

Proposed Field Protocol for Gas Range Carbon Monoxide Emissions Testing

For the
Chicago Regional Diagnostics Working Group
July 2001
Project Manager
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Survey Objectives

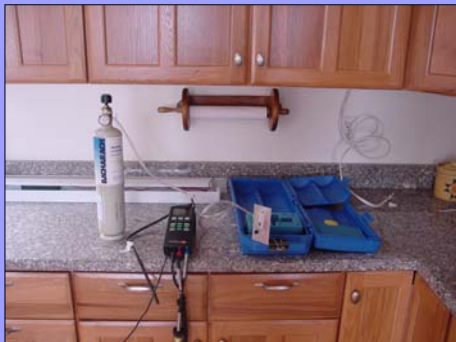
- Write Field Protocol for Gas Range Carbon Monoxide Emissions Testing.
 - Protocol.
 - Range inspection, client education, etc.
 - Range top burners.
 - Best method for measuring.
 - Oven burners.
 - Best method for measuring.
 - Allowable burner emission levels.

Survey Methods

- Review literature.
- Test 25 ranges in field.
- Test range top burner devices in lab. chamber.
- Analyze test data.
- Draft protocol for review by resource people.
- Final protocol.

Field Testing

- Five tests on Right Front burner, 10 and 5 min.
- One test on LF, RR, and LR burners, 5 min. each.
- Oven bake burner test, 30 minute.
- Tests with data logger at 15 second frequency.
- Room levels of CO monitored and recorded.



Calibration Check



Field Test Setup

Range Burner Test



Instrument Station



Instrument used for
primary testing:
Testo 300xl

Open Flame



Open Kettle



CO Hot Pot, model 0



CO Hot Pot, model 1

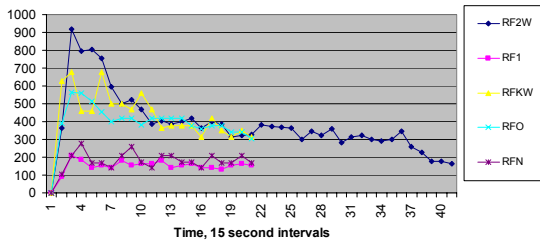


CO Hot Pot, model 2



Right Front Burner Tests

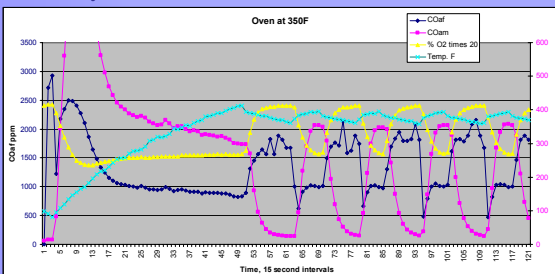
Various Methods on Right Front Burner, COaf ppm



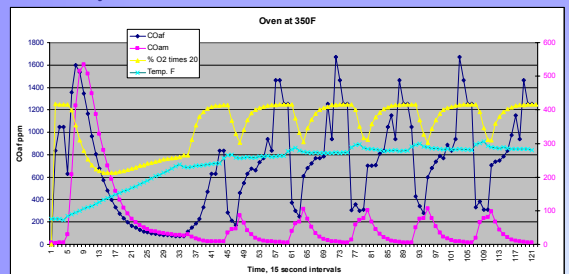
Oven Bake Burner Test



Typical Oven Bake Burner Cycles



Typical Oven Bake Burner Cycles



Carbon Monoxide from Combustion

- “In all combustion sources of CO
 1. the ratio of carbonaceous fuel to oxygen is either too high to permit the complete formation of CO₂, or
 2. the temperature is too low to permit oxidation to occur.””

Source: *An Introduction to Air Chemistry*, Samuel Butcher and Robert Charlson, Academic Press, 1972, pp. 139 - 140

Carbon Monoxide from Combustion

- “In all combustion sources of CO
 1. the ratio of carbonaceous fuel to oxygen is either too high to permit the complete formation of CO₂. . .” **Caused by**
 - a. Too much fuel for amount of oxygen
 - b. Not enough oxygen for amount of fuel
 - 1) Improper air adjustment
 - 2) Wrong fuel for setup (LP for natural gas setup)
 - 3) Dirty or improperly aligned burners”

Carbon Monoxide from Combustion

- “In all combustion sources of CO. . .
 2. the temperature is too low to permit oxidation to occur.” **Caused by**
 - a. Quenching by impingement
 - 1) Pots and pans, no grate, improper grate spacing
 - b. Quenching by too much airflow
 - 1) Strong draft, air blowing across burner”

Laboratory/Chamber Testing Objectives

- Objective: Which of 5 range top test devices. . .
 - Show best repeatability?
 - Show best relationship between device and ambient CO readings?
 - What is minimum warm-up time for burner and test device?

Laboratory/Chamber Testing Method

- Five tests one top burner repeated three times.
- Each test 30 minutes, with 15 minute decay and 15 minute chamber purge.
 - CO, O₂, and CO₂ readings taken at range top burner test device and chamber ambient.

Emissions Laboratory, Chicago



Laboratory Guru, Ed Krug



Emissions Testing Equipment



Emissions Chamber



Range Burner on High for Tests



Open Flame



Open Kettle



CO Hot Pot, model 0



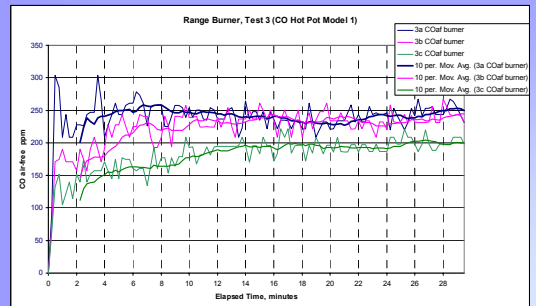
CO Hot Pot, model 1



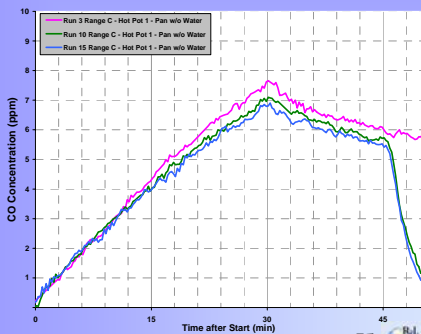
CO Hot Pot, model 2



Sample Chamber Burner Results



Sample Chamber Ambient Results



Begin Tangent

$CO_{as-measured}$ vs. $CO_{air-free}$

- Protocol calls for both.
- $CO_{as-measured}$ is percentage or concentration.
- $CO_{air-free}$ is emission rate, adjusted (normalized) for zero excess-air conditions.
- Indoor ambient air CO must always be measured and read as-measured.

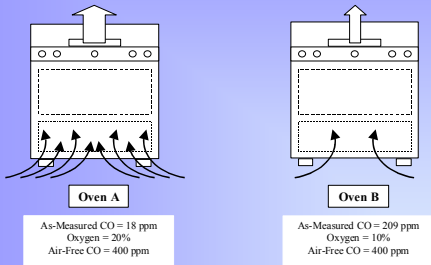
CO_{as-measured}

- Measured as percentage or ppm: 0.08% = 800ppm
- Measured with, e.g., Monoxor II or Testo 325.
- Diluted to varying degrees by excess air.
- Not a rate of emission, but a concentration.
- Protocol requires for measuring range top burners.
- Indoor ambient air CO must always be measured and read as-measured.

CO_{air-free}

- Diluted CO_{as-measured} sample is adjusted to simulate oxygen-free (air-free) conditions, that is, conditions with zero excess air.
- This normalized CO_{air-free} reading is still expressed as a ppm value, but it is actually an emission rate.
- Protocol requires for measuring emissions from oven bake burners.
- Read with, e.g., Testo 300 or Bacharach PCA.

CO_{as-measured} vs. CO_{air-free}



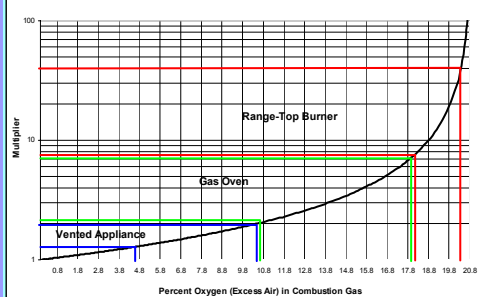
From CO_{as-measured} to CO_{air-free}

$$CO_{air-free} = \left(\frac{20.9}{20.9 - O_2} \right) \times CO_{ppm} \quad \text{Natural gas \& propane}$$

$$CO_{air-free} = \left(\frac{12.2}{CO_2} \right) \times CO_{ppm} \quad \text{Natural gas}$$

$$CO_{air-free} = \left(\frac{14}{CO_2} \right) \times CO_{ppm} \quad \text{Propane}$$

CO_{ppm} to CO_{air-free} Multiplier Ranges



Proposed Gas Range Protocol

- Inspection
- Client education
- Range top burner testing
- Oven bake burner testing
- Closure of test procedure

The Proposed Gas Range Protocol

- Based on ANSI Standard Z21.1 for manufacturers.
- Covers residential floor-mounted ranges, drop-in range tops, and built-in ovens.
- Phase 1: Inspection and client education.
- Phase 2: Instrumented testing of range top burners and oven bake burners.

The Protocol Does Not Cover

- Misuse of gas ranges, for example, for space heating.
- These cooking appliances:
 - Outdoor gas grilles;
 - Ovens in catalytic cleaning mode;
 - Vented ovens; and
 - Range/ovens with closely located, down-vented, and operating exhaust fans, e.g., JennAir units.
- Oven broil burners.

Tools for Protocol

- Timing device.
- Combustible gas leak detector.
- **CO Hot Pot, model 1.**
- Emissions measurement instrument.
- Optional thermometer.
- Flashlight.
- Inspection mirror.
- Calculator for determining $CO_{air-free}$.
- Oven mitten.

Phase 1: Inspection

1. Range top inspection (pg. 2 of protocol)
2. Oven area inspection (pg. 2-3)
3. Code compliance (pg. 3)
4. Verify gas set up/gas supply match (pg. 3-4)
5. Check flexible connector (pg. 4)
6. Check for gas leaks (pg. 4)
7. Pass/fail, analyst use discretion if problem outside scope of protocol (pg.4)

Phase 1: Client Education

1. Oven bottom vent hole blockage (pg. 4 of protocol)
2. Don't use range as space heater (pg. 4)
3. Install CO alarm in house (pg. 4)
4. Have range checked & tuned every 2 years (pg. 5)
 - a. Use protocol.
 - b. Test gas pressure.
 - c. Make necessary adjustments.
5. Keep oven clean at all times (pg. 5)
6. Client flame awareness (pg. 5)

Phase 2: Measurement of Emissions

- A. Safety During the Test Period (pg. 5 of protocol)
 - B. Emission Testing Equipment (pg. 5)
 - C. Preparation for Burner Testing (pg. 6)
 - D. Range Top Burner Testing (pg. 6-7)
 - E. Oven Bake Burner Testing (pg. 7-8)
 - F. Burner or Range Failure (pg. 8-9)
 - G. Closure of Test Procedure (pg. 9)
- Tools Required for Protocol (pg. 9)

Range Top Burner Testing

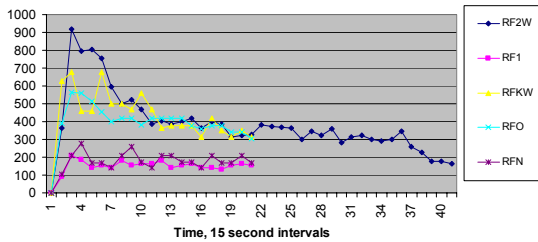


Phase 2: D. Range Top Burner Testing

- Test before oven.
- Use CO Hot Pot, model 1.
- Turn burner to highest setting.
- Take $CO_{as-measured}$ reading after 6 min. warm up (or before if CO emissions have stabilized).
- Average high/low readings for two minutes (if hovering around 35 ppm).
- Average must be CO ppm of 35 or less (this equates to a source strength of $CO_{air-free}$ of 800 ppm).

Range Burner Testing

Various Methods on Right Front Burner, COaf ppm



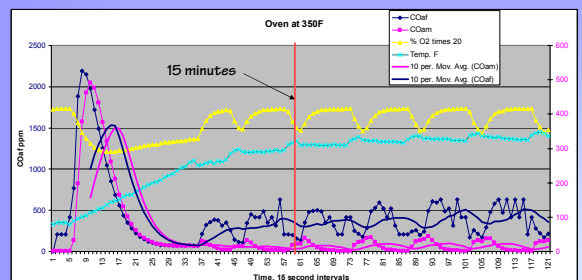
Oven Bake Burner Testing



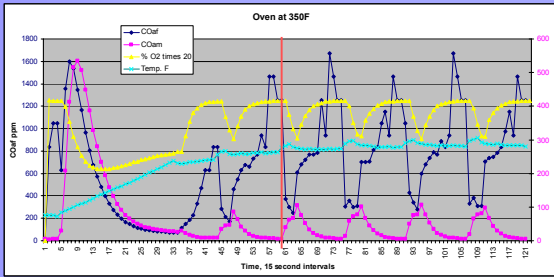
Phase 2: E. Oven Bake Burner Testing

- Visually inspect oven.
- Oven on and set to 350°F.
- Warm-up time of 15 minutes.
- Record min. & next max. $CO_{as-measured}$ after warm-up.
- Average corresponding min. & max. $CO_{air-free}$.
- Averaged $CO_{air-free}$ must be 800 ppm or less.

Low-Emission Oven



High-Emission Oven



G. Closure of Test Procedure

1. Pack up equipment and remove from house.
2. Return range to condition in which found, unless this will create unacceptable situation, for example, foil on bottom of oven.

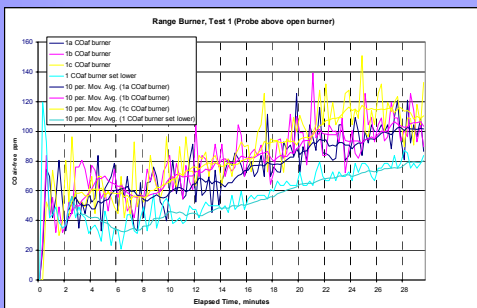
Ranking Protocol Sections:
 Best to do it all, but if you can't,
 here is the most-to-least important

1. Visual inspection and client education.
2. Instrumented oven testing.
3. Instrumented range top burner testing.

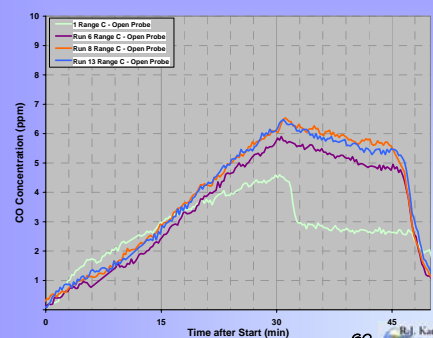
CO Hot Pot, model 1



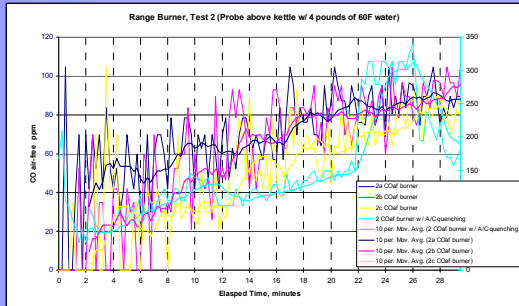
Open Flame, Chamber Burner Results



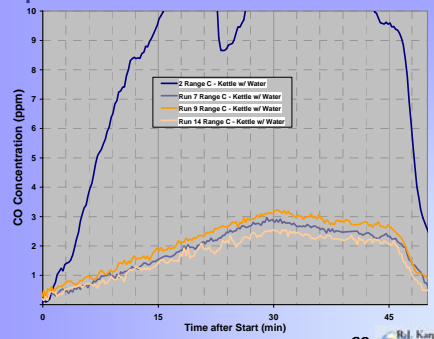
Open Flame, Chamber Ambient CO



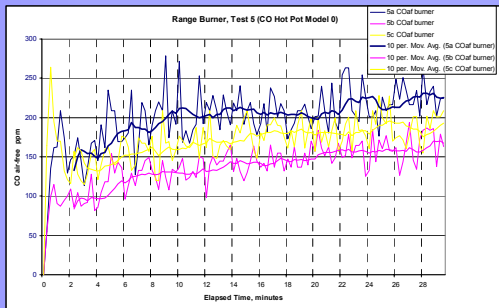
Open Kettle, Chamber Burner Results



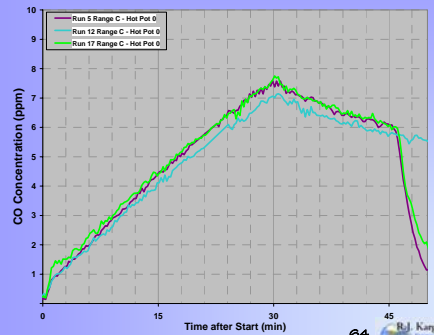
Open Kettle, Chamber Ambient CO



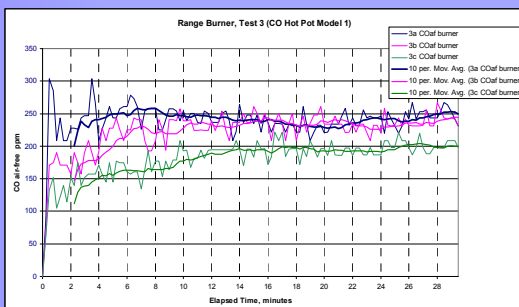
Hot Pot O, Chamber Burner Results



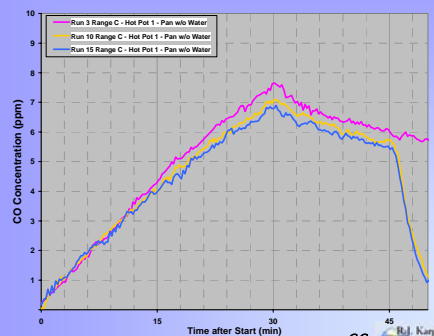
Hot Pot O, Chamber Ambient CO



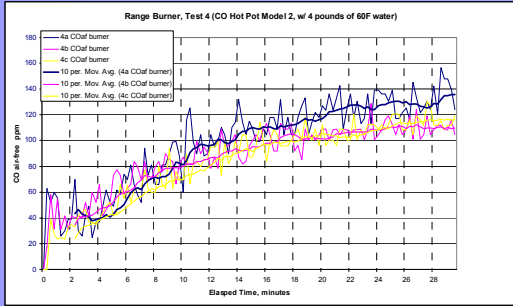
Hot Pot 1, Chamber Burner Results



Hot Pot 1, Chamber Ambient CO



Hot Pot 2, Chamber Burner Results



Hot Pot 2, Chamber Ambient CO

