The Marshall™ The Good-One®

Performance Testing of Marshall Model Good-One® Smoker

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March 12, 2008
Finalized: April 26, 2008

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1. Introduction

A test program was conducted to examine the performance of the Marshall Model Good One Smoker. Over the course of about two 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 uniformed 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 20 pounds of lump charcoal. Smoker vents were adjusted open to 2-1/2 turns for the intake and 1-1/2 turns for the exhaust. Two gallons of water were added to the smoking chamber. The damper valve was adjusted to achieve the nominal smoking temperature desired, typically in the 250 degree F range.

All efforts were made to achieve optimal smoking conditions.

- Tests were conducted during similarly cool weather days.
- 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 15 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.

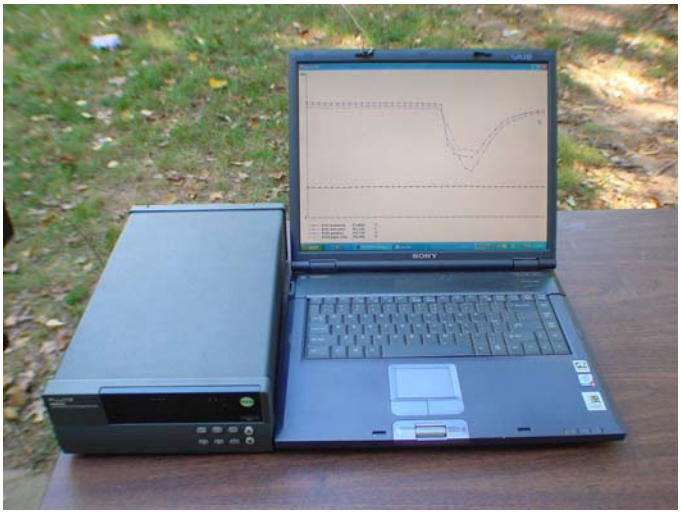

Figure 1. Close-up of the computer and data acquisition system. Picture taken during data acquisition, showing data from a lid opening experiment.

The cooking grate in the smoke chamber was instrumented on all 4 food grates, at 15 locations (see Figure 2-4).

The nomenclature used in this report defines the uppermost (smaller) grate as the top grate. The remaining 3 grates are numbered 1, 2 and 3 from top to bottom. Temperature measurements were made laterally across the grates (left, center, and right) and centered front to back (see Figure 2). The left and right measurements were made 6 inches from each side of the smoking chamber. The front and rear measurements were made 3 inches from the edges of the grate. Temperature measurement locations are identified in Table 1.

Grate	Center	Left Side	Right Side	Front	Rear
Top	yes				
1	yes	yes	yes	yes	yes
2	yes	yes	yes	yes	yes
3	yes	yes	yes		

Table 1. Temperature locations in the smoke chamber.

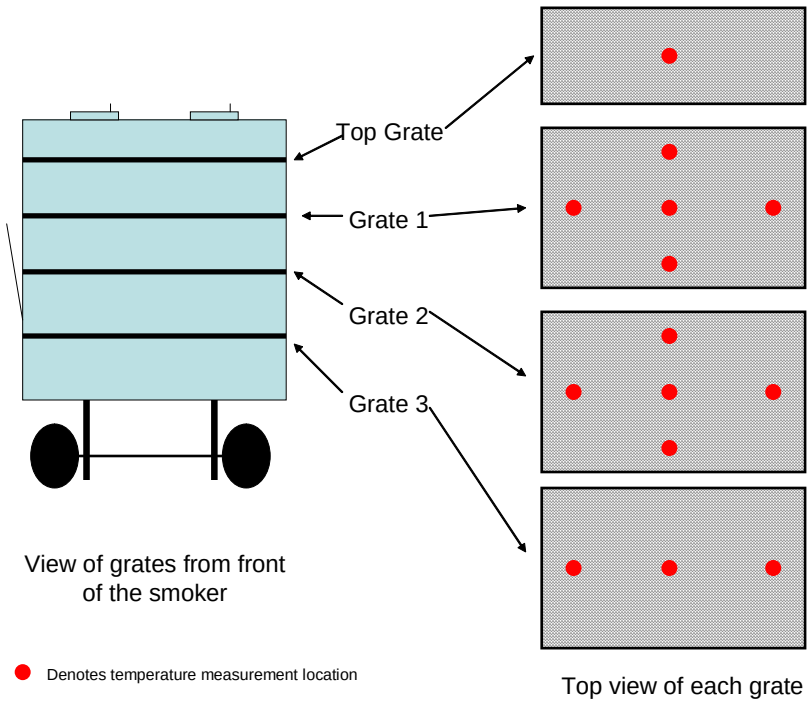

Figure 2. Drawing depicting locations of temperature measurements within the smoker.

Additionally, a measurement was made coincident with the location of the tip of the factory installed dial thermometer, and on the grate in the firebox.

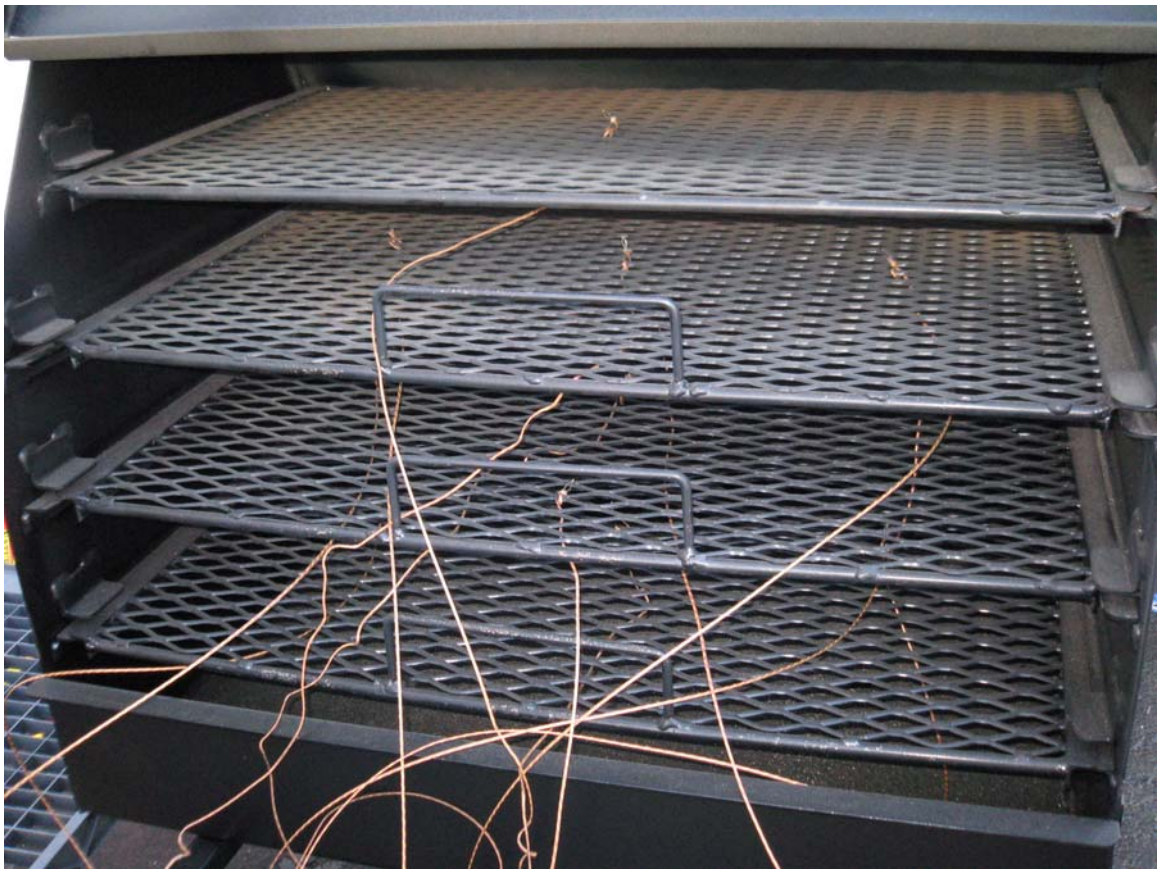

Figure 3. A view of a partial installation thermocouples. All wires are then ported out to the front bottom of the lid.

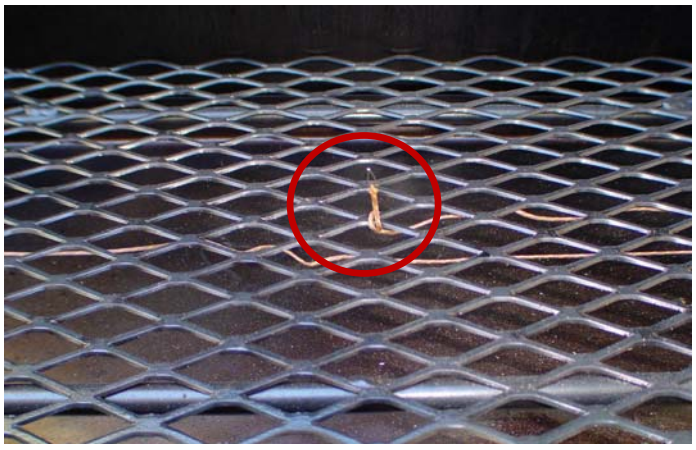

Figure 4. A close-up view of the center thermocouple (circled in red). Measurement is one inch above the grate.

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	January 26	Shakedown	250	65
2	February 3	Full Burn	250	75
3	February 18	Full burn	255	55
4	March 4	Full burn	250	48
5	March 12	Full Burn	250	60

Table 1. Test matrix

4. Temperature Uniformity

Tests 3, 4 and 5 provided the best opportunity for examining uniformity in burn.

- Over a 5- hour period, at a nominal temperature of 250 degrees, the following temperature variations were observed.
    - Vertical temperature differences can be expressed as follows:

Nominal temperature difference between	Degrees F
top and #1	3 to 5
#1 and #2	4 to 5
#2 and #3	15 to 18

Nominal temperature difference between	Degrees F
top and #1	3 to 5
top and #2	7 to 10
top and #3	22 to 28

These temperature differences are to be expected, as the hot air rises in the smoking chamber. (See Figure 5)

- The temperature stability differences between running the smoker without water, and running with 2 gallons of water in the bottom of the cooker was measurable, but not significant. This is illustrated by comparing the temperatures in the first half hour in Figure 5 with those of the remainder of the test.

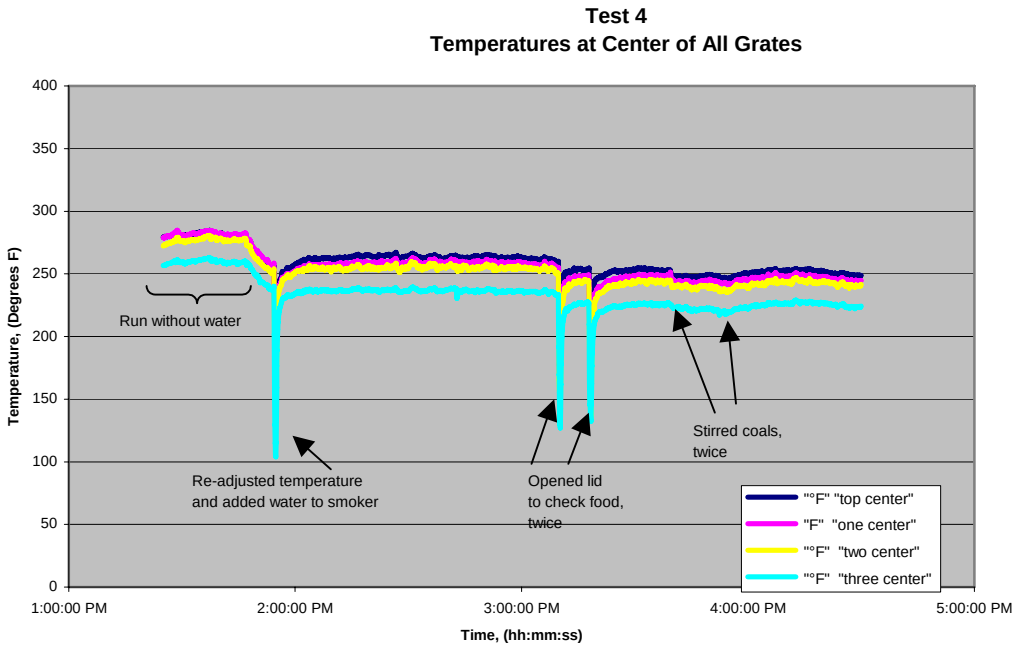

Figure 5. Test 4 results.

- Lateral (left and right) temperature differences ranged between 3 and 6 degrees F for grates 1 and 2, and slightly greater, between 3 and 10 degrees for the bottom grate 3. (See Figures 6-8)
- Front to back temperature differences ranged between 1-4 degrees for grate 1, and 20 degrees for grate 2. The rear measurement is much hotter, due to its proximity to the damper valve and firebox.

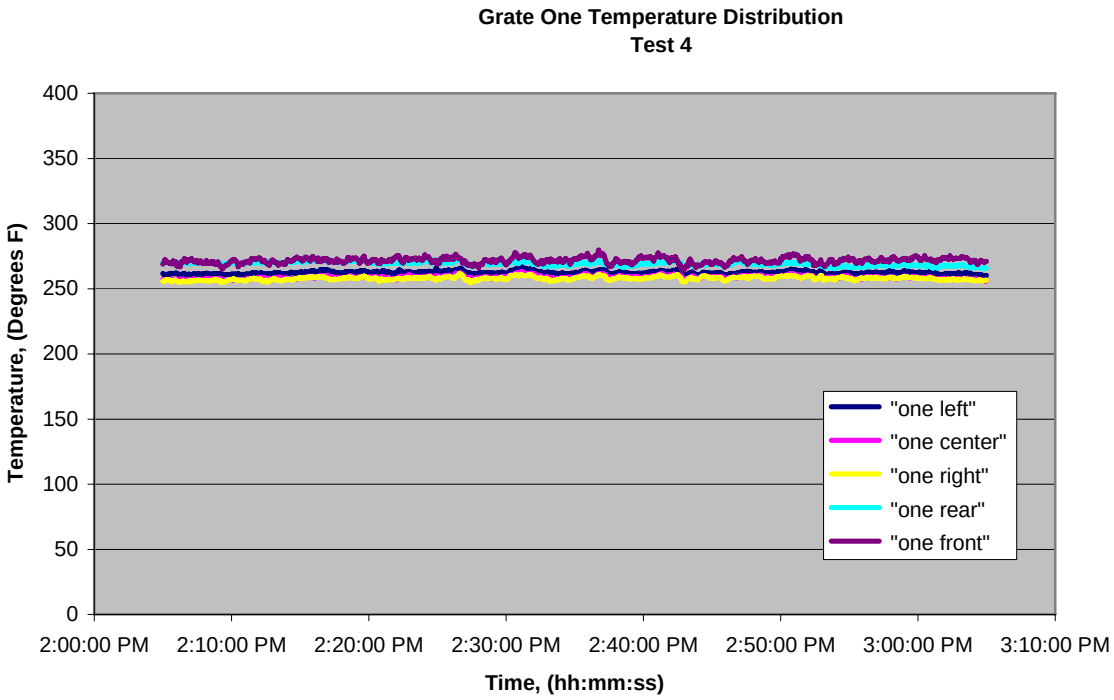

Figure 6. Temperature distribution across grate 1.

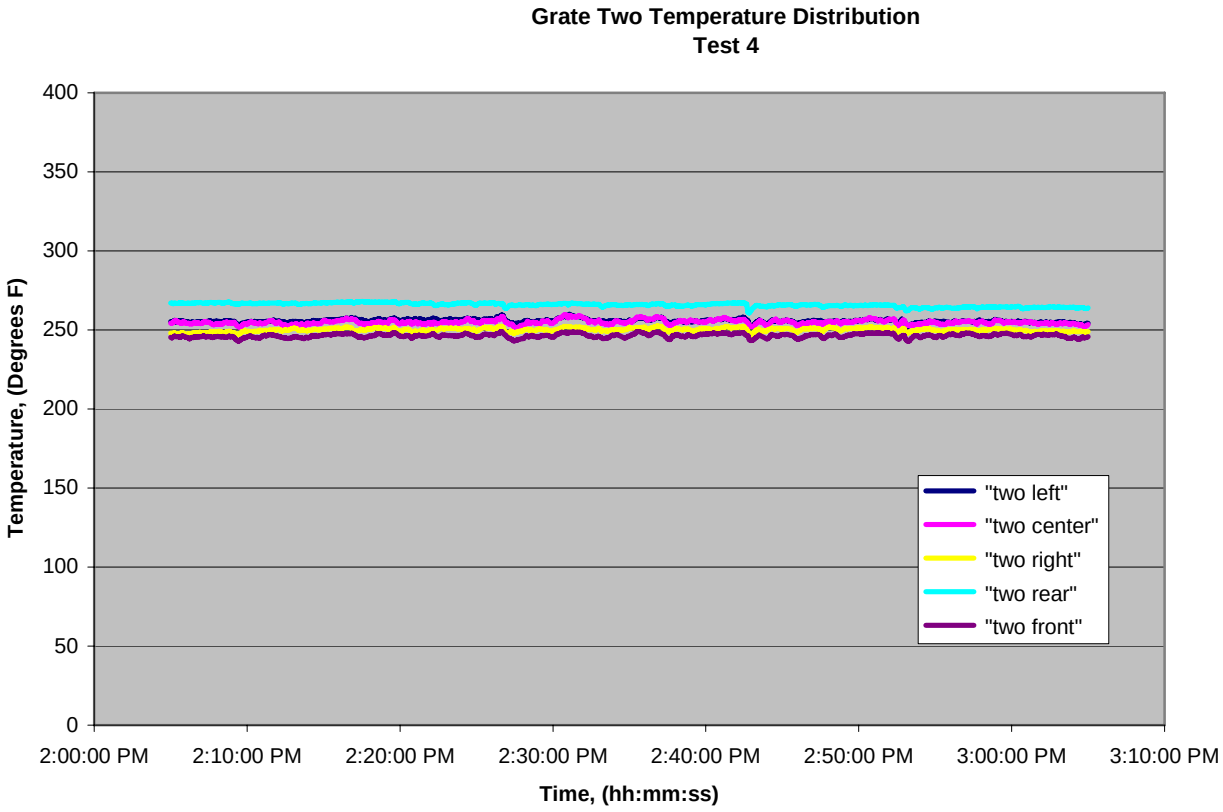

Figure 7. Temperature distribution across grate 2.

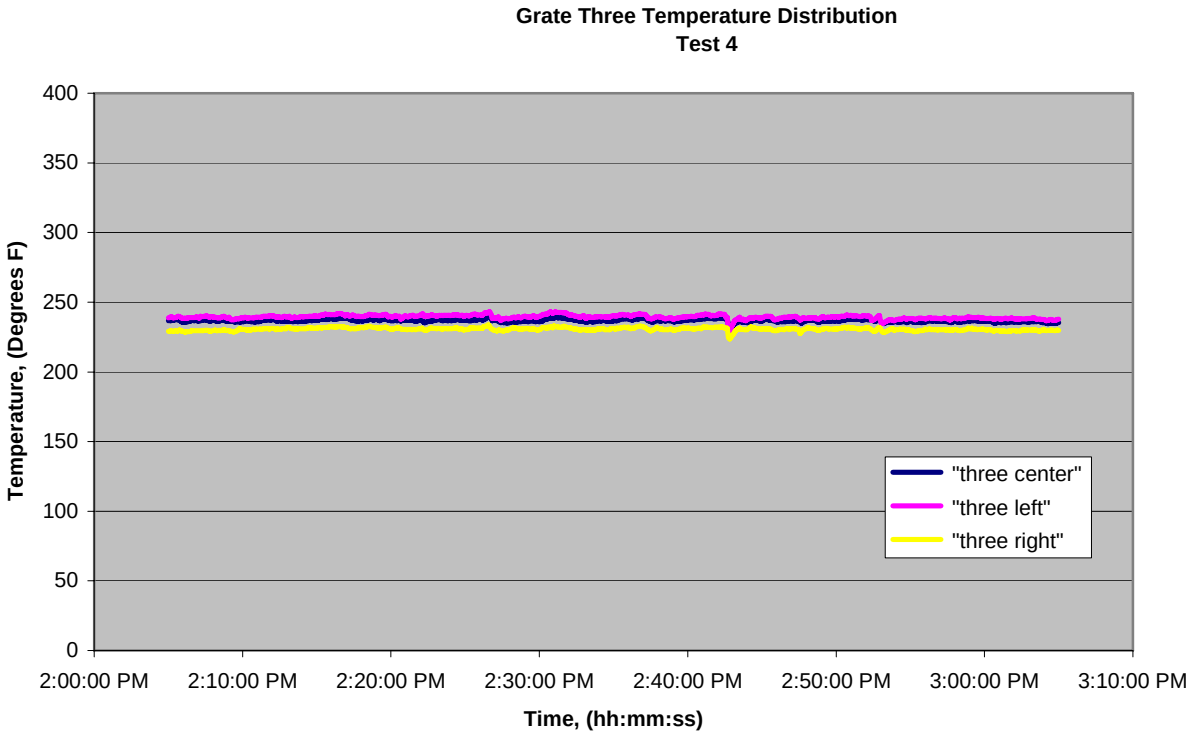

Figure 8. Temperature distribution across grate 3.

- Temperature stability over a 1-hour period has been demonstrated to within 2 degrees of the target temperature with no adjustments of any kind.

- Temperature stability over a 4-hour period can easily be kept steady to within 5 degrees of the target temperature, with only a few minor adjustments to the damper valve (see Figure 9).

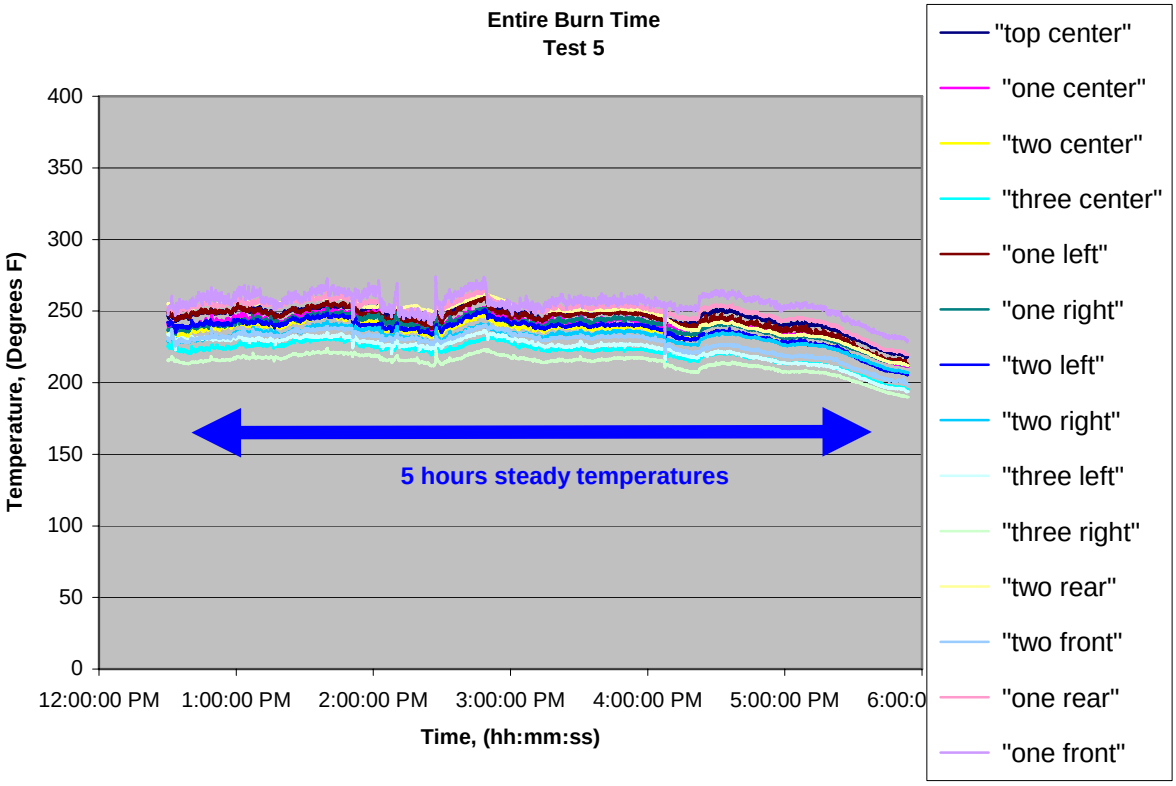

Figure 9. Five hour test run, test #5

- Over the maximum burn time of nearly approximately 5 hours, without only small 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.

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 third type of change was achieved by rearranging the coals in the firebox. This becomes necessary over long burn times to ensure steady charcoal burn performance. Variations in temperature caused by this activity are not desired. The results of each are summarized below.

a. Response of damper adjustments

For a small temperature adjustment (approximately 35 degrees F) the following results were achieved.

- Small temperature adjustments of 5 degrees or more were easily achieved with small adjustments of the damper valve. For example, a nominal temperature rise of 35 degrees is shown in Figure 10. In this example, a 20 degree rise (more than 50% of total rise) was obtained in under 1 minute, and the total stabilized temperature rise was obtained in under 6 minutes.

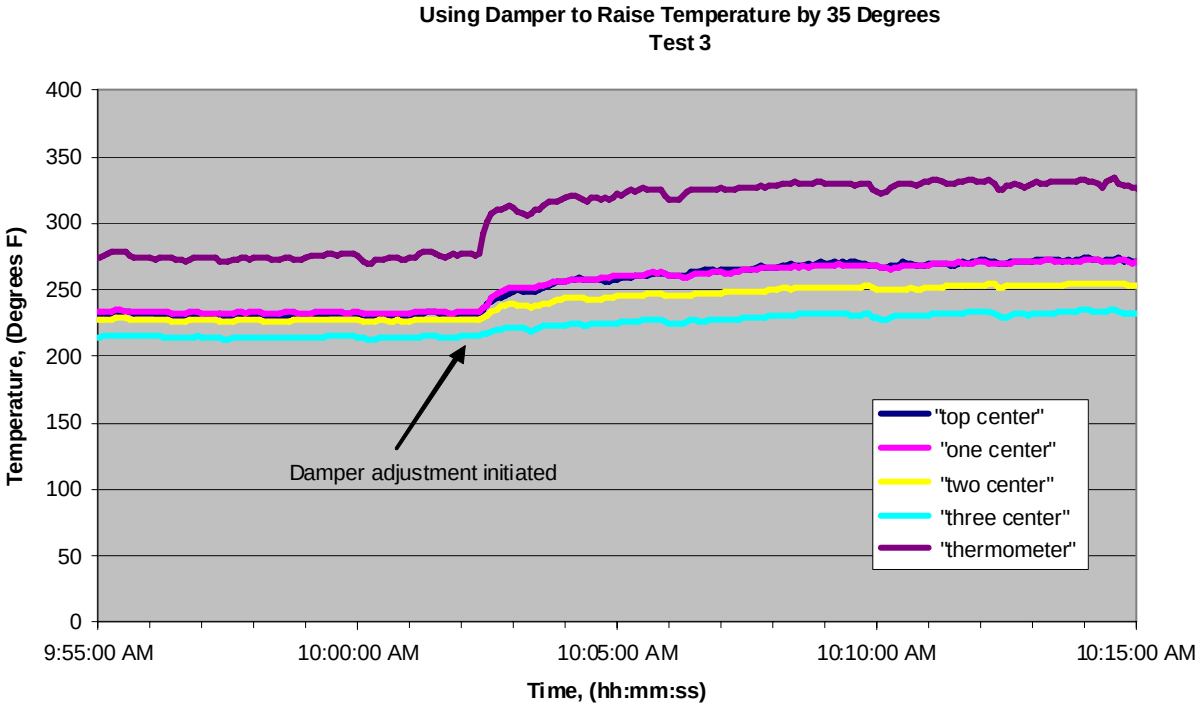

Figure 10. Temperature recovery during damper adjustments.

b. Recovery of temperatures when opening lid

- With the smoker at 250 degrees F, the lid was opened fully for 30 seconds. The temperature dipped to around 150F, and recovered to within about 7

degrees of original (approximately 243 F) in about 2 minutes (see Figure 11). 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.

c. Temperature changes caused by rearranging hot coals in firebox

- With the smoker at 250 degrees F, the burning coals were rearranged to ensure an even burn in the firebox. Refer back to Figure 5. After rearrangement, the temperatures dipped about 3-5 degrees, but then recovered to the original temperature within about 10 minutes.

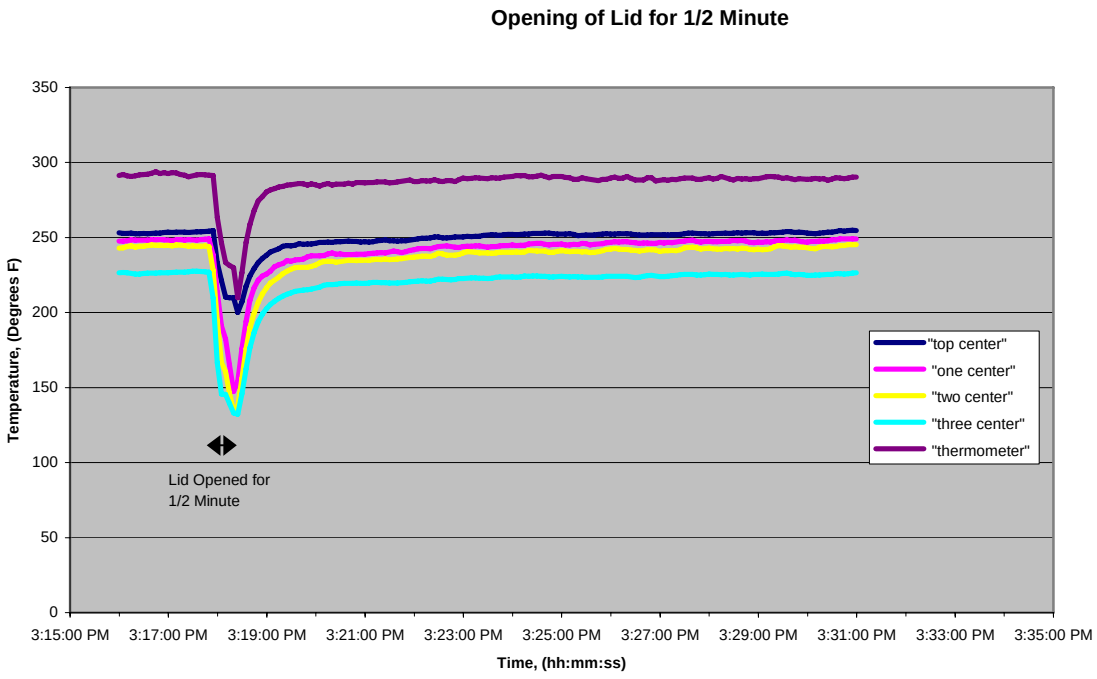

Figure 11. Temperature recovery following opening of lid.

6. Charcoal Burn Performance

Three tests (Tests number 3-5) were conducted in which a maximum burn time could be established. All three tests started with 20 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)**
3	4-1/2 hours	Approximately 4.4 lbs/hr
4	4-1/2 hours	Approximately 4.4 lbs/hr
5	5 hours	Approximately 4 lbs/hr

Table 2. Maximum burn times.

The average maximum burn time for 20 pounds of lump charcoal was between 4-1/2 to 5 hours. The average burn rate of charcoal during the stable cooking time was between 4 and 4.4 lbs/hr.

7. Firebox temperatures

The temperature of the firebox was measured during Test 3. The temperature measurement was made at the center of the cooking grate in the firebox. On average, the temperatures were very high. With the cover closed, the temperatures ranged from 700 to 800 F. This is highly dependent on the amount of coals present at any given time, their proximity to the temperature probe, and the position of the damper valve. With the cover opened, the temperatures averaged 600 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

An 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 were made on the smoker during two tests (Tests 4 and 5). Results are shown in Table 3.

Test number	Dial Thermometer reading (F)	Thermocouple reading (F)	Temperature Error (F)	Top Grate (F)	Difference (F)
4	286	306	20	266	20
4	286	303	17	264	22
4	269	281	12	247	22
5	276	295	19	254	22

Table 3. Results of thermometer testing.

The temperature measurements can be summarized as follows. The reading of the dial thermometer is consistently lower than actual temperature at the thermometer location, as measured by a thermocouple wrapped around the dial thermometer. These measurements vary between 12 and 20 degrees too low.

However, if one compares the dial thermometer reading to the temperature at the center of the top grate, it is very consistently indicating a temperature that is about 20 degrees too high. In other words, if using the dial thermometer to determine the temperature of the cooking grates, it will over predict the temperature of the top grate by about 20 degrees.

Reasons for these discrepancies were discussed on the report on the Open Range model. However, an additional factor with the Marshall model is that the stem of the dial thermometer protrudes directly under the top vent of the smoke chamber. This is a significant reason for the high temperature readings by the dial thermometer, as the hottest air escaping the smoker must travel directly past the probe. It is suggested that the location be offset to eliminate this factor.

9. Summary

Several tests have been conducted to examine the performance of the Marshall Model smoker. Tests examined the temperature stability of the smoker, the distributions of temperature throughout the smoking chamber, 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 between 3 and 6 degrees.
- Temperature stability with time indicates variations in temperature of about 2 degrees over 1 hour *without any adjustments being made*, and about 5 degrees over 4 hours, *with only small adjustments being made.*
- Small changes in smoking chamber temperatures (35 degrees for example) can be achieved within minutes, achieving 50% of the desired temperature rise in under a minute, and fully achieved by 6 minutes.
- 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 for 20 pounds of charcoal are between 4-1/2 and 5 hours. This correlates to a charcoal burn rate of about 4 to 4.4 pounds per hour.
- Firebox temperatures at grate level ranged from 700-800 F when the lid is closed, and approximately 600 F when open.
- Front to rear temperature variations are larger than lateral variations due to the proximity to the heat source (firebox and damper valve). Variations can range from 4 to 20 degrees depending on operating conditions.
- Vertical temperature differences were measured, with the top grate being the hottest. Grate 1 was 3 to 5 degrees cooler than the top, grate 2 was 7 to 10 degrees cooler than the top, and grate 3 was 22 to 28 degrees cooler than the top grate.
- The dial thermometer reads about 20 degrees hotter than the temperatures at the top grate.
- Temperature changes caused by rearranging the coals in the firebox are small (3-5 degrees) and short lived (full recovery of initial temperature in 10 minutes).

10. Recommendations

Based on the results of this testing, the following recommendations can be made.

- To minimize vertical temperature variations, a reverse flow system should be explored. This would allow the exhaust from the smoke chamber to be pulled from the bottom, instead of venting out the top. Chimneys ported out the lower sides of the smoke chamber, with the top vents closed, is one configuration that should be explored.
- The dial thermometer should be relocated away from the upper vent opening, just below the top grate. Further, additional thermometers should be installed slightly below each grate. Long stem thermometers should be used. The dials should be enclosed on the outside of the smoker, to shield from the outside air.
- Increased fuel burn times, and reduced charcoal use can be achieved if the firebox were insulated. There are many ways to do this, either with a double wall or by using high temperature insulation under a thin sheet metal jacket.
- The smoke chamber should be fitted with additional shelving slots in between the four already in place. It seems that a 7-10 pound pork butt never really fits well between the shelves (too tall), and an additional ½ space of vertical clearance would be welcomed when necessary.
- A standard aluminum baking sheet pan with brackets fits very nicely over the two retractable handles of the smoker. I have built one and find it to be an invaluable accessory.
- The firebox, when used for direct grilling, should have the ability to raise and lower the grates, with additional brackets welded inside the firebox.
- The firebox grate should be stainless steel. Temperatures are so high in the firebox that there is no real way to season the plain steel grate that is supplied, and so it rusts very quickly and easily. This makes preparation for grilling time consuming.