Variation of Carbon Monoxide Measurements from Two Propane Range-Top Burners

The tables and graphs below show the results of range-top burner tests for two burners fired with propane, each having a firing rate of 10,000 Btu per hour. For each of the two burners, four different test methods were used. The test methods were:

A. CO Hot Pot[1] placed on the burner. At the beginning of the test, five pounds of water at 60^{O}F was placed in the stainless steel tea pot in the Hot Pot. The intake end of the CO/O_2 instrument[2] probe was placed at the center of the CO Hot Pot about eight inches above the burner (three inches above the top of the tea pot containing water).
B. CO Hot Pot placed on burner, but no water in stainless steel tea pot.
C. Probe of instrument used to measure carbon monoxide and oxygen was placed eight inches above the burner at its projected center. The CO Hot Pot was not used.
D. A stand-alone aluminum tea pot was filled with five pounds of 60^{O}F water at the start of the test. The probe of instrument used to measure carbon monoxide and oxygen was placed eight inches above the burner at its projected center. The CO Hot Pot was not used.

For each of the four test methods described above, three readings are listed in the two tables:
1. COppm, which is carbon monoxide as-measured (without regard for oxygen percentage) in parts per million (ppm).
2. Oxygen percentage in the combustion exhaust gases. The atmospheric percentage is 20.9.
3. COafree, which is carbon monoxide air-free (the as-measured sample adjusted to simulate zero percentage oxygen). The equation is used for this adjustment is:

$$CO_{AFppm} = \left(\frac{20.9}{20.9 - O_2}\right) \times CO_{ppm}$$

Where: CO_{AFppm} = Carbon monoxide, air-free ppm.
CO_{ppm} = As-measured combustion gas carbon monoxide ppm.
O_2 = Percentage of oxygen in combustion gas, as a percentage.

This sample of two range-top burners is certainly not large enough to allow prediction of the levels of CO emissions from range-top burners. However, two conclusions can be drawn:

- The method used to measure the CO emissions is important. The results show great variation among the four measurement methods used. For field testing, it is probably best to closely simulate the normal every day use of the burners. Method A is the closest simulation.
- There can be a significant difference between as-measured ppm values and air-free ppm values, due primarily to the high percentage of oxygen in the combustion exhaust gas. Because air-free measurement gives a better idea of the CO source strength, it is recommended that air-free measurement be used.

[1] The CO Hot Pot has a stainless steel tea pot inside of an 8 inch diameter galvanized stovepipe that is twelve inches in height. The diameter of the tea pot is about 6 ½ inches, leaving ¾ of an inch of space between the inside of the stove pipe and the outside of the tea pot through which combustion gases from the burner are able to flow. Four inches from the top of the stove pipe is a probe holding device for the probe of a carbon monoxide and oxygen measurement device.

[2] A Bacharach PCA 25 was used for this testing.

Test Results for Burner 1

Notice that emission samples were taken every 30 seconds. Five minutes is highlighted because it is the time at which gas range manufacturers are instructed to take an emissions sample according to ANSI Standard Z21.1, 1993, *Household Cooking Gas Appliances.*

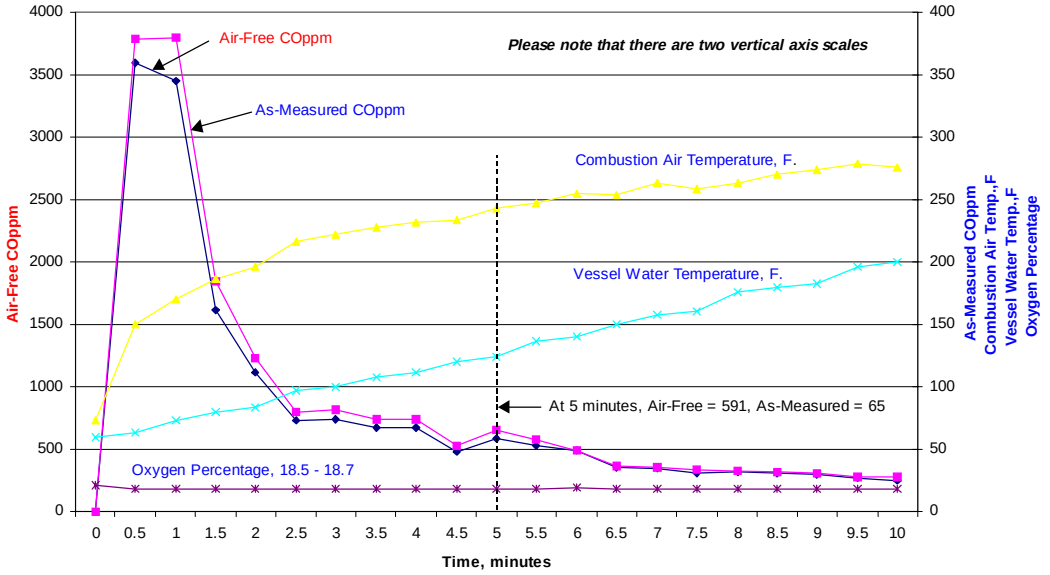
Range Testing Results, Burner 1

Burner No. 1 10,000 Btuh	SS CO Hot Pot 5 pounds of water			SS CO Hot Pot No water			No CO Hot Pot, No Kettle Probe 8 inches above burner			Separate Kettle 5 pounds of water		
Elapsed Time	COppm	Oxygen	COafree	COppm	Oxygen	COafree	COppm	Oxygen	COafree	COppm	Oxygen	COafree
0	0	20.9		0	20.9		0	20.9		0	20.9	
0.5	379	18.7	3601	127	18.8	1264	20	20.2	597	66	19.9	1379
1	380	18.6	3453	126	19.1	1463	10	20	232	71	20.1	1855
1.5	185	18.5	1611	85	19	935	5	20.1	131	57	20.3	1986
2	123	18.6	1118	69	18.9	721	4	20.3	139	36	20.3	1254
2.5	80	18.6	727	49	19.1	569	4	20.1	105	23	20.4	961
3	82	18.6	745	41	19.2	504	4	20	93	15	20.4	627
3.5	74	18.6	672	36	19.2	443	4	19.9	84	10	20.3	348
4	74	18.6	672	33	19.2	406	4	19.9	84	9	20.5	470
4.5	53	18.6	482	32	19.3	418	4	20.5	209	8	20.4	334
5	65	18.6	591	32	19.3	418	4	20.1	105	7	20.4	293
5.5	58	18.6	527	29	19.4	404	3	20.2	90	5	20.5	261
6	49	18.8	488	33	19.4	460	4	19.6	64	5	20.4	209
6.5	37	18.7	352	36	19	396	4	20.3	139	5	20.6	348
7	36	18.7	342	34	19.3	444	3	20	70	4	20.5	209
7.5	34	18.6	309	30	19.4	418	3	19.8	57	4	20.5	209
8	33	18.7	314	29	19.2	357	4	19.9	84	4	20.6	279
8.5	32	18.7	304	27	19.2	332	4	19.9	84	3	20.5	157
9	31	18.7	295	27	19.3	353	3	20.1	78	3	20.6	209
9.5	28	18.7	266	27	19.3	353	3	20	70	3	20.4	125
10	28	18.6	254	26	19.3	340	3	19.9	63	3	20.5	157

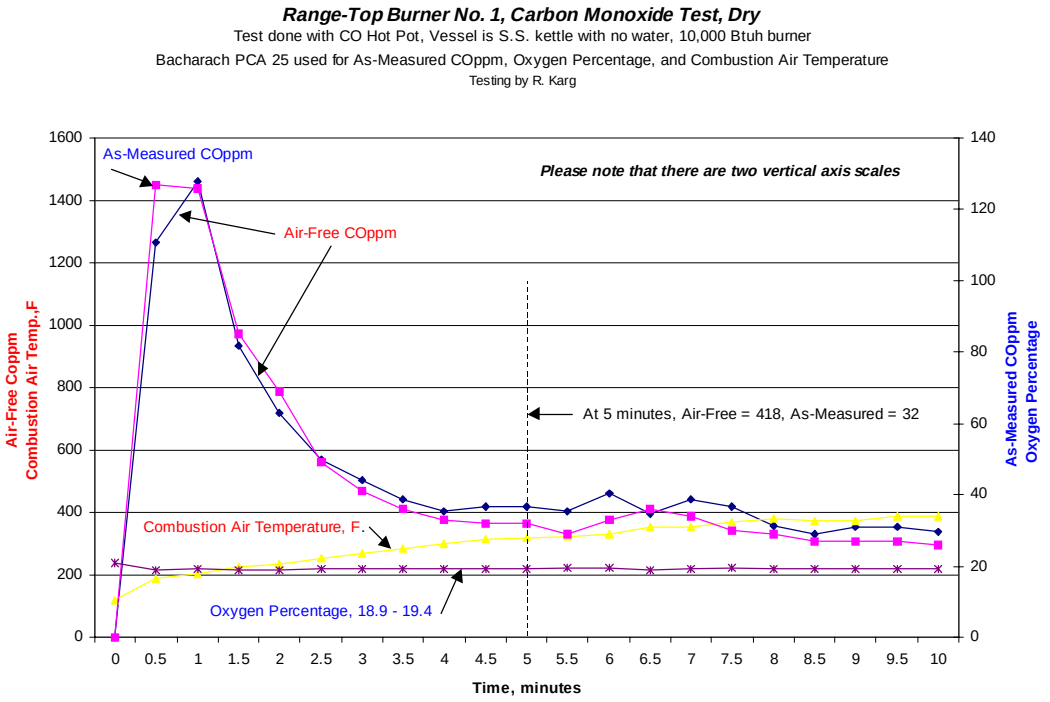
The graph below is for burner 1, test type A. Please note that there are two vertical axis scales.

Range-Top Burner No. 1, Carbon Monoxide Test, Wet

Test done with CO Hot Pot, Vessel is S.S. kettle with 5 pounds of water, 10,000 Btuh burner
Bacharach PCA 25 used for As-Measured COppm, Oxygen Percentage, and Combustion Air Temperature
Testing by R. Karg



The graph below is for burner 1, test type B. Please note that there are two vertical axis scales.



Test Results for Burner 2

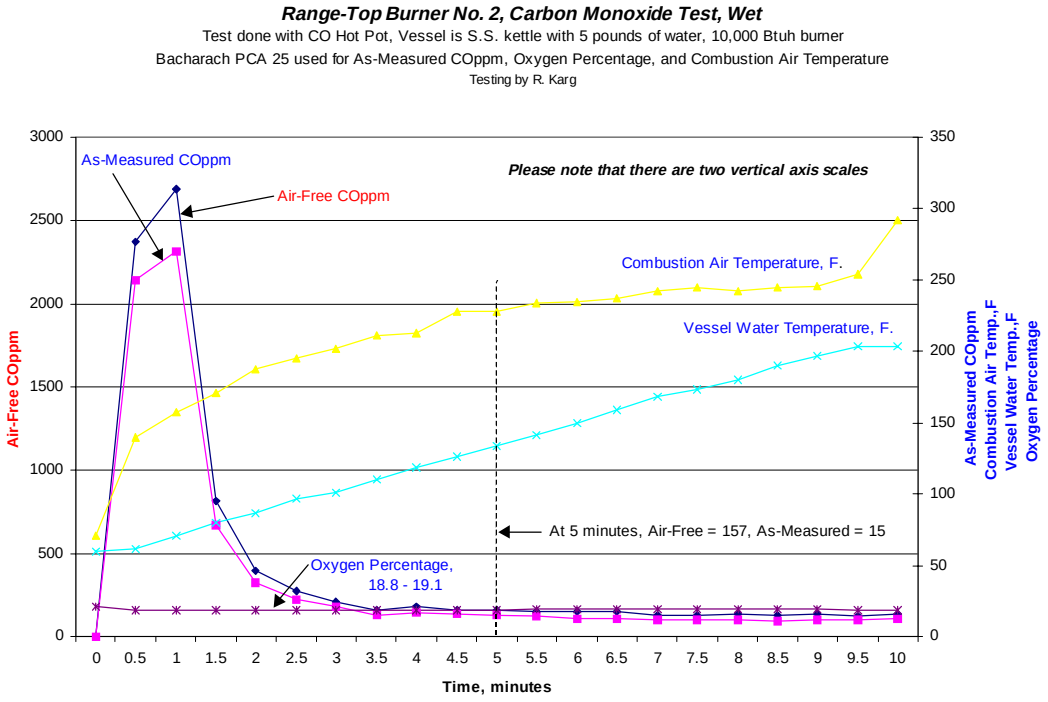
Notice that emission samples were taken every 30 seconds. Five minutes is highlighted because it is the time at which gas range manufacturers are instructed to take an emissions sample according to ANSI Standard Z21.1, 1993, *Household Cooking Gas Appliances.*

Range Testing Results, Burner 2

Burner No. 2	SS CO Hot Pot			SS CO Hot Pot			No CO Hot Pot, No Kettle			Separate Kettle		
10,000 Btuh	5 pounds of water			No water			Probe 8 inches above burner			5 pounds of water		
Elapsed Time	COppm	Oxygen	COafree	COppm	Oxygen	COafree	COppm	Oxygen	COafree	COppm	Oxygen	COafree
0	0	20.9		0	20.9		0	20.9		0	20.9	
0.5	250	18.7	2375	20	19.5	299	16	20.2	478	140	19.5	2090
1	270	18.8	2687	20	19.4	279	15	19.5	224	143	19.5	2135
1.5	78	18.9	815	14	19.5	209	20	19.7	348	66	19.6	1061
2	38	18.9	397	11	19.5	164	14	19.7	244	44	19.7	766
2.5	26	18.9	272	10	19.4	139	11	19.7	192	23	19.6	370
3	21	18.8	209	9	19.4	125	10	19.3	131	16	19.6	257
3.5	15	18.9	157	8	19.4	111	6	20	139	13	19.6	209
4	17	18.9	178	7	19.6	113	9	19.4	125	11	19.6	177
4.5	16	18.8	159	7	19.6	113	11	19.5	164	10	19.7	174
5	15	18.9	157	7	19.5	105	14	18.5	122	9	19.6	145
5.5	14	19	154	7	19.5	105	10	19.4	139	8	19.6	129
6	13	19.1	151	7	19.3	91	10	19.1	116	8	19.8	152
6.5	13	19.1	151	7	19.5	105	11	18.8	109	8	19.7	139
7	12	19	132	7	19.6	113	12	18.9	125	7	19.6	113
7.5	12	19	132	7	19.4	98	15	19	165	7	19.6	113
8	12	19.1	139	7	19.4	98	12	19	132	7	19.6	113
8.5	11	19.1	128	7	19.4	98	11	19.1	128	7	19.5	105
9	12	19.1	139	7	19.5	105	10	19	110	6	19.5	90
9.5	12	18.9	125	7	19.4	98	13	19.1	151	5	19.5	75
10	13	18.9	136	7	19.6	113	10	19.3	131	6	19.7	105

Variation of Carbon Monoxide Readings from Two Propane Range-Top Burners

The graph below is for burner 2, test type A. Please note that there are two vertical axis scales.



The graph below is for burner 2, test type B. Please note that there are two vertical axis scales.