

Final Report

Performance Testing of
Open Range Model Good One Smoker

Submitted to: AceofHeartsbbq.com

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December 13, 2007
Finalized: April 26, 2008

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1. Introduction

A test program was conducted to examine the performance of the Open Range Model Good One Smoker. Over the course of a few months, several tests were performed to measure the operating temperatures of the smoker under various conditions. The tests have proven sufficient for determining the performance of the smoker.

The report is written in sections, each addressing a particular testing parameter of interest (for instance, temperature stability). The report contains data and plots selected and derived from a variety of tests, thus, it may appear to the uninitiated that the temperatures have “suddenly changed”. This is because no two tests were exactly the same. Nevertheless, the results and conclusions drawn would be valid for all conditions a customer may experience.

2. Testing set-up and procedures

Smoker tests were run using hardwood lump charcoal as supplied. Each test used 10 pounds of lump charcoal. Smoker vents were adjusted open to 1-1/2 turns each (intake and exhaust). The damper valve was adjusted to achieve the nominal smoking temperature desired, typically in the 225-250 degree F range.

All efforts were made to achieve optimal smoking conditions.

- Tests were conducted during mild weather.
- Shelter from the wind was employed as necessary.
- Smoker was leveled prior to each test.
- Prior to testing, the smoker was seasoned to avoid complications associated with testing on a factory finish (primarily those associated with uneven radiation effects).

The smoker was fitted with 5 fire-rated thermocouples, connected to a PC-based data acquisition system, as shown in Figures 1-4. Temperature measurements were automatically recorded every 5 seconds during the duration of the test. The accuracy in temperature measurements is within 1 degree Fahrenheit.



Figure 1. Overview of the test set-up, showing smoker, computer, and data acquisition system.

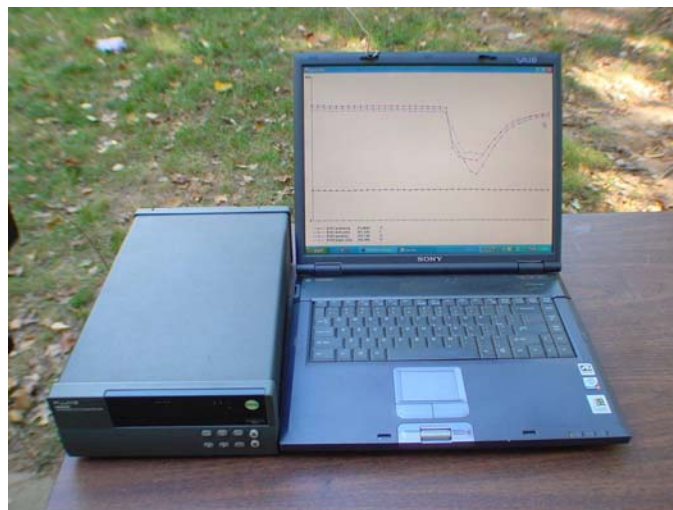


Figure 2. Close-up of the computer and data acquisition system. Picture taken during data acquisition, showing data from a lid opening experiment.

The cooking grate in the smoke chamber was instrumented in 3 measurement locations (see below). The measurements were laterally across the grate (left, center, and right) and centered front to back. The left and right measurements were made 4-1/2 inches from each side of the smoking chamber.

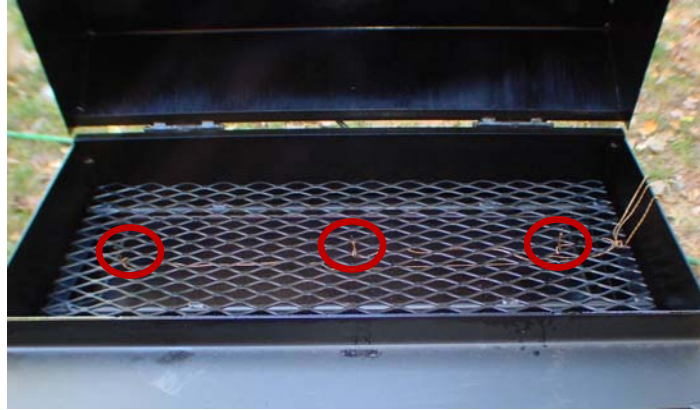


Figure 3. A view of 3 thermocouples located on the left, middle, and right sides (circled in red). All wires are then ported out to the right side.

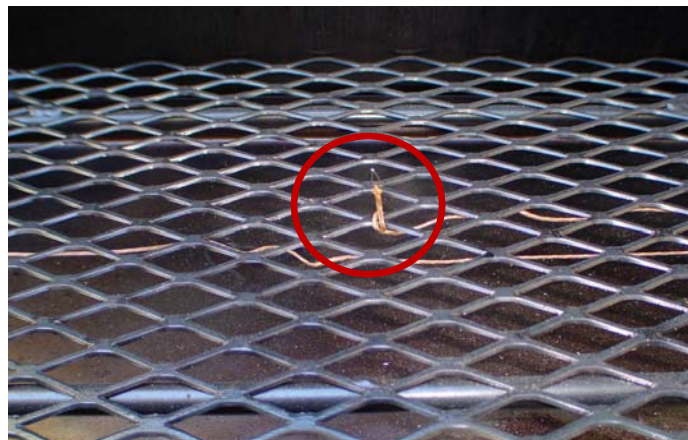


Figure 4. A close-up view of the center thermocouple (circled in red). Measurement is one inch above the grate.

Other temperatures locations were also measured. These included a measurement at the location of the dial thermometer provided with the cooker, the temperature of the firebox, and ambient (outdoor) temperature.

3. Test Matrix

Several tests were performed over a period of two months. Table 1 identifies the tests that were run. Additional information regarding each test is provided in the table. This report will reference the test number in the matrix when describing testing.

Test number	Date	Type of test	Nominal smoking chamber temperature (F)	Nominal outdoor temperature (F)
1	October 6	Shakedown	250	65
2	October 13	Variable burn	250	75
3	November 4	Full burn	255	55
4	November 11	Full burn	250	48
5	November 18	Thermometer checks		
6	December 1	Variable burn	240	60

Table 1. Test matrix

4. Temperature Uniformity

Test 4 provided the best opportunity for examining uniformity in burn, although it is believed that improvements may still be obtained with additional testing.

- Over a 3 hour period, at an average temperature of 254 degrees, lateral temperature differences averaged less than 3 degrees F. Temperature stability over time indicates a temperature variance of less than 5 degrees F from the average of 254 degrees (See Figure 5).

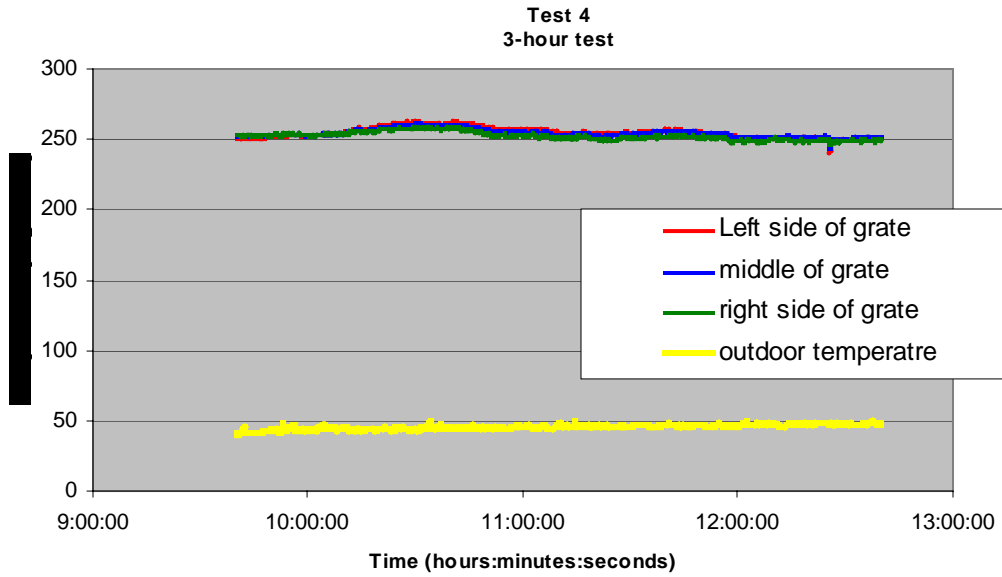


Figure 5. Three hour test run, test #4

- Over the maximum burn time of nearly approximately 5 hours, without any adjustments being made, temperatures averaged 247 degrees, with an average lateral temperature difference of less than 4 degrees. Temperature stability over time indicates a temperature variance of less than 10 degrees F.
- The vertical temperature difference between that at grate level, as compared to the location of the thermometer is approximately 10 to 15 degrees, depending upon cooking conditions. The thermometer level is always hotter than the grate level. This is to be expected, as the hot air rises in the smoking chamber. (See Figure 6)

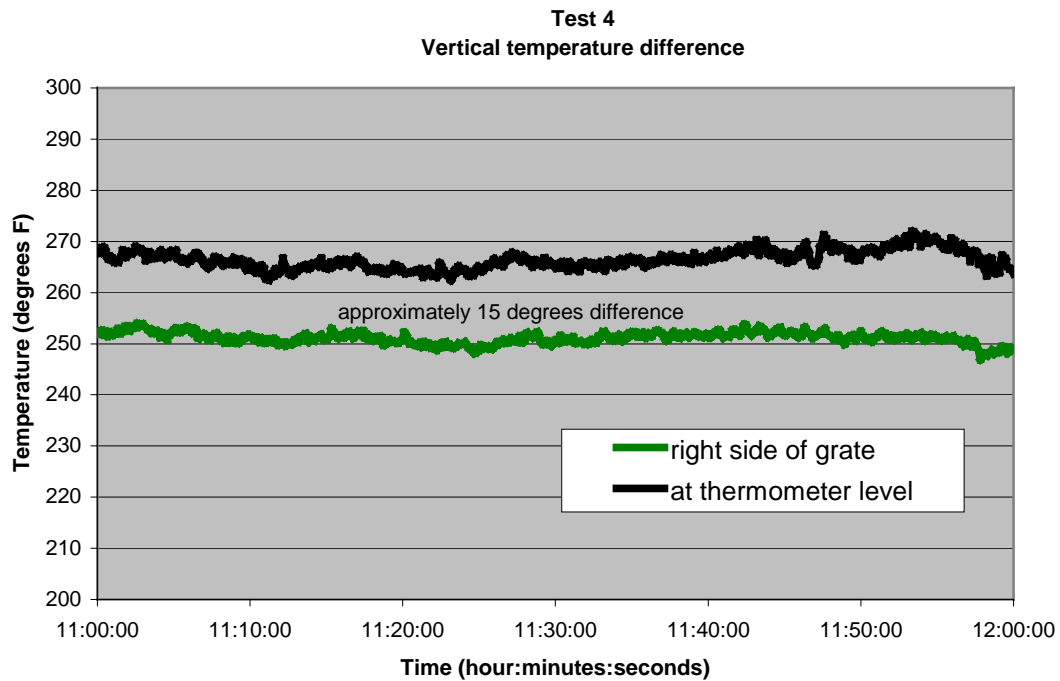


Figure 6. Difference in temperature at cooking grate versus thermometer location, test #4

5. Temperature Response

Response of the smoking chamber temperatures was explored. The first type of change was achieved through manipulation of the damper valve. This is representative of an intentional action to raise or lower the smoking temperature, without making adjustments to the fire or firebox. The second type of change was achieved by opening the lid on the smoking chamber. This represents an undesired change that would occur when opening the lid to check the cooking progress of the food. The results of each are summarized below.

a. Response of damper adjustments

For a small temperature adjustment (approximately 20 degrees F) the following results were achieved.

- Temperature adjustments of between 5 and 20 degrees increase and decrease were easily obtained with just a small “bump” of the damper. These temperature changes were achieved in less than 1 minute (see Figure 7).

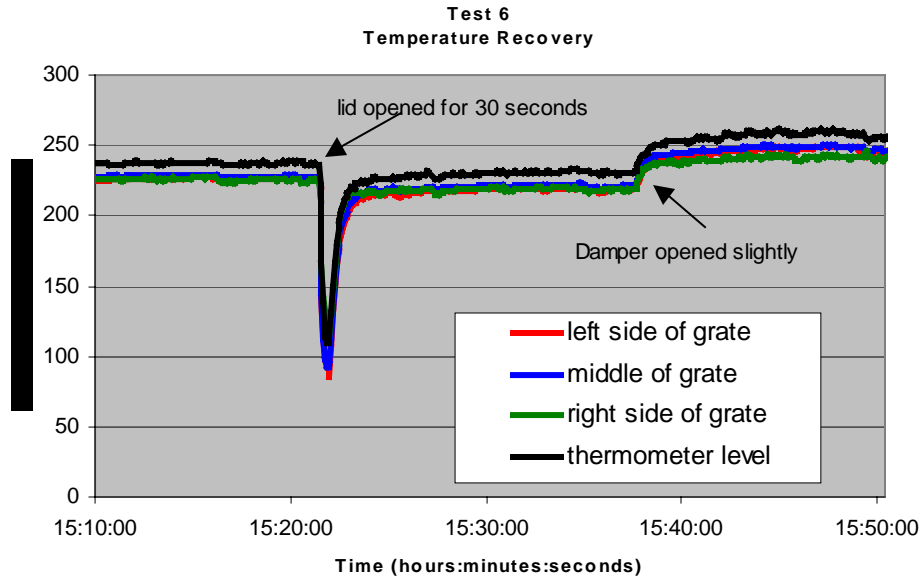


Figure 7. Temperature recovery during lid opening and damper adjustments, test #6

Similarly, for a large temperature adjustment (approximately 100 degrees F) the following results were achieved.

- With the smoker at 225 degrees, the damper was opened to achieve a 100 degree rise in temperature. Within 1 minute, 85% of the temperature rise was achieved. Within 4 minutes, the full 100 degree rise was stabilized.

b. Recovery of temperatures when opening lid

- With the smoker at 225 degrees F, the lid was opened fully for 30 seconds. The temperature dipped to around 100F, and recovered to within about 7 degrees of original (approximately 218 F) in about 2 minutes (see Figure 7). For a 1 minute opening, temperature recovery was similar, occurring in under 4 minutes.

This temperature level is very stable, and a slight bump of the damper would easily restore the full level.

6. Charcoal Burn Performance

Two tests (Test number 4 and 6) were conducted in which a maximum burn time could be established. All three tests started with 10 pounds of lump charcoal started by one chimney load of lit coals. The maximum burn time was considered to be the time in which a stable cooking temperature was obtained in the smoking chamber. The lengths

of time it took to start the fire and obtain stable temperatures, and the time it took to die down was excluded from the calculation of maximum burn time. Table 2 summarizes the maximum burn times achieved in each test.

The average burn rate of charcoal was calculated using the maximum burn time. Thus, while a fire may have burned for longer than the maximum (stable) time, burn rates were calculated on the maximum time indicated in Table 2. Thus, the burn rate is actually lower than that calculated, but that value is not practical for use in estimating the amount of charcoal necessary for a particular length cook.

Test	Maximum burn time	Average burn rate of charcoal (pounds per hour)
4	9 hours	Approximately 1.1 lbs/hr
6	7 hours	Approximately 1.4 lbs/hr

Table 2. Maximum burn times.

The average maximum burn time for 10 pounds of lump charcoal was 8 hours. The average burn rate of charcoal during the stable cooking time was 1.25 lb/hr.

7. Firebox temperatures

The temperature of the firebox was measured during Test 6. The temperature measurement was made at the center of the cooking grate. No attempts were made to adjust this temperature. On average, the temperatures were very high. With the cover closed, the temperatures ranged from 600 to 800 F. This is highly dependent on both the amount of coals present at any given time, and their proximity to the temperature probe. With the cover opened, the temperatures averaged 350-450 F. These temperatures are approximate, as they exhibit large variation, especially when the cover is open. This is due to the additional effects of wind on the open grill surface.

8. Thermometer check

Closer examination was conducted to measure the accuracy of the standard dial thermometer provided with the smoker. A check of thermometer reading versus thermocouple readings made at the same location was made on the smoker (in-situ) during two tests (Tests 4 and 6) and during a stovetop experiment.

In-situ testing indicated a susceptibility to outdoor temperature conditions. For example, mild temperatures and very low winds experienced in test 6 yielded thermometer readings that were much closer to actual temperatures, typically lower by about 5 degrees (see Table 3). However, the dial thermometer over predicts the temperature at grate level by about 9 degrees.

Test number	Thermometer reading (F)	Thermocouple reading (F)	Temperature at Grate on Right Side (F)
6	230	235	226
6	250	252	243
6	244	251	242

Table 3. Results of in-situ thermometer testing

A stovetop experiment confirmed the findings of the in-situ tests, as shown in Table 4. The stem of the dial thermometer was placed in a pot of boiling water, while the dial was shielded from the rising steam. Temperatures were checked against a thermocouple measurement of the water temperatures. Various depths of stem immersion were tested. Also, during a few tests, the dial was surrounded by ice, to simulate cooking on a cold day. These results showed a wide variety of variation in temperature error. In all cases, the dial thermometer reads lower than the actual temperature.

Depth of stem immersion in water (inches)	Thermometer reading (F)	Thermocouple reading (F)	Temperature Error (F)
3.75	206	211	5
2.75	206	211	5
1.75	192	210	18
1.75 with ice	186	209	23
1.75 with ice and fanned	180	208	28

Table 4. Results of stovetop thermometer testing

9. Summary

Several tests have been conducted to examine the performance of the Open Range Model smoker. Tests examined the temperature stability of the smoker, the ability of the smoker to change and recover temperature, temperatures of the firebox and grill, and the accuracy of the thermometer supplied with the unit.

The following results and conclusions from the test program can be identified.

- Lateral temperatures differences in the smoking chamber were very small, averaging less than 3 degrees.
- Temperature stability with time indicates variance in temperature of less than 5 degrees over 3 hours, less than 10 over 5 hours, *without any adjustments being made.*
- The vertical temperature difference between that at grate level, as compared to the location of the thermometer is approximately 10-15 degrees, depending upon cooking conditions
- Large changes in smoking chamber temperatures (100 degrees) can be achieved within 1-4 minutes, while small changes (5-20 degrees) can be obtained in under a minute.
- Temperature recovery following opening the smoking chamber lid during a typical food check of 30 seconds to 1 minute can be achieved in 2 and 4 minutes respectively. Temperatures recover to within approximately 7 degrees of original temperature. *A fine tune of the damper may be necessary to achieve complete recovery.*
- Maximum stable burn times are in excess of 7 hours, based on 10 pounds of charcoal. This correlates to a charcoal burn rate of about 1.25 pounds per hour.
- Firebox temperatures at grate level ranged from 600-800 F when closed, and range from 350-450 F when open.
- The original equipment dial thermometer over-predicts the temperature at the grate by about 9 degrees. *A new type of thermometer should be considered for use.*