CO Testing for the Real World

Field inspections of gas ranges and laboratory tests provide the basis for a proposed CO emissions testing protocol.

by Rick Karg

Gas ranges are probably the most common unvented gas appliances in use in North America. With homes becoming tighter, the potential for any type of unvented gas appliance to set the stage for carbon monoxide (CO) poisoning is increasing. Ranges and ovens are no exception. Poorly operating ranges and ovens that have closed air shutters, damaged orifices, or warped flame spreaders can emit hazardous levels of CO. CO problems can also arise when equipment users operate a gas range or oven as a space-heating appliance, alter the oven by, for instance, lining the oven bottom with aluminum foil and inadvertently covering the secondary air ports; or misuse the equipment in other ways (see "Educating the Client").

In an effort to develop a field protocol for testing gas ranges, my company, R.J. Karg and Associates, inspected 25 natural gas and propane ranges in randomly selected houses in the Portland and Bar Harbor, Maine, areas. With the help of GARD Analytics, we also conducted three days of laboratory tests. We were dismayed to find during field tests that about half of the ovens gave off more than the threshold level, 800 ppm, of CO. Some of the ovens that failed were fairly new and others were older. No correlation emerged between oven characteristics and high CO emission levels that would have allowed me to predict which ovens would fail and which wouldn't—a fact that emphasizes the importance of regularly conducting safety tests correctly.

The authors of a study by the Gas Research Institute found that "gas range CO and NO_2 emission rates decreased following routine service adjustments." To minimize the risk of CO poisoning, gas ranges should be checked and tuned once every two years by a trained technician with an instrument capable of measuring carbon monoxide to one part per million, and oxygen as a percentage.

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Measuring CO Correctly

One of the most important findings to emerge from our field tests was the realization that, to measure CO levels reliably, a warm-up period is critical (see Figure 1). Ovens require 15 minutes and range top burners require 6 minutes to reach steady state. There is no requirement that oven broil burners be tested, since these are used much less often and for less time than bake ovens or range top burners.

By now most field technicians have used meters to measure CO emissions for furnaces, water heaters, and other combustion appliances. When measuring CO emissions from a vented appliance, the metal probe is inserted into a hole drilled in the metal vent pipe. Measurement of CO emissions from a gas oven is performed using a similar technique. However, rather than inserting the probe into a hole drilled in a vent pipe, the technician inserts it into the oven port that is usually located at the rear of the flat range top. A vacuum pump in the measurement device pulls combustion gases through the metal probe, into the plastic hose and the CO measurement cell, and finally expels the gases through an exhaust port.

I experimented with five ways of testing range top burners. I found that the CO Hot Pot with a bowl inside its stovepipe resulted in the most repeatable measurements (see photo on opposite page). This measuring device is fairly easy to construct. Details on how to build it are available on the Web at www.karg.com/makehotpot.htm.

For our proposed protocol, we decided to adopt the burner emission threshold of 800 ppm specified by the



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Field analyst Jack Hamblen conducts a CO emissions test on a stove top. The CO Hot Pot is covering the burner being tested.

American National Standards Institute (ANSI) standard. Our CO emission thresholds are based on field and laboratory research, as well as on consultation with scientists and air quality experts. As more research is conducted in the areas of combustion emissions from gas ranges and assessment of human health risk factors related to CO, these emission thresholds may change.

The proposed protocol covers residential grade floor-mounted gas ranges, drop-in range top burners, slide in ranges, and built-in ovens only. It is not intended for use with outdoor gas grills; ovens vented into flues or chimneys; or range/ovens with closely located, down-vented, and operable exhaust fans, such as the JENN-AIR down-vented exhaust fan. The protocol is not intended to determine whether gas ranges operate acceptably during misuse—for example when they are used for space heating.

Two Ways to Measure CO

There are two ways of measuring CO: the as-measured method and the air-free method. Most technicians today use the as-measured method. In this method, the CO is measured from a sample of combustion gases without taking into account

Educating the Client

It is very important to educate your clients. Give them a copy of Carbon Monoxide Questions and Answers or other materials on CO poisoning. (For a video and CD instructional resource, see "The Silent Killer," *HE* Nov/Dec '01, p. 46.) Always take the time to explain the following points:

• Never block the holes in the oven bottom with aluminum foil or anything else. These vent holes can also be blocked through storing too much in the drawer under the oven. Blockage of the vent holes can result in dangerously high CO emissions.

• Never use a gas range as a space heater. It is not designed for that purpose.

• Install a CO alarm in the house, following the manufacturer's instructions. Make sure the alarm complies with the current UL Standard 2034.

• Have the gas range checked and tuned once every two years by a technician with an instrument capable of measuring carbon monoxide. Make sure that the technician follows the testing procedure described in this article; tests the gas pressure; and makes any necessary adjustments to ensure that all the burners are operating acceptably. The level of carbon monoxide emissions from a burner can only be determined with an instrument that measures CO and O_2; it cannot be determined by visual inspection of the flames.

• Keep the oven clean at all times. There is evidence that dirty ovens emit more CO than clean ovens.

• Natural gas and propane burners should burn steadily with a clear, blue flame. The flame normally makes a slight hissing sound, but it should not sound like a blowtorch. If the flames burn yellow or burn loud or irregularly, have the gas range serviced as soon as possible. Avoid using a bad burner until it has been properly adjusted or repaired.

the amount of excess air diluting the CO concentrations. Levels of CO in kitchen and home air must be measured this way.

Excess air is the oxygen (O_2) in the combustion gases that exceeds the exact amount needed for perfect combustion. When combustion is perfect, just the right amounts of fuel and O_2 are supplied to the combustion process so that all the oxygen is utilized—no O_2 remains in the combustion gases.

The basic problem with the as-measured method is this: As the amount of excess air increases (think dilution air), the as-measured CO value falls for a given source strength of CO. In other words, the amount of excess air in the sample can significantly influence the as-measured value. Not taking into consideration a high percentage of O_2 can cause the technician to mistakenly think that a hazardous burner is working properly (see Figure 2).

Dilution air for vented appliances is fairly predictable. But the percentage of O_2 in ovens can range from 13% to 20%, because ovens cycle on and off. In a furnace, you have to abort a test for CO emissions if the furnace stops firing. In ovens, the cycle can be as short as 30 seconds. After the oven has reached steady state, you have to take measurements while the burner is operating.

Air-free measurement of CO takes into account the amount of excess air—dilution air—by incorporating an adjustment to the as-measured ppm value, thus simulating air-free (oxygen-free) conditions in the combustion gases. To do this, a reading of O_2 percentage is taken from the combustion gases along with the as-measured CO reading. This can be done with a single meter that measures CO and O_2, or it can be done with two different meters, one measuring CO ppm and one measuring O_2 percentage.

If air-free CO is determined with a single meter, an integral electronic chip calculates the air-free level from the as-measured CO ppm and O_2 percentage. If two meters are used, an equation is used to determine the air-free level of CO in a combustion gas sample.

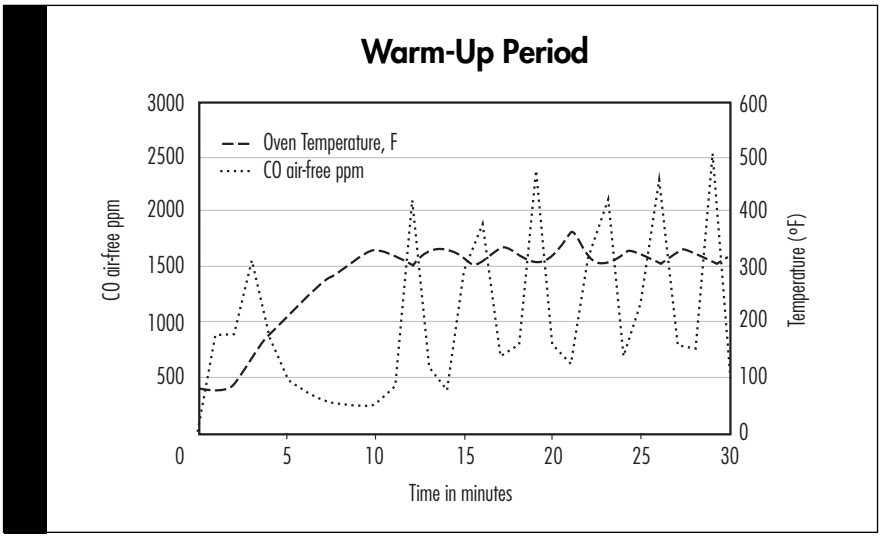


Figure 1. Field tests of ovens showed that a 15-minute warm-up is required before oven burner CO can be measured with reliability. Notice that after 15 minutes, the oven temperature reaches steady state and the CO emissions settle into a regular sawtooth pattern. Range top burners require a 6-minute warm-up before steady-state conditions are reached.

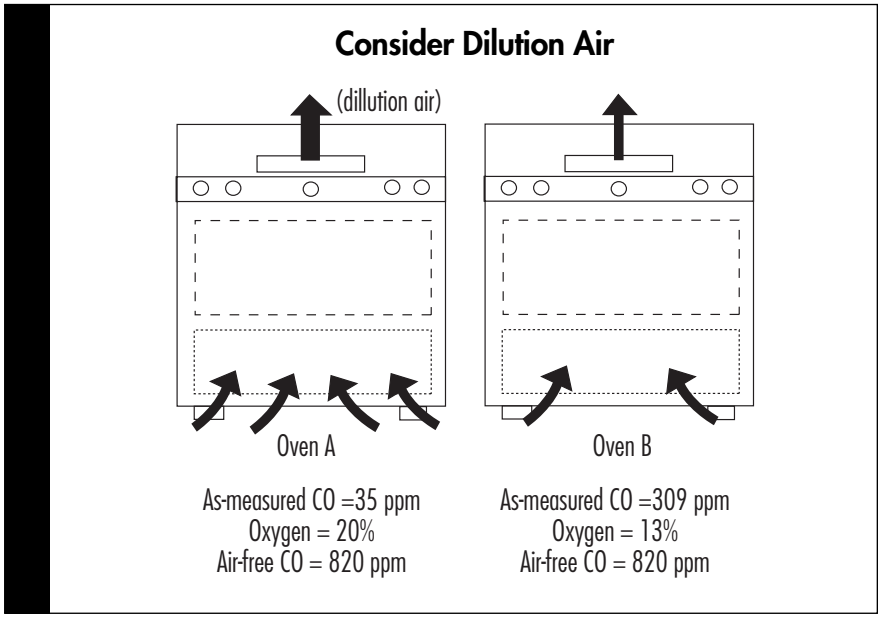


Figure 2. Both of these ovens would fail our proposed protocol, which uses an air-free threshold of 800 ppm. A technician using CO as-measured might pass Oven A and fail Oven B. However, each oven would produce equal CO levels in the kitchen air.

In the Field

The complex nature of combustion and dilution air flow patterns in the field makes it difficult to measure CO emissions accurately. Therefore, the proposed protocol will sometimes result in false failures and false passes. And because there is a broad variety of gas ranges in the field, the technician may encounter problems that are not addressed in the proposed protocol. When this happens, the technician must be experienced enough to be able to judge whether to pass or fail a burner or range.

To complete this entire testing procedure, including allowing each burner time to warm up, takes about an hour. While I feel it is best to complete the entire procedure I understand that devoting this much time may not always be practical. Based on the results of the field test, I think the highest-priority tasks to complete are the general inspection and client education, followed by the oven inspection. Since most of the range top burners tested were not emitting excessive levels of CO, inspecting these burners would be a lower priority. However, it is always best to be thorough.

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For the full text of the proposed gas range testing protocol, see www.karg.com/rangeprotocol.htm.

For the source of the quotation from the study by the Gas Research Institute, see Tikalsky, S., et al. *Gas Range/Oven Emission Impact Analysis*, Gas Research Institute No. 87/0119. Chicago: Gas Research Institute, 1987, p.114.

For more information on air-free measurement of CO emissions, see *Air-Free Measurement of Carbon Monoxide Emissions from Gas Ranges: Analysis and Suggested Field Procedure*. This paper is available at www.karg.com/airfreeCO.htm.

Carbon Monoxide Questions and Answers and other CO safety materials are available through

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