

# Residential Gas Ranges

Overview of Types  
How Carbon Monoxide is Emitted  
How They Operate

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Residential Gas Ranges:  
Types, Combustion Basics, and Operation

# Overview of Gas Range Types

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Residential Gas Ranges:  
Types, Combustion Basics, and Operation

Standing-pilot range



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Residential Gas Ranges:  
Types, Combustion Basics, and Operation

Drop-in Range with sealed burners



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Drop-in Range with sealed burners (GE)



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Older range with vented oven and side heater



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Enclosed Controls  
make adjustment  
more difficult

### Enclosed Controls



Old Tappan Range

Sealed burners, convection oven



Gas convection oven



Convection fan

Oven bake burner

Gas convection oven



Convection fan

Oven bake burner

Residential Gas Ranges:  
Types, Combustion Basics, and Operation



High-end range with sealed range top burners, radiant broil burner, and convection oven.

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Types, Combustion Basics, and Operation



Radiant broiler burner, convection oven

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Types, Combustion Basics, and Operation



Infrared grill

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Infrared grill burner mesh

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JENN-AIR range, gas burners

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Types, Combustion Basics, and Operation



JENN-AIR range top burner

JENN-AIR electric convection oven



Kitchen Aide free-standing range, sealed burners



Kitchen Aide slide-in range, sealed burners



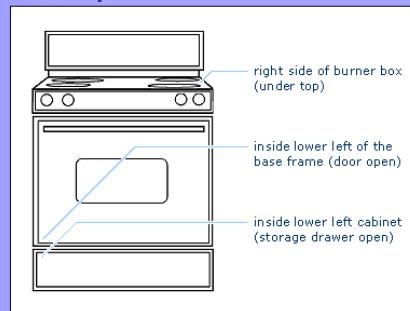
AGA cook stove (English)



Heartland gas range  
Sealed top burners with electric convection oven



### Typical Label Locations



# How Carbon Monoxide is Emitted from Ranges

## 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 CO<sub>2</sub>, 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

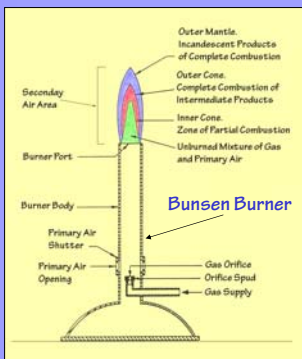
## Carbon Monoxide from Combustion

- "In all combustion sources of CO
  1. the ratio of carbonaceous fuel to oxygen is either too high to permit the complete formation of CO<sub>2</sub>..." **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 nat. gas setup)
      - 3) Dirty or improperly aligned burners

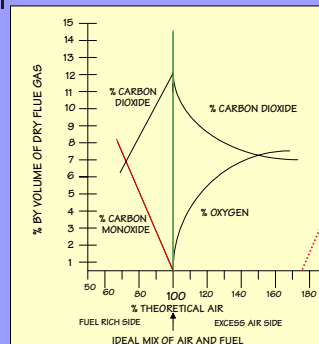
## Carbon Monoxide from Combustion

- "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

## Gas Flame Analysis



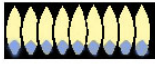
## Theoretical Combustion Air Curves



Actual percentage values vary for fuel being measured

## Quality of Flames

The combustion quality of burner flames can be initially determined visually



(A) Yellow Flames --  
Adjustment required



(B) Yellow Tips on  
Outer Cones --  
Normal for propane



(C) Soft Blue Flames --  
Normal for Nat. Gas

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## Gas Range CO Problems/Solutions

- **Gas Pressure**
  - Make sure pressure is set for 3" to 5" W.C. for natural gas or 9" to 11" for propane. If conversion from natural gas to propane was done improperly, CO is a likely by-product.

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## Gas Range CO Problems/Solutions

- **Orifice Size**
  - Dirty, damaged, or improperly sized orifice can result in CO.
    - Clean dirty orifices.
    - Replace damaged orifices (over tightening an adjustable orifice can damage it by distorting the shape of the needle).
    - Replace orifices that are sized incorrectly.

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## Gas Range CO Problems/Solutions

- **Primary-Air Shutter Adjustment**
  - If it is open or closed too far, CO can result.
  - To adjust, open all the way, then slowly close until you see a well-defined blue flame that stays just above the burner ports.

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## Gas Range CO Problems/Solutions

- **Secondary-Air Supply**
  - Make sure nothing is restricting secondary airflow to the burners. This is more likely to occur with oven bake burners than with range top burners.

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## Gas Range CO Problems/Solutions

- **Burner Air Tube Condition**
  - Dirty air tubes can block or misdirect air-gas flow.
  - Check and clean all burner air tubes.

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## Gas Range CO Problems/Solutions

- **Gas Injection into Air Tube**
  - Orifice must inject air-gas mixture straight into the burner mixing tube. If the gas is injected at an angle, the amount of primary air will be reduced (less negative pressure) and CO will result.

## Gas Range CO Problems/Solutions

- **Burner Ports**
  - Clogged or dirty burner ports can result in CO.
    - Clean each dirty port. Ream if necessary.

## Gas Range CO Problems/Solutions

- **Over-Gassed Burners**
  - If flame appears to be too large or noisy, reduce the gas flow to the burner by
    - Restricting the adjustable orifice.
    - Reducing the gas pressure (propane to natural gas conversion).
  - In gas oven, over gassed burner might extend flames beyond the edges of the flame spreader.
    - If this has happened, check for warped flame spreader plates.

## Gas Range CO Problems/Solutions

- **Oven Flame Spreader Plate Warpage**
  - A warped spreader plate can increase CO emissions. If warped, replace.

# Introduction to Gas Range Operation

Standing-pilot range



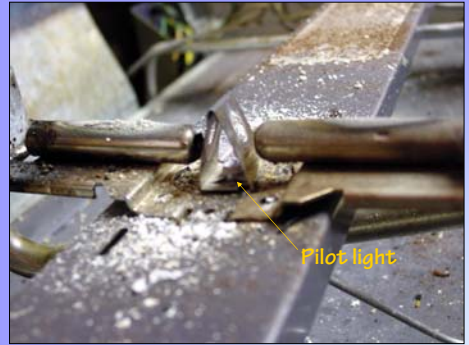
Residential Gas Ranges:  
Types, Combustion Basics, and Operation

Accessible top burners



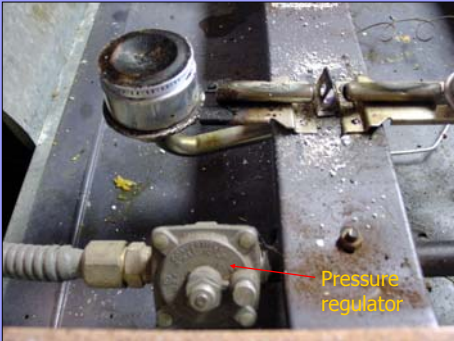
Residential Gas Ranges:  
Types, Combustion Basics, and Operation

Standing pilot



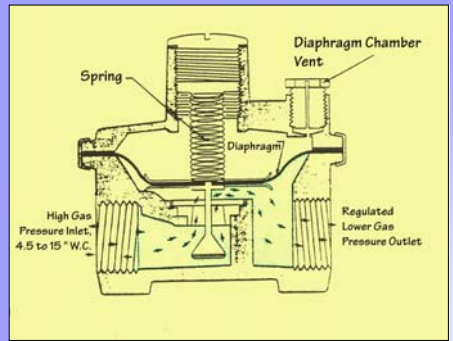
Residential Gas Ranges:  
Types, Combustion Basics, and Operation

Pressure regulator & burner



Residential Gas Ranges:  
Types, Combustion Basics, and Operation

Pressure regulator



Residential Gas Ranges:  
Types, Combustion Basics, and Operation

Burner removal

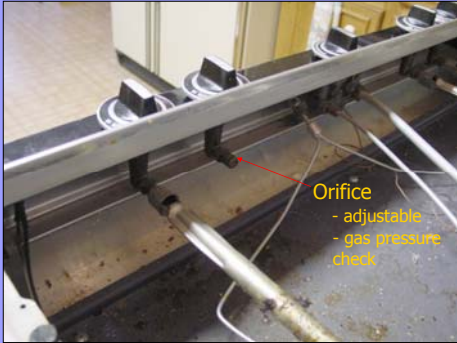


Residential Gas Ranges:  
Types, Combustion Basics, and Operation

Burner removed





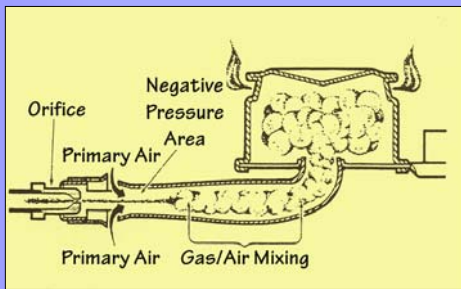


Adjustable orifice

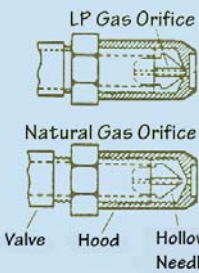
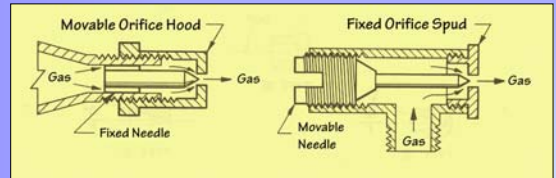


Adjustable orifice

### Range Top Burner Schematic



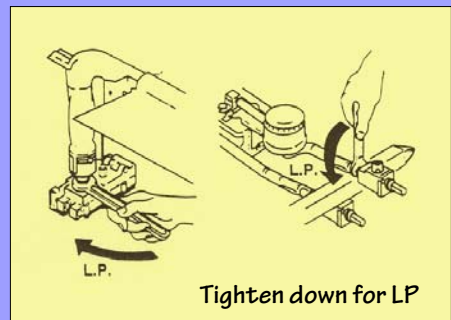
### Adjustable Orifices



Orifice Hood  
Screwed Down  
for LP Gas

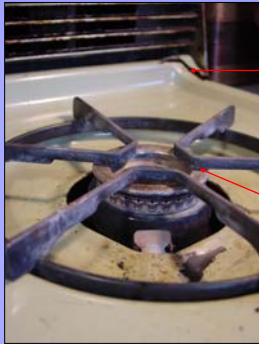
Orifice Hood  
set for  
Natural Gas

Adjustable orifice



Orifice adjustment

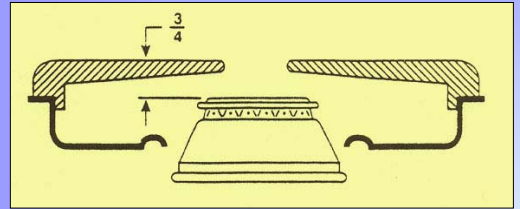
Burner grate gone bad



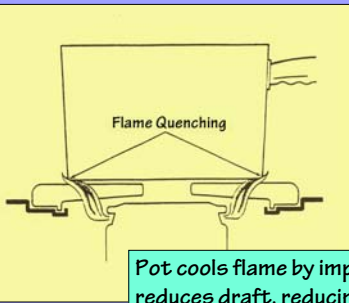
Cracked range top

Zero-clearance grate

### Surface Burner Grate Height



Flame Quenching



Pot cools flame by impingement, but reduces draft, reducing quenching by airflow. Effect on CO...?

Oven with vent outlet



Oven vent outlet

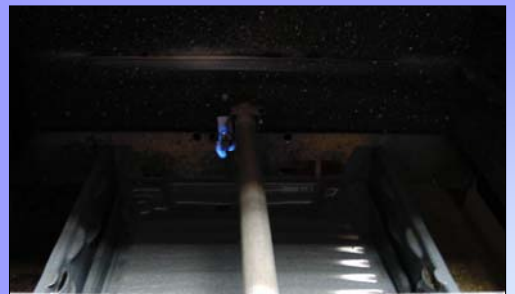
Oven bottom vents

Oven burner w/o oven bottom



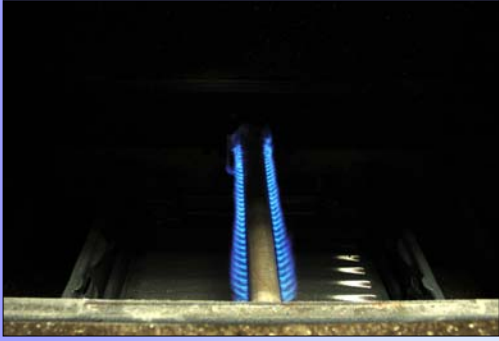
Oven pilot

Oven burner lighting



Residential Gas Ranges:  
Types, Combustion Basics, and Operation

Oven burner lit



Residential Gas Ranges:  
Types, Combustion Basics, and Operation

Oven burner & bottom



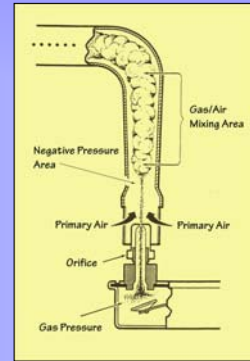
Residential Gas Ranges:  
Types, Combustion Basics, and Operation

Oven burner from below



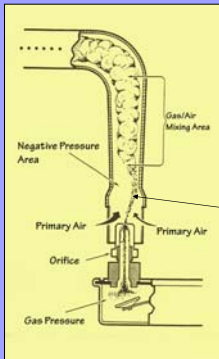
Residential Gas Ranges:  
Types, Combustion Basics, and Operation

Oven burner schematic



Residential Gas Ranges:  
Types, Combustion Basics, and Operation

Oven burner schematic



**Problem...**

Skewed gas flow due to over tightening of adjustable orifice

Residential Gas Ranges:  
Types, Combustion Basics, and Operation

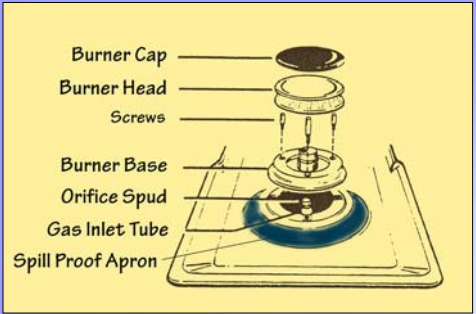
Sealed burner range



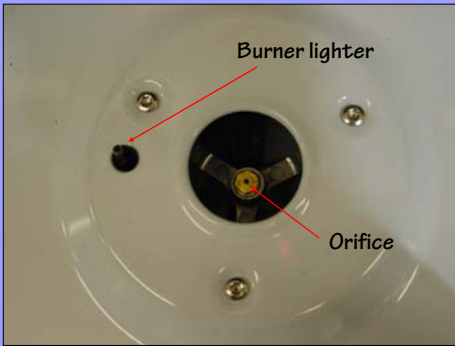
Sealed burners



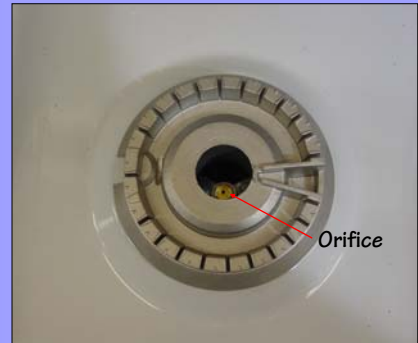
### Sealed, Spill Proof Burner



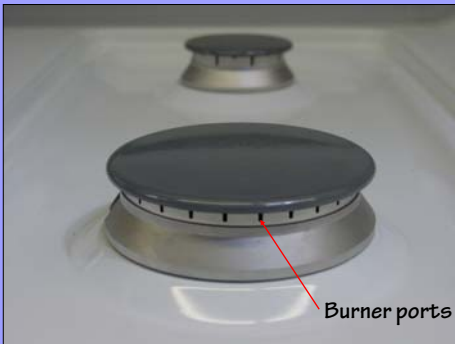
Sealed burner orifice



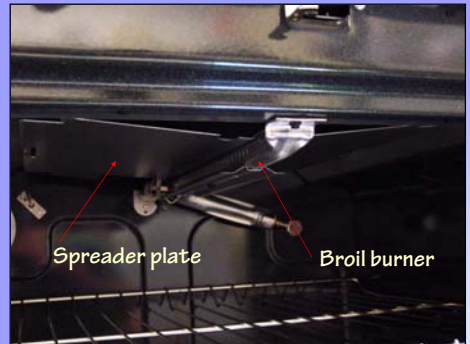
Sealed burner



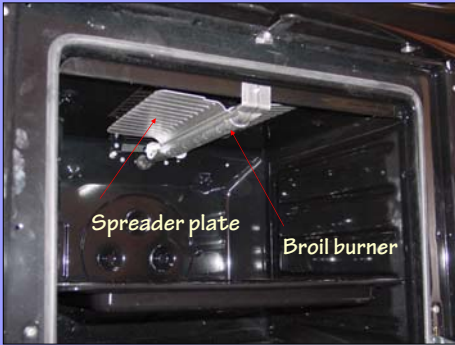
Sealed burners assembled



Two-burner oven, broil burner



Oven broil burner



## Two Methods of Measuring Carbon Monoxide: As-Measured & Air-Free

### Combustion Air

- Primary Air
  - Air mixed with fuel before combustion.
- Secondary Air
  - Additional air required for combustion during combustion process.
- Excess Air
  - Air (oxygen) in excess of ideal amount.

### Properties of Gases

	Natural	Propane	Butane
Symbol	CH <sub>4</sub>	C <sub>3</sub> H <sub>8</sub>	C <sub>4</sub> H <sub>10</sub>
L.E.L	5%	2.4%	1.5%
U.E.L	15%	9.8%	7.3%
Btu/cf	1024	2500	3200
Specific Gravity	0.64	1.52	2.0
Ignition Temp. °F	1170	900	825

### CO<sub>as-measured</sub> vs. CO<sub>air-free</sub>

- Range protocol calls for both.
- CO<sub>as-measured</sub> is percentage or concentration.
- CO<sub>air-free</sub> is emission rate, adjusted (normalized) for zero excess-air conditions.
- Indoor ambient air CO must always be read as-measured.

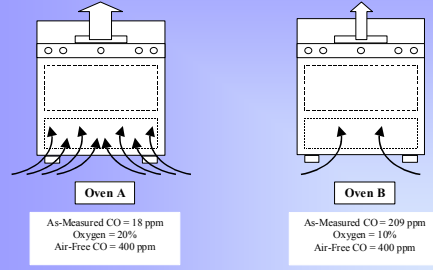
### CO<sub>as-measured</sub>

- 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 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 (excess oxygen).
- This normalized  $CO_{air-free}$  reading is still expressed as a ppm value, but it is actually an emission rate.
- Range protocol requires for measuring emissions from oven bake burners.
- Read with, e.g., Testo 300 or Bacharach PCA.

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

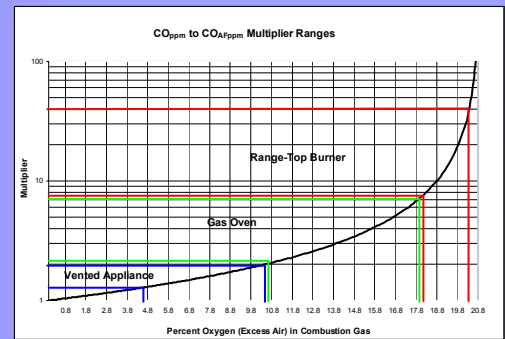


### From $CO_{as-measured}$ to $CO_{air-free}$

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

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

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



# And Finally ...

## ANSI Standards for CO

- Household Cooking Gas Appliances (Z21.1)
  - 800 ppm air-free after all burners operate for five minutes (range top burners have 5 pounds of water on each).
- Storage Water Heaters, 75,000 Btuh or less (Z21.10.1).
  - 400 ppm air-free for natural and induced draft and for power burners.
- Unvented Room Heaters (Z21.11.2).
  - 200 ppm air-free.
- Gas-Fired Low-Pressure Steam and Hot Water Boilers (Z21.13).
  - 400 ppm air-free.
- Gas-Fired Central Furnaces, except Direct-Vent (Z21.47).
  - 400 ppm air-free "with outlet of drafthood blocked"
- Decorative Gas Appliances for Installation in Solid-Fuel Burning Fireplaces (Z21.60).
  - 25 ppm as-measured or 400 ppm air-free.

## Equipment Needed for Testing and Adjusting Gas Ranges

- Digital CO/Oxygen combustion analyzer
- Combustion gas detector
- CO Hot Pot™
- U-Tube manometer
- Various hand tools
- Calculator
- Gas Match™ or other lighting device
- Vacuum cleaner
- Brushes and rags
- Flashlight

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## Minimizing Analysts Liability

- Calibrate equipment according to manufacturer's specs., usually every six months.
- Receive proper training.
- Record findings on each job.
- Install or recommend UL-approved CO alarm.
- Administer regimented client education.
  - CO alarm use and maintenance.
  - Don't use range as space heater.

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