the engine, from engine/mechanical to fuel and ignition components, has a definite effect on emissions. And these effects are predictable.

By looking at the relationship between the four gases making up the exhaust, we can zero in on predictable causes for different problems.

- **Exhaust gas analysis lets us measure the success of our repairs and adjustments.** This is a big benefit of exhaust analysis. Since these are dynamic tests, we can watch the analyzer readings after each repair or adjustment to determine whether or not we've fixed a problem. No more guessing about when a car is completely fixed.

This month and next month, **Driveability Clinic** will present a troubleshooting guide highlighting the most common causes and cures for poor tailpipe emissions. We hope it's useful to you.

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Circle No. 145.
OTC Tool and Equipment Division, SPX Corp.
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— By Ralph Birnbaum

Good Combustion

Our first example shows acceptable emission levels in a good running engine. Exhaust gas emission levels for our engine should look like these:

CO_2 is HIGH

Carbon dioxide is produced when carbon and oxygen combine during combustion. CO_2 levels increase with an increase in combustion efficiency.

CO and O_2 are equal

CO is the relationship between air and fuel available for combustion. It is the basic fuel mixture, and tells us if the mixture is rich or lean. When the engine is at stoichiometry, CO and O_2 levels should be almost equal, indicating balanced combustion.

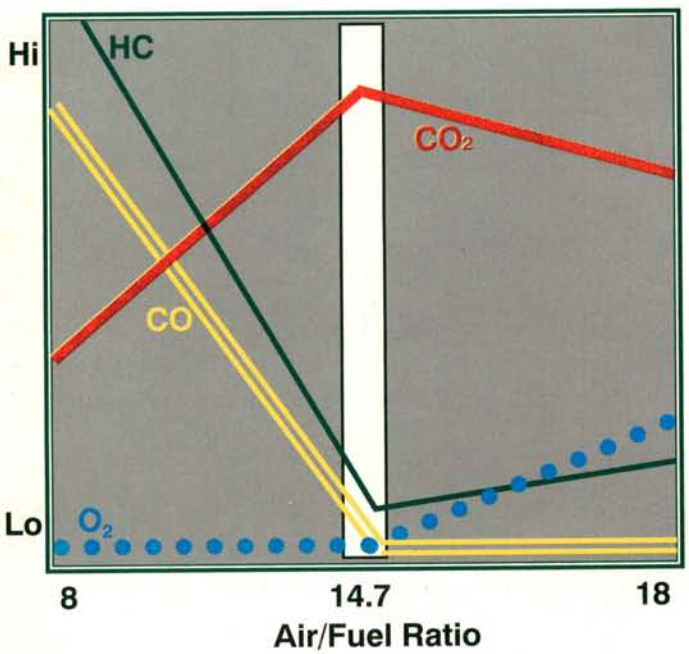
HC is LOW

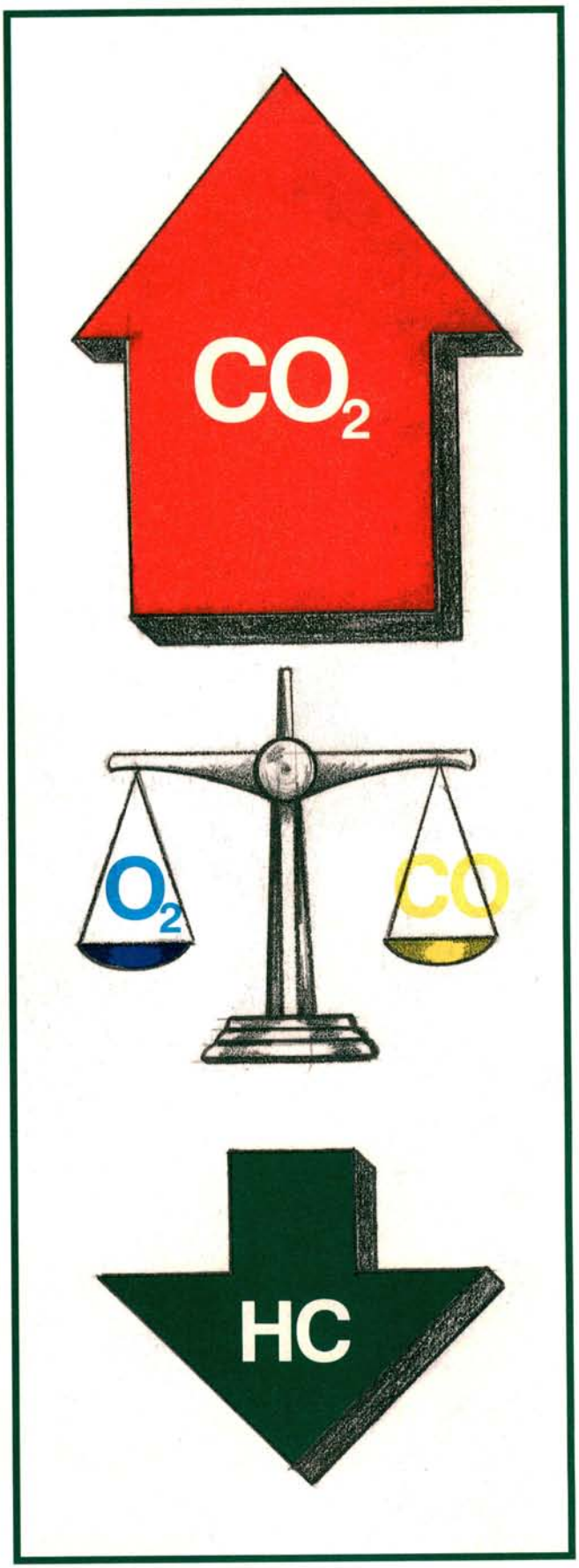
A low HC (Hydrocarbon) level tells us that the fuel/air mixture is being burned efficiently. But be careful, a good catalytic converter can clean up higher than normal levels of HC and CO, masking a problem. So keep your eye on O_2.

This brings us to a definition of stoichiometry.

***Stoichiometry* is the point at which the fuel mixture burns most efficiently. The chart below shows the relationship between each of the four gases being measured.**

The vertical, white bar in the center of the chart represents the stoichiometric range. Please note that HC, CO and O_2 emissions are almost *equal* as we near stoichiometry. At the same time CO_2 emissions *increase*.





High CO

Since CO tells us about the fuel/air ratio, anything which affects that ratio can cause a change in CO. Note that the following causes of High CO all occur before the combustion chamber.

- **High fuel pressure.**
- **A leaking fuel injector, or injectors.**
- **A faulty input to the computer which keeps the injectors open too long.** A bad coolant temperature sensor or a thermostat which sticks open can fool the computer into thinking that the engine is cold. This increases injector ON time, causing an overly rich mixture.
- **A plugged air filter** or other restriction in the air intake that limits the amount of air available for combustion.
- **A sticking choke, or bad choke pull-off.** On carbureted cars, a choke which stays closed too long, or sticks in a partially closed position, will result in increased CO.
- **A high float level, leaking power valve, or leaking accelerator pump check ball.** Once again, these are problems on carbureted cars.
- **A saturated charcoal canister or faulty purge valve.**
- **A fuel-saturated crankcase.** Fuel vapors will be drawn into the intake through the PCV system. Aside from infrequent oil changes, and short-trip driving, any of the preceeding causes for High CO can also cause crankcase contamination.

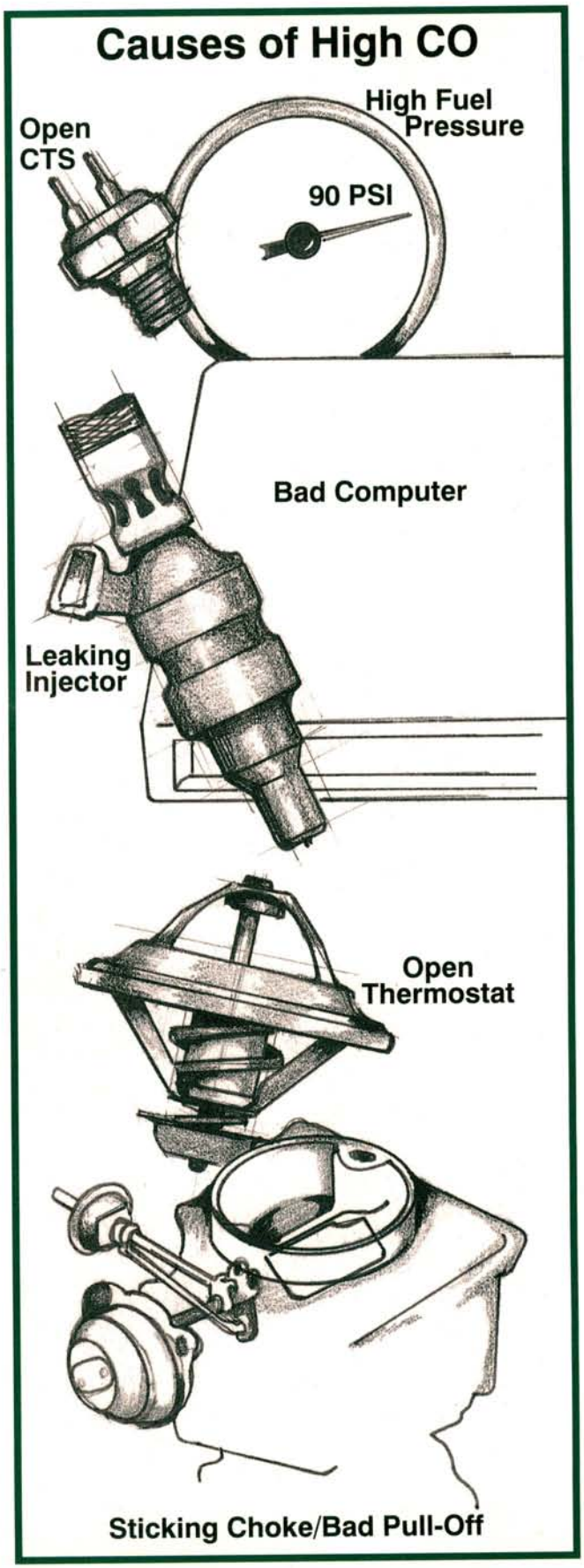
Cautions:

- **Higher than normal CO levels may occur without a corresponding increase in HC.** The engine may be able to burn a slightly richer mixture without an apparent loss in performance. If CO gets too high, however, a miss will result, and HC levels will rise.
- **Catalytic converters mask small problems with the fuel/air mixture, so O_2 becomes a better indicator of a rich condition than CO.** With the exception of a few lean running 1989-93 models, O_2 emissions of 0.5 percent or less will tell you that there isn't enough oxygen available for the amount of fuel being delivered.

Low CO/High O_2

Think LEAN when you think of Low CO. You'll notice that we included a high O_2 reading as part of our analysis of a lean condition. Once again, the efficiency of a good catalytic converter may make it difficult to tell if Low CO readings are the result of lean condition, or of catalytic cleaning.

Here's where four gas really starts to shine as a troubleshooter. Low CO levels at the tailpipe may not be telling you anything about a lean condition. But the extra oxygen left over when a lean mixture



burns will give you an added clue that pre-catalyst CO is too low.

Possible Causes of a Lean Mixture

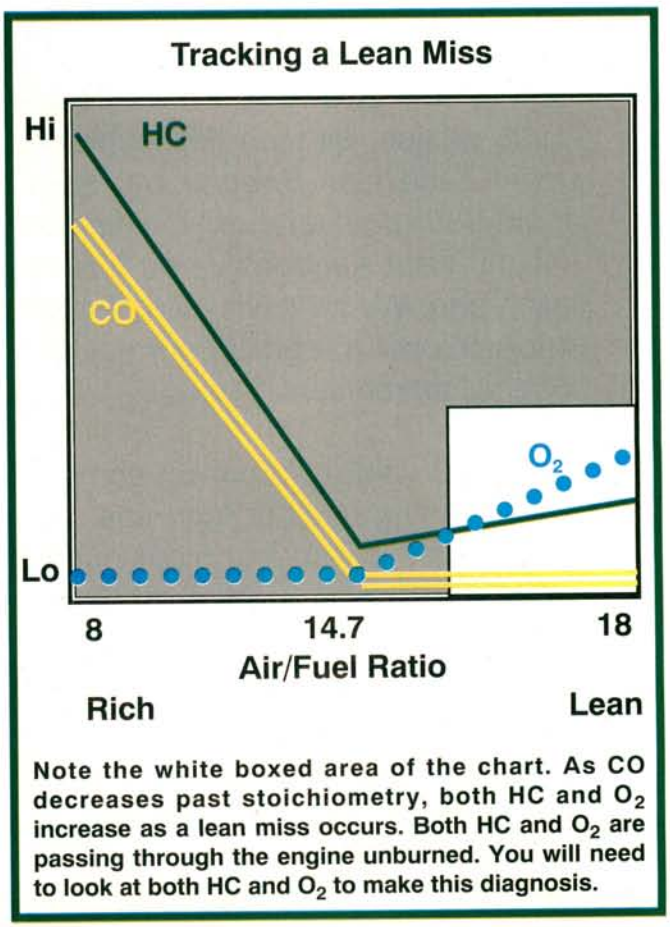
Lean mixtures are caused by too little fuel, too much air, or a combination of the two. Look for the following as causes for Low CO:

- **Low fuel pressure.** Check for a plugged fuel filter, weak fuel pump, or restriction in the fuel inlet hose.
- **Plugged injectors.**
- **Vacuum leaks.**
- **Bad O_2 sensor.**
- **On carbureted cars look for the following:**
  1) low float level,
  2) plugged jets,
  3) a bad altitude compensator,
  4) leaking carburetor base gasket, and,
  5) an improperly adjusted mixture screw.
- **A misfire will also cause High O_2, but in this case, HC levels will rise.**

Cautions:

Since we're using both CO and O_2 to evaluate a lean condition, please observe these exceptions to the presence of High O_2:

- High O_2 accompanied by High HC will indicate a



Note the white boxed area of the chart. As CO decreases past stoichiometry, both HC and O_2 increase as a lean miss occurs. Both HC and O_2 are passing through the engine unburned. You will need to look at both HC and O_2 to make this diagnosis.

mixture so lean that it's causing a lean miss.
• High O_2 can also be caused by an exhaust leak that is drawing air. Make sure the exhaust isn't acting as a downstream pulse air system. This will produce abnormally high O_2 readings at the tailpipe.

High HC

So far we've looked at the balance between fuel and air in the combustion chamber. The fuel/air ratio can vary within certain limits and still not cause a misfire. But when fuel mixtures go to extremes, the results are incomplete combustion and high HC emissions.

Other things can cause incomplete combustion too. In fact, anything that prevents complete combustion will cause an increase in HC.

If all the available hydrocarbons are consumed in the combustion process, HC emissions are zero. No engine is completely efficient, however, so there will be some HC left over, even at stoichiometry. Once again, the catalyst does a good job of cleaning up the remaining unburned hydrocarbons.

But an engine with a serious misfire will send so many hydrocarbons down the pipe, that the catalyst will be unable to clean things up.

Causes of High HC

• **Poor secondary ignition.** These are probably the first things we think of when we troubleshoot a misfire—a bad spark plug, plug wire, cap or rotor, or a weak or cracked ignition coil. Don't forget overadvanced ignition timing.
• **Low compression.** Low or no compression in a cylinder or cylinders will cause a miss. Include worn rings, burned valves, and blown head gaskets.
• **Extremely High CO.** Any of the problems listed in the section under High CO can cause a misfire if the mixture gets too rich to burn.
• **Extremely Low CO.** Any of the problems listed under Low CO can cause a misfire if the mixture gets too lean to burn.
• **A sticking EGR.**

Things That Come with High HC:

• **Lower than normal CO_2.**
• **Higher than normal O_2.**
• **CO may be Low, High, or even normal.**

Two Down, Two To Go

So far, we've concentrated on getting better acquainted with our old friends, HC and CO.

Next month, we'll return to show how O_2 and CO_2 can be used to round out your four gas troubleshooting skills. Y'all come back.