Rational, Model SCC 62G Gas Combination Oven Performance Test

Application of ASTM Standard
Test Method F 1639-05

FSTC Report # 5011.06.10

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Specific appreciation is extended to Rational, for supplying the Food Service Technology Center with the SCC 62G gas combination oven for controlled testing in the appliance laboratory.

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Executive Summary

The SCC 62G is the newest generation gas combination oven from Rational, incorporating the new SelfCooking Control. This is a step forward in control technology, giving the oven the ability to measure and adjust temperature, humidity and cook time during the cooking event. The advantage to the operator is consistant food product, regardless of who is operating the oven. The oven can also run in manual mode which allows the operator to select specific temperature and humidity settings.

The SCC 62G is a full size, 6-pan capacity gas combination oven, powered by a 75,000 Btu/h burner.

The Food Service Technology Center (FSTC) tested the Rational, Model SCC 62G combination oven under the controlled conditions of the American Society for Testing and Materials (ASTM) *Standard Test Method for the Performance of Combination Ovens.*[1] Oven performance is characterized by preheat duration and energy consumption, idle energy rate, cooking energy rate and efficiency, production capacity, water consumption, and condensate temperature. Cooking tests were conducted with 2 ½-pound whole chickens (deli WOGs).

Cooking-energy efficiency is a measure of how much of the energy that an appliance consumes is actually delivered to the food product during the cooking process. Cooking-energy efficiency is therefore defined by the following relationship:

$$Cooking\ Energy\ Efficiency\ \% \quad = \quad \frac{E_{Chicken} + E_{pans}}{E_{oven}} \quad \times \quad 100\%$$

[1] American Society for Testing and Materials, 2005. Standard Test Method for the Performance of Combination Ovens. ASTM Designation F1639-05, in the Annual Book of ASTM Standards, West Conshohocken, PA.

A summary of the ASTM test results is presented in Table ES-1.

Table ES-1. Summary of the Rational SCC 62G Gas Combi Performance.

	Manual Mode	SelfCooking Control
Rated Energy Input Rate (Btu/h)	75,000	75,000
Measured Energy Input Rate (Btu/h)	77,870	77,870
Preheat Time (min)	6.3	8.7
Preheat Energy (Btu)	8,022	10,900
Idle Energy Rate, Gas (Btu/h)	34,260	0.0
Idle Energy Rate, Electric (kW)	0.23	0.06
Whole Chickens		
Light-Load Cooking-Energy Efficiency (%)	33.5 ± 1.7	34.6 ± 1.5
Heavy-Load Cooking-Energy Efficiency (%)	58.9 ± 5.5	55.9 ± 3.2
Production Capacity (lb/h)	131.5 ± 4.1	131.0 ± 11.3

During the cooking tests, the oven produced similar heavy-load cooking-energy efficiencies for each control mode— 58.9% for manual and 55.9% using the SelfCooking Control. Each of these efficiency numbers are relatively high among combis currently tested by the FSTC. [2-6]

From an energy standpoint, the preferred control mode would be the SelfCooking Control, due to the idle energy savings. In SelfCooking Control mode, the yearly energy cost to operate was estimated using a model that assumed 200 lbs of food cooked over a 12 hour day, 365 days per year. Using energy costs of $1.20 per therm and $0.15 per kWh, the estimated energy cost for the SCC 62G was $937 per year.

1 Introduction

Background

Many food service operations rely heavily on the versatility of ovens. Operators can cook a variety of foods in large quantities with a single appliance. Ovens are often used for cooking fundamental menu items such as fresh-baked desserts, crusty breads, and familiar comfort foods, such as roasted meats and potatoes. In addition to the traditional uses of ovens for roasting and baking, they may be used to cook a surprising range of foods usually associated with other appliances. For example, ovens in high-volume kitchens prepare large quantities of griddle standards such as bacon, eggs, sausages and French toast.

Combination ovens offer even more options with their ability to add steam to the oven cavity. In addition to baking and roasting, a combination oven is also capable of steaming, proofing and rethermalizing various food products. Foods can be cooked in a convection oven dry heat only mode, a steam only mode and a combination of dry heat and steam modes. The programmability of combination ovens also allows food to be cooked partially in one mode at a certain temperature, and then finished in another mode and at a separate temperature. For example, a turkey can be cooked in combination mode at low temperature for several hours, and then stepped to a higher temperature in dry heat mode to finish.

The Food Service Technology Center (FSTC) has focused on the development of standard test methods for commercial food service equipment since 1987. The primary component of the FSTC is a 10,000 square-foot appliance laboratory equipped with energy monitoring and data acquisition hardware, 60 linear feet of canopy exhaust hoods integrated with utility distribution systems, appliance setup and storage areas, and a state-of-the-art demonstration and training facility.

Introduction

The test methods, approved and ratified by the American Society for Testing and Materials (ASTM), allow benchmarking of equipment such that users can make meaningful comparisons among available equipment choices. The test method for combination ovens was submitted to the American Society for Testing and Materials (ASTM) F26 Committee on Food Service Equipment, and accepted as a standard test method (Designation F 1639-95) in 1995.[1] Further combination oven testing is documented in several FSTC reports.[2-5]

The glossary in Appendix A is provided so that the reader has a quick reference to the terms used in this report.

Objectives

The objective of this report is to examine the operation and performance of the Rational, Model SCC 62G, gas combination oven under the controlled conditions of the ASTM Standard Test Method. The scope of this testing is as follows:

1. Verify that the appliance is operating at the manufacturer's rated energy input.
2. Determine the time and energy required to preheat the appliance from room temperature to 350°F using manual control mode.
3. Determine the time and energy required to preheat the appliance from room temperature to a ready-to-cook state using the Self-Cooking Control mode.
4. Determine the idle energy rate with the appliance set to maintain 350°F in the cooking cavity using the manual control mode.
5. Determine the idle energy rate with the appliance in SelfCooking Control mode.
6. Document the water consumption, cooking-energy consumption and cooking-energy efficiency under heavy- and light-load conditions using whole chickens as the test product in both Self-Cooking Control and manual control modes.
7. Determine the product cook time and production capacity in both SelfCooking Control and manual control modes.

8. Characterize the combi's cooking uniformity by steaming ice loads.
9. Estimate the annual operating cost for operting the combination oven in both SelfCooking Control and manual control modes using a standard cost model.

Appliance Description

The Rational, Model SCC 62G Combi Oven, is a full size, 6-pan capacity, gas combination oven (Figure 1-1). The oven is powered by a 75,000 Btu/h burner located on the left-hand side of the cooking cavity. Steam is introduced into the cavity using a fresh steam generator, while heat is distributed using a single direction, multi-speed fan driven by a brushless DC motor.

The SCC 62G oven has a unique SelfCooking Control mode that automates the cooking process for numerous food products. For example, to cook whole chickens, chicken is first selected from the control menu. The oven will preheat to a specific temperature, then prompt the user to load the food. A temperature probe is inserted into the chicken, and after the door is closed, the oven fully controls the cooking process until the chickens are finished.

This method of cooking differs from the usual operation of a combination oven because the SCC 62G monitors and adjusts oven temperature, humidity and cook time as the food is cooking. While many combination ovens allow the user to insert a temperature probe and cook to a specific temperature, the SCC 62G continuously (once a second) evaluates the oven climate and food temperature, and adjusts the oven as necessary to optimize the cooking process.

In addition to the SelfCooking Control mode, the SCC 62G can be easily switched to manual mode, where it can be run continuously in dry heat, moist heat, or combination moist and dry heat modes. The humdity level in the oven can be specified, and 5 fan speeds are available. Up to 250 programs can also be stored to cook food in any combination of moist heat, dry heat and combined moist and dry heat. Appliance specifications are listed in Table 1-1,

and the manufacturer's literature is in Appendix B. The appliance is pictured in Figure 1-1.

Figure 1-1. The Rational SCC 62G combi.

Table 1-1. Appliance Specifications.

Manufacturer	Rational
Model	SCC 62G
Generic Appliance Type	Gas combination oven
Rated Input	75,000 Btu/h
Technology	Combination dry heat and steam
Construction	All stainless-steel construction
Controls	SelfCooking Control
	Programmable control panel with 250 stored recipes
Compartment Capacity	6 full-size (18" x 26") sheet pans, 12 half-size (18" x 13") sheet pans, 12 full-size (12" x 20" x 2$^1/_2$") steam pans, or 4 eight-bird chicken racks
Cavity Size	25" x 33" x 21" (w×d×h)
Dimensions	42 $^1/_8$" x 38 $^1/_4$" x 29 $^3/_4$" (w×d×h), without stand 42 $^1/_8$" x 38 $^1/_4$" x 58" (w×d×h), including stand

2 Methods

Setup and Instrumentation

The SCC 62G combi oven was installed in accordance with the manufacturer's instructions and Section 9 of the ASTM standard test method.[1] The oven was positioned on a tiled floor under a 4-foot-deep canopy hood, with the lower edge of the hood 6 feet, 6 inches above the floor and the oven a minimum of 6 inches inside the vertical front edge of the hood. The exhaust ventilation operated at a nominal rate of 300 cfm per linear foot of hood.

Gas to the oven was measured with a positive-displcement meter that generated a pulse for each 0.05ft^3 of gas used, and a watt-hour transducer that generated a pulse for each 0.00001 Wh measured electricity. Water consumption was measured with an in-line flow sensor installed on the water inlet hose. Oven cavity temperature was monitored with 24 gauge, type K, Teflon insulated thermocouple wire located in the geometric center of the oven cavity. The condensate water temperature was measured with an additional type K thermocouple wire immersed in the condensate water, just as it entered the floor drain. The transducer and thermocouples were connected to a computerized data acquisition unit that recorded data every 5 seconds. Figure 2-1 shows the Rational SCC 62G combi oven instrumented with the data acquisition system.

Energy Input Rate and Thermostat Calibration

The energy input rate was determined by turning the oven on, in manual combination dry and moist heat mode, and measuring the energy consumed from the time the oven first began operating until the time when the burner first cycled off. The energy consumed and the time elapsed were used to calculate the maximum energy input rate. Thermostat calibration was verified by allowing the oven to operate with the thermostat set to the specified operating temperature of 350°F for a period of one hour and then monitoring the oven cavity temperature for an additional sixty minutes.

Figure 2-1.
The Rational SCC 62G instrumented for testing.

Preheat and Idle Tests

With the SCC 62G oven's capability of operating in both manual and SelfCooking Control modes, preheat and idle tests were performed for each control setting. The manual mode preheat test recorded the time and energy required for the oven, using the combination dry and moist heat setting, to increase the cavity temperature from 75 ± 5°F to a temperature of 348°F. Recording began when the oven was first turned on, so any time delay before the energizing of the elements was included in the test. Although the specified operating temperature is 350°F, research at the Food Service Technology Center has indicated that a combination oven is sufficiently preheated and ready to cook when the oven temperature is within 2°F of the oven set point.

The preheat test in SelfCooking Control mode measured the time and energy consumed by the oven as it increased the cavity temperature from 75 ± 5°F to the point when the control panel indicated the oven was ready to cook.

For the manual mode idle test, the oven was first allowed to stabilize for one hour at 350°F in combination dry and moist heat mode. Energy and water consumption were subsequently monitored for a 3-hour period. The idle test was also performed with the oven set to SelfCooking Control mode.

Two addional idle tests were performed using manual control mode with the oven operating in dry heat only and moist heat (steam) only settings. The dry heat only test used a cavity temperature of 350°F, and the moist heat (steam) test used a cavity temeprature of 212°F.

Cooking Tests

Whole Chicken Tests

The cooking tests were performed in both manual and SelfCooking Control modes. For the manual mode tests, the oven was stabilized for one hour at 350°F, then the chickens were loaded and cooked to a final average temperature of 200°F.

In SelfCooking Control mode, the chickens were cooked using the “Roasted Chicken” and “Medium Dark” settings. These settings produced the 200°F average final chicken temperature specified by the Test Method. The oven was allowed to preheat until the controls indicated the oven was ready to cook, then the chickens were loaded and the temperature probe inserted into the breast of one of the chickens. The chickens were allowed to cook until the controls indicated cooking was complete.

Tests in each mode were performed with (nominal) 2 ½-pound whole chickens loaded onto manufacturer supplied 8-bird chicken racks. Heavy-load tests consisted of four racks for a total of 32 chickens, and light-load tests consisted of one rack for a total of 8 chickens.

During the testing, energy, time, water consumption, oven temperature, chicken temperature, and condensate drain temperature were measured and logged on a computer at 5-second intervals. Product weight was recorded prior to and immediately after each test to determine weight loss.

The cooking tests were replicated a minimum of three times for each control mode to ensure that the reported results had an uncertainty of less than ±10%. The results from each test run were averaged, and the absolute uncertainty was calculated based on the standard deviation of the results.

The ASTM results reporting sheets appear in Appendix C, and the cooking-energy efficiency data sheets appear in Appendix D of this report.

3 Results

Energy Input Rate and Thermostat Calibration

The maximum energy input rate was 77,870 Btu/h, 3.8% higher than the nameplate rate of 75,000 Btu/h, but within the 5% tolerance of the ASTM standard.

At a thermostat setting of 350°F in manual mode, the oven cavity temperature averaged 359.6°F over the sixty minute test period. After adjusting the thermostat to 340°F, the cavity temperature averaged 350.8°F. Therefore, all tests in manual mode were conducted at an indicated setpoint of 340°F.

Preheat and Idle Rate Tests

Preheat Energy and Time

The preheat test in manual mode consumed 8,022 Btu over a period of 6.3 minutes as the oven cavity temperature reached 348°F. In SelfCooking Control mode, the oven preheated to 473.5°F over a period of 8.7 minutes, while consuming 10,900 Btu. Table 3-1 summarizes the results of the input rate and preheat tests for both control modes. Figure 3-1 shows the oven's energy consumption rate and the cooking cavity temperature during the preheat test in manual mode. Figure 3-2 shows the preheat chart for the oven in Self-Cooking Control mode.

Table 3-1. Input and Preheat Test Results.

Rated Energy Input Rate (Btu/h)	75,000
Measured Energy Input Rate (Btu/h)	77,870
Preheat (Manual Mode):	
Time (min)	6.3
Energy (Btu)	8,022
Preheat (SelfCooking Control Mode):	
Time (min)	8.7
Energy (Btu)	10,900

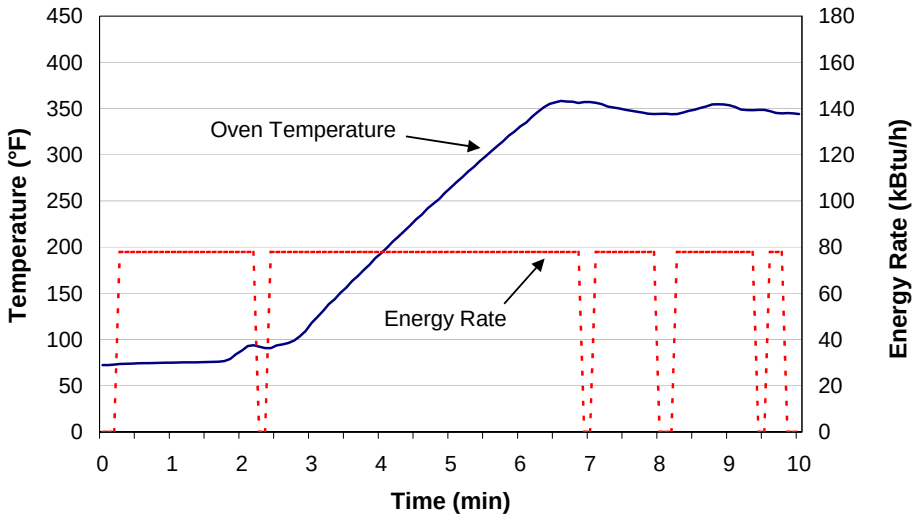

Figure 3-1. Preheat characteristics in manual mode.

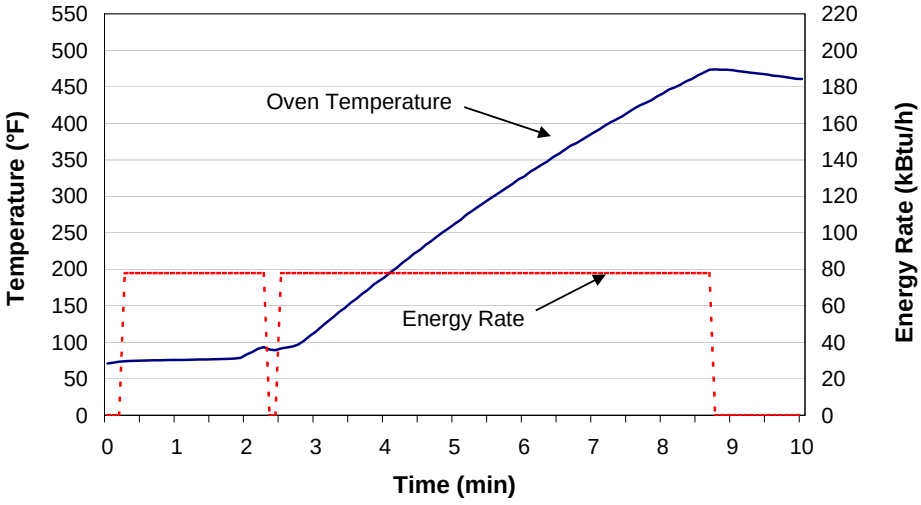

Figure 3-2. Preheat characteristics in SelfCooking Control mode.

Idle Energy Rate

The idle energy and water consumption rates using the combination setting in manual mode were 34,260 Btu/h and 25.5 gal/h, respectively. In SelfCooking Control mode, the oven did not maintain a set cavity temperature, and, therefore, did not consume any gas or water. During the test, the oven used a small amount of electric energy (60 Watts) for the controls. Table 3-2

summarizes the results from the ASTM idle tests, as well as the two additional tests that were run with the dry heat and moist heat settings in manual mode.

Table 3-2. Idle Test Results.

	Self Cooking Control Mode	Manual-Combination Dry and Moist Heat	Manual-Dry Heat Only	Manual-Moist Heat Only
Oven Setpoint (°F)	N/A	350	350	212
Idle Energy Rate (Btu/h)	0.0	34,260	5,900	26,260
Idle Duty Cycle (%)	0.0	50.4	8.7	38.6
Electric Energy Rate (kW)	0.06	0.23	0.28	0.25
Water Consumption Rate (gal/h)	0.0	25.5	0.0	27.2

Cooking Tests

In manual mode, the SCC 62G cooked the heavy-load whole chickens in 38.0 minutes with a cooking-energy efficiency of 58.9%. The cooking-energy rate during the tests was 63,700 Btu/h. Production capacity was 131.5 lb/h, with a product shrinkage of 28.4%. Water consumption was 13.2 gallons, which equaled a rate of 20.9 gal/h. The maximum drain water temperature was 170°F, and the average drain water temperature was 142°F.

In SelfCooking Control mode, heavy-load cook time was 38.6 minutes and the cooking-energy efficiency was 55.9%. The cooking-energy rate was 70,380 Btu/h. Production capacity was 131.0 and product shrinkage was 28.2%. The oven consumed 12.7 gallons of water, equaling a rate of 19.8 gal/h. Maximum drain water temperature was 179°F, with an average of 143°F.

The light-load tests using manual mode were completed in 28.7 minutes, with a cooking-energy efficiency of 33.5%. The cooking-energy rate during the light-load tests was 37,410 Btu/h. The production rate was 41.5 lb/h, and the product shrinkage was 28.6%. Water consumption was 11.8 gallons, which equaled a rate of 24.7 gal/h. Maximum drain water temperature was 158°F, with an average of 136°F.

The light-load tests using SelfCooking Control mode were completed in 28.0 minutes, with a cooking-energy efficiency of 34.6%. The cooking-energy rate during the light-load tests was 47,680 Btu/h. The production rate was 43.6 lb/h, and the product shrinkage was 30.9%. Water consumption was 9.2 gallons, which equaled a rate of 19.7 gal/h. Maximum drain water temperature was 156°F, with an average of 135°F.

Test Results

Cooking-energy efficiency is defined as the quantity of energy consumed by the food and pans (or chicken racks) expressed as a percentage of energy consumed by the oven during the cooking test:

$$\text{Cooking-Energy Efficiency \%} = \frac{E_{chicken} + E_{pans}}{E_{oven}} \times 100\%$$

Energy imparted into the chicken is calculated using the measured values of initial and final temperature, initial and final weight, the specific heat of the chicken, and the heat of vaporization of water at 212°F. Energy imparted into the chicken racks is calculated using the measured values of initial and final temperature of the racks, weight of the racks, and the specific heat of the metal. Energy consumed by the test oven is determined by measuring gas energy use during the test.

Table 3-3 summarizes the results of the cooking-energy efficiency and production capacity tests in both manual and SelfCooking Control modes. Appendix D lists the physical properties and measured values of all the test variables for each test run.

Table 3-3. Whole Chicken Cooking Test Results.

	Manual Mode		SelfCooking Control	
	Heavy-Load	Light-Load	Heavy-Load	Light-Load
Number of Chickens	32	8	32	8
Cook Time (min)	38.0	28.7	38.6	28.0
Cooking Energy Rate (Btu/h)	63,700	37,410	70,380	47,680
Cooking-Energy Efficiency (%)	58.9 ± 5.5	33.5 ± 1.7	55.9 ± 3.2	34.6 ± 1.5
Production Rate (lb/h)	131.5 ± 4.1	41.5 ± 2.5	131.0 ± 11.3	43.6 ± 4.2
Product Shrinkage (%)	28.4	28.6	28.2	30.9
Energy Consumed by Oven (Btu/lb)	492	922	546	1116
Average Condensate Temperature (°F)	142	136	143	135
Water Consumption (gal/h)	20.9	24.7	19.8	19.7

Figure 3-3 illustrates the relationship between cooking-energy efficiency and production rate for the SCC 62G combi oven in SelfCooking Control mode. The oven's production rate is a function of the number of chickens cooked and the cook time. Heavy loads exhibit higher efficiencies due to better use of the available compartment space, as opposed to light-load single rack tests, where most of the space in the cooking compartment is empty.

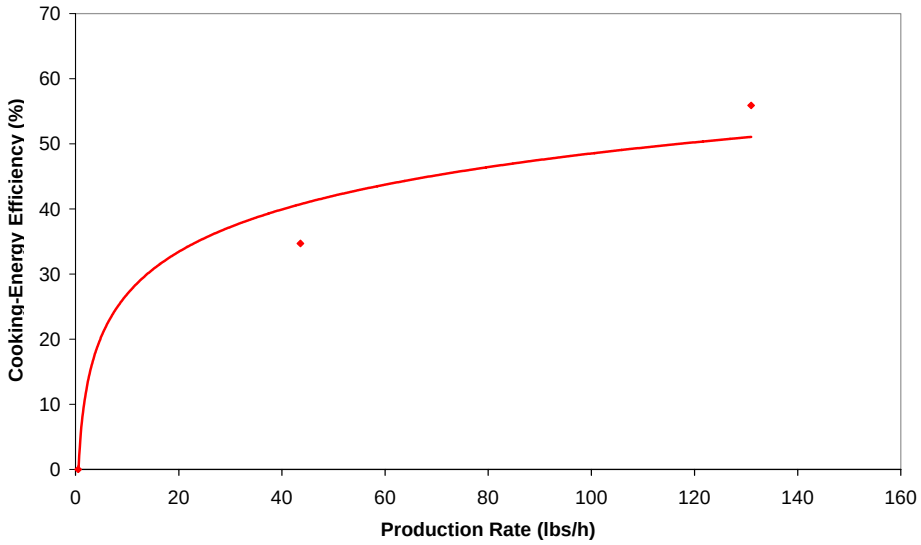

Figure 3-3. Combi part-load cooking-energy efficiency.

Note: Light-load = single rack/load; Heavy-load = 4 racks/load.

Ice-Load Uniformity Test

To evaluate the cooking uniformity of the SCC 62G combination oven, researchers referred to the ice-load uniformity test contained in the ASTM *Standard Test Method for the Performance of Steam Cookers*.[7]

The ice-load uniformity test was designed to emulate frozen vegetables, while allowing researchers to accurately monitor simulated food temperature during the cooking event. For each test, 12 full-size hotel pans filled with ice were used to determine the steaming uniformity within the cooking cavity. During the test, the last pan reached a temperature of 170°F in 39.3 minutes. At this time, the maximum temperature difference between the hottest and coldest pan was 5.8°F. The last pan to reach the 170°F endpoint required an additional 1.5 minutes beyond the cook time of the fastest pan. Figure 3-4 shows the individual pan temperatures during a single ice-load test and Table 3-4 summarizes the results of the ice-load uniformity test.

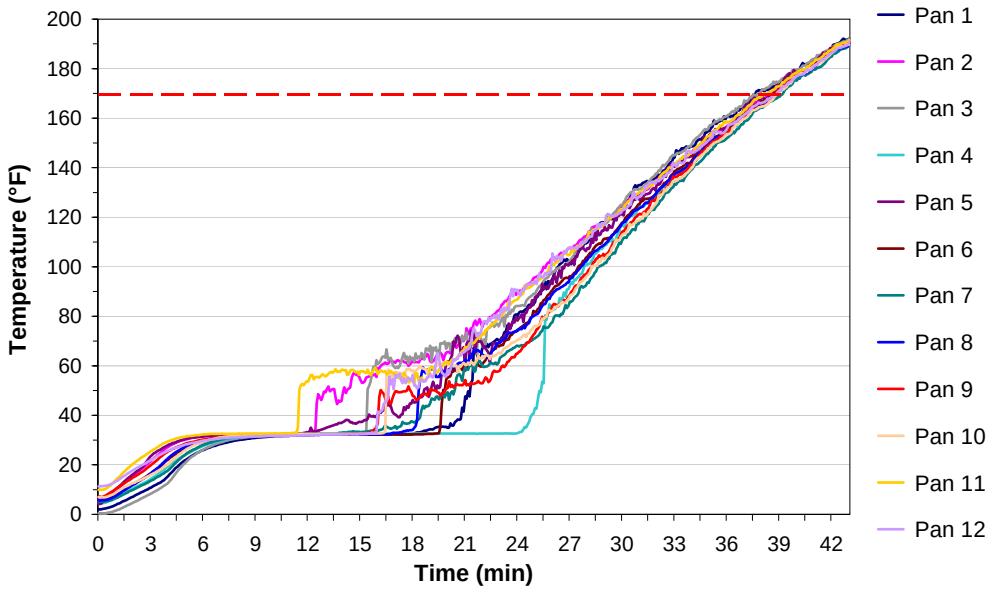

Figure 3-4.
Ice-load temperature profile.

Table 3-4. Ice-Load Uniformity Test Results.

Number of Pans	12
Cook Time (min)	39.3
Initial Ice-Load Temperature (°F)	4.3
Final Ice-Load Temperatures (°F):	173.4
Pan 1 (Top Front)	172.7
Pan 2	174.3
Pan 3	171.6
Pan 4	173.4
Pan 5	172.6
Pan 6	170.4
Pan 7	173.0
Pan 8	175.3
Pan 9	172.1
Pan 10	176.2
Pan 11	173.8
Pan 12 (Bottom Rear)	175.3
Maximum Temperature Difference (°F)	5.8
Maximum Time Delay* (min)	1.5

* Time required for ice load in last pan to reach 170°F after first pan reaches the endpoint.

Energy Cost Model

Appliance test results are useful not only for benchmarking appliance performance, but also for estimating appliance energy consumption. Because the SCC 62G was tested in both Manual and SelfCooking Control modes, a model was prepared for each set of results. Table 3-5 shows the assumptions for the oven's operation in SelfCooking Control mode.

Table 3-5. Daily Oven Operation Assumptions in Self Cooking Control mode.

Operating Time per Day (h)	12
Operating Days per Year (h)	365
Number of Preheats per Day	6*
Total Amount of Food Cooked per Day (lb)	200
Percentage of Food Cooked Under Heavy-Load Conditions (%)	80
Percentage of Food Cooked Under Light-Load Conditions (%)	20

* The SelfCooking Control mode preheats to a ready state before each cooking event.

Assuming the SCC 62G oven cooked 200 lbs of food a day (12 hours), 365 days a year, with six preheats per day, it is estimated the oven would consume 712.2 Therms of gas and 547.5 kWh of electricity annually. Using rates of $1.20 per Therm and $0.15 per kWh, this translates to an annual cost to operate of $937 per year. This assumes the oven is always operated in the SelfCooking Control mode.

Table 3-6 shows the assumptions for the oven's operation in Manual mode.

Table 3-6. Daily Oven Operation Assumptions in Manual mode.

Operating Time per Day (h)	12
Operating Days per Year (h)	365
Number of Preheats per Day	2*
Total Amount of Food Cooked per Day (lb)	200
Percentage of Food Cooked Under Heavy-Load Conditions (%)	80
Percentage of Food Cooked Under Light-Load Conditions (%)	20

* This assumes the oven is turned off between morning and afternoon shifts.

Assuming the SCC 62G oven cooked 200 lbs of food a day (12 hours), 365 days a year, with two preheats per day, it is estimated the oven would consume 1,675.0 Therms of gas and 1,043.9 kWh of electricity annually. Using rates of $1.20 per Therm and $0.15 per kWh, this translates to an annual cost to operate of $2,167 per year. This assumes the oven is always operated in manual mode. Appendix E presents detailed calculations for the energy cost model.

4 Conclusions

The SCC 62G is the newest generation of gas combination oven from Rational, incorporating the new SelfCooking Control. This is a step forward in control technology, giving the oven the ability to measure and adjust temperature, humidity and cook time during the cooking event. The advantage to the operator is consistant food product, regardless of who is operating the oven. The oven can also run in manual mode which allows the operator to select specific temperature and humidity settings.

During the cooking tests, the oven produced similar heavy-load cooking-energy efficiencies for each control mode— 58.9% for manual and 55.9% using the SelfCooking Control. Each of these efficiency numbers are relatively high among ovens currently tested by the FSTC. [2-6]

Production capacities for the two control modes were nearly identical. The SCC 62G produced 131.5 lbs of chicken per hour in manual mode and 131.0 lbs/h with the SelfCooking Control. These are the highest production capacities seen to date from a combination oven of this size tested by the FSTC. [2-6]

From an energy standpoint, the preferred control mode would be the SelfCooking Control, due mainly to idle energy consumption. In manual control mode, the oven had an idle energy rate of 34,260 Btu/h, and used water at a rate of 25.5 gal/h. In SelfCooking Control mode, the oven turned off after the completion of each cooking event and therfore used no gas or water, and only a small amount of electricity for the controls. These energy savings more than make up for the need to preheat before each cooking event, as shown by the energy cost models.

Conclusions

With the low energy consumption and ease of operator use associated with the SelfCooking Control, the Rational SCC 62G is a good candidate for any facility looking to add the versatility of a combination oven.

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6. Sorensen, G., Zabrowski, D., 2006. *Cleveland, Model OGS-6.20 Gas Combination Oven Performance Test: Application of ASTM Standard Test Method F1639-05.* Food Service Technology Center Report 5011.06.02, April.

7. American Society for Testing and Materials, 2005. *Standard Test Method for the Performance of Steam Cookers.* ASTM Designation F1484–05. In annual book of ASTM Standards, West Conshohocken, PA.

A Glossary

Boiler

Self-contained electric, gas, or steam coil powered vessel wherein water is boiled to produce steam for the steam cooker. Also called a steam generator.

Condensate

A mixture of condensed steam and cooling water, exiting the steam cooker and directed to the floor drain.

Condensate Temperature (°F)

The temperature at which the condensate enters the floor drain.

Cooking Energy (kWh or kBtu)

The total energy consumed by an appliance as it is used to cook a specified food product.

Cooking Energy Consumption Rate
(kW or kBtu/h)

The average rate of energy consumption during the cooking period.

Cooking-Energy Efficiency (%)

The quantity of energy input to the food products; expressed as a percentage of the quantity of energy input to the appliance during the heavy- and light-load tests.

Duty Cycle (%)
Load Factor

The average energy consumption rate (based on a specified operating period for the appliance) expressed as a percentage of the measured energy input rate.

$$\text{Duty Cycle} = \frac{\text{Average Energy Consumption Rate}}{\text{Measured Energy Input Rate}} \times 100$$

Energy Input Rate (kW or kBtu/h)
Energy Consumption Rate
Energy Rate

The peak rate at which an appliance will consume energy, typically reflected during preheat.

Heating Value (Btu/ft^3)
Heating Content

The quantity of heat (energy) generated by the combustion of fuel. For natural gas, this quantity varies depending on the constituents of the gas.

Ice Load

12 x 20 x 2½ in. hotel pan filled with 8.0 ± 0.2 lb of water and subsequently frozen to 0±5°F. This is used to simulate a food product load in the ice load cooking uniformity test.

Idle Energy Rate (kW or Btu/h)
Idle Energy Input Rate
Idle Rate

The rate of appliance energy consumption while it is "holding" or maintaining a stabilized operating condition or temperature.

Idle Temperature (°F, Setting)

The temperature of the cooking cavity/surface (selected by the appliance operator or specified for a controlled test) that is maintained by the appliance under an idle condition.

Idle Duty Cycle (%)
Idle Energy Factor

The idle energy consumption rate expressed as a percentage of the measured energy input rate.

$$\text{Idle Duty Cycle} = \frac{\text{Idle Energy Consumption Rate}}{\text{Measured Energy Input Rate}} \times 100$$

Glossary

Measured Input Rate (kW or Btu/h)
Measured Energy Input Rate
Measured Peak Energy Input Rate

The maximum or peak rate at which an appliance consumes energy, typically reflected during appliance preheat (i.e., the period of operation when all burners or elements are "on").

Pilot Energy Rate (kBtu/h)
Pilot Energy Consumption Rate

The rate of energy consumption by the standing or constant pilot while the appliance is not being operated (i.e., when the thermostats or control knobs have been turned off by the food service operator).

Preheat Energy (kWh or Btu)
Preheat Energy Consumption

The total amount of energy consumed by an appliance during the preheat period.

Preheat Rate (°F/min)

The rate at which the cooking surface heats during a preheat.

Preheat Time (minute)
Preheat Period

The time required for an appliance to heat from the ambient room temperature (75 ± 5°F) to a specified (and calibrated) operating temperature or thermostat set point.

Production Capacity (lb/h)

The maximum production rate of an appliance while cooking a specified food product in accordance with the heavy-load cooking test.

Production Rate (lb/h)
Productivity

The average rate at which an appliance brings a specified food product to a specified "cooked" condition.

Rated Energy Input Rate
(kW, W or Btu/h, Btu/h)
Input Rating (ANSI definition)
Nameplate Energy Input Rate
Rated Input

The maximum or peak rate at which an appliance consumes energy as rated by the manufacturer and specified on the nameplate.

Steam Cooker

Cooking appliance wherein heat is imparted to food in a closed compartment by direct contact with steam. The compartment can be at or above atmospheric pressure. The steam can be static or circulated.

Test Method

A definitive procedure for the identification, measurement, and evaluation of one or more qualities, characteristics, or properties of a material, product, system, or service that produces a test result.

Typical Day

A sampled day of average appliance usage based on observations and/or operator interviews, used to develop an energy cost model for the appliance.

Water Consumption (gal/h)

Water consumed by the steam cooker. Includes both water used in the production of steam and cooling water (if applicable) for condensing/cooling unused steam.

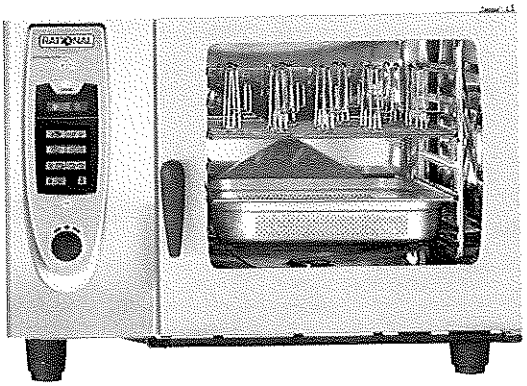
B Appliance Specifications

Appendix B includes the product literature for the Rational, Model SCC 62G gas combination oven.

RATIONAL

Item No. _____

SelfCooking Center® 62 Gas (6 x 18" x 26"/12 x 12" x 20")



SelfCooking Control® - 7 operating modes:

Roasts

Grills

Poultry

Fish

Baked dishes

Side dishes

Finishing®

Combi-Steamer mode - 3 operating modes:

Moist Heat (steam) 85 °F-265 °F (30 °-130 °C)

Dry Heat (hot air) 85 °F-575 °F (30 °-300 °C)

Combination of moist heat and dry heat 85 °F-575 °F (30 °-300 °C)

Options:

Left-hand hinged doors • Safety door lock • RS 232 serial interface • RS 485 converter • Ethernet interface • Integral fat drain • Special voltages • lockable control panel • unit with mobile oven rack rack • unit with souse-vide core temperature probe

Accessories:

• Stands • Heat shield for left hand side wall • Grids, containers, trays, CombiFry® (frying baskets) • Superspike (poultry grid), CombiGrill® grids • Mobile plate rack • Transport trolley • Thermocover • CombiLink® software package • Combi-Duo kits for 2 units one on top of the other • Adapters for sheet pans 18"x26" • Cleaner Tabs and Rinse Aid-Tabs

Description:

Unit for the automatic cooking **(SelfCooking Control® Mode)** of roasts, grills, poultry, fish, baked dishes, side dishes, and for automatic Finishing®.

Combi-Steamer **(Combi-Steamer Mode)** for most cooking methods employed in the catering trade, with optional use of steam and hot air, separately, sequentially or combined.

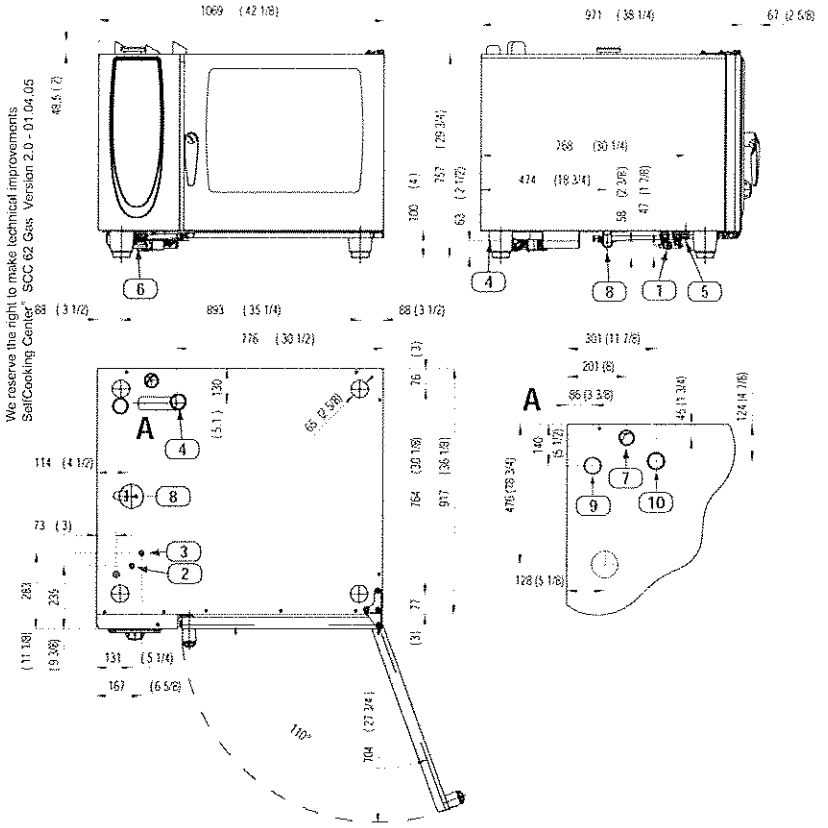
Features:

High-performance fresh steam generator • Microprocessor-controlled cooking process • Clear control panel with pictograms • Self-explanatory operation concept with easy-to-read clear text displays which can be read from any angle, Help Function, touch screen, press buttons and central dial with Push Function to confirm entries • Individual programming of at least 350 cooking programs with up to 12 steps • Rack monitoring with individual time programming of each rack in non-stop loading • Adjustable foreign languages display • Free time selection from 0-24 hours • Sensor-controlled cabinet humidity, actual humidity in cabinet can be adjusted and requested on the control panel • Demand-related energy supply by means of modulating, low-noise high-performance blower burner system • Core temperature probe with 6 measuring points and automatic correction if inserted incorrectly • Positioning aid for core temperature probe • Function Delta-T cooking • Automatic cleaning system independent of mains pressure, with 6 cleaning stages, unsupervised cleaning even overnight • Seamless hygienic cooking cabinet with rounded corners • Automatic, active rinsing and drainage of steam generator by pump • Limescale level of steam generator automatically sensed, automatic indication of when descaling is necessary, limescale level displayed at any time • Menu-guided descaling program • Preselected starting time adjustable for time and date • Temperature unit adjustable in °C or °F • ServiceDiagnostic System with automatic service notices display • Airflow optimized cooking cabinet • Integral, maintenance-free grease extraction system with no additional grease filter • Safety temperature limiter for cabinet and steam generator • Halogen cooking cabinet lighting from shock-proof CERAN glass • Cool down function for fast cabinet fan cooling • Automatic vapor quenching • Humidifying function can be programmed with humidity values from 85 °F-500 °F (30 °-260 °C) for Dry Heat and Combination • 5 air speeds programmable • Integral fan impeller brake • Operating and warning displays • Rear-ventilated double glass doors, hinged inside pane for easy cleaning • Door handle with right/left and slam function • Door locking positions • Proximity door contact switch • Drip collector and door drip pan with continuous discharge to unit drain • Press-fit cabinet seal • Lengthwise loading for accessories • Hinging rack with additional rail for grease drip container, hinging racks swivel for easy cleaning • 3 grids 20"x 24" (2/1 GN) • Rail distance 2 5/8" (68 mm) • Maximum rack height 5 1/4 ft. when original stand used • U-shaped rack rails with notched recesses for easy loading • All-round heat insulation • Swivel air baffle with quick-release locks • Hinged control panel allows front servicing and inspection • Integral hand shower with infinitely variable regulation, automatic retracting system and integral water shut-off function • Separate solenoid valves for normal and soft water • Height-adjustable feet • HACCP data memory and output via integral USB interface • Material inside and out CrNi steel CNS 304.

Approvals:

NRTL/C

Consultant/Contractor:



SelfCooking Center® 62 Gas (6 x 18" x 26"/12 x 12" x 20")

1 Common water supply (cold water)
2 Water supply cold water
3 Water supply soft or hot water
4 Drain
5 Electrical connection
6 Equipotential bonding
7 Vent pipe 2" (50 mm)
8 Gas supply ¾"
9 Exhaust pipe steam
10 Exhaust pipe hot air

Minimum Clearance 2" (50 mm)
Left side 20" recommended for servicing unit without the ability to move for servicing

Measurements in mm (inches)

Technical specification:

Electrical connection:
Connected load: 0.4 kW
1 NAC 120 V cord supplied
Recommended breaker: 1 x 15 A

Notes:
Dedicated circuit breaker required
Do not use fuses
Dedicated ground wire required
Comes with 8' cord and 5-15 plug
Wire size: AWG 14-3

Natural gas/LPG liquid gas:
Max. rated thermal load:
81.000 BTU/81.000 BTU (21.5 kW/23 kW)
Hot air:
81.000 BTU/81.000 BTU (21.5 kW/23 kW)
Moist heat:
75.000 BTU/75.000 BTU (20 kW/21 kW)

Water connection:
3/4" NPS for 1/2" pressure hose
Note: Connect to drinking water only.

Drain connection:
2" (50 mm) O.D. (outside diameter)
Non-threaded stainless outlet
Note: connect only to 2" (50 mm) diameter steam temperature resistant pipe
Gas connection: 3/4"
Required gas pressure:
Natural gas 6" to 10.5"
LPG 10" to 13"
Dimensions:
Width: 42 1/8" (1069 mm)
Height: 29 3/4" (757 mm)
Depth: 38 1/4" (971 mm)

Shipping weight
Net: 370 lbs (168 kg)
Gross: 391 lbs (177.5 kg)
Cubing packing: 46.9 cu.ft. (1.33 m³)
Freight class: 85, F.O.B.
Cooking medium:
Moist heat 85 °F-265 °F
Dry heat: 85 °F-575 °F
Combination: 85 °F-575 °F

Capacity:
Full size sheet pans: 6 x 18" x 26"
Steam pans: 12 x 12" x 20"
GN-container/grids : 6 x 2/1 GN
Lengthwise loading for sheet pans and 12 x 1/1 GN

External Heat Source Proximity:
Each Combi-Steamer must be clear of all external sources of heat • Increased appliance temperature may cause damage to unit components • Installations must comply with all local electrical, plumbing and ventilation codes • RATIONAL recommends water treatment based on the results of water testing • Consult owners manual for additional installation requirements.

Bidding specifications:
The RATIONAL SelfCooking Center® unit cooks with hot air and pressureless steam – singular, sequentially and in combination.
Cooking Modes: 7 SelfCooking Control® Modes for the automatic cooking of roasts, grills, poultry, fish, baked dishes, side dishes, and for automatic Finishing®
3 Combi-Steamer modes for Steaming (85 °F-265 °F), Hot Air (85 °F-575 °F), Combi-Steaming (85 °F-575 °F).

Unit shall be equipped with:
High-performance fresh steam generator • Clear control panel with pictograms • Core temperature probe with 6 measuring points • Sensor-controlled cabinet humidity • Automatic cleaning system • Seamless hygienic cooking cabinet with rounded corners • Integral, maintenance-free grease extraction system • Halogen cooking cabinet lighting • Automatic vapor quenching • Humidifying function • 5 air speeds programmable • Integral fan impeller brake • Rear-ventilated double glass doors • Door handle with right/left and slam function • Drip collector and door drip pan • Mobile oven rack• All-round heat insulation • Integral hand shower with infinitely variable regulation, automatic retracting • Separate solenoid valves for normal and soft water • HACCP data memory and output via integral USB interface. • With optional rack adapter Art.-No.: 60.62.050

RATIONAL Cooking Systems
455 E. State Parkway, Suite 101 – Schaumburg IL, 60173 USA
Tel.: +1 847 2735000 / Fax.: +1 8477559583

C Results Reporting Sheets

Manufacturer:	Rational
Model:	SCC 62G
Date:	June 2006

Test Combination Oven

Description of operational characteristics: The Rational, Model SCC 62G Combi Oven, is a full size, 6-pan capacity, gas combination oven with fresh steam generator (Figure 1-1). The oven is powered by a 75,000 Btu/h burner located on the left-hand side of the cooking cavity. The oven incorporates a multi-speed, single direction fan driven by a brushless DC motor. The SCC 62G oven has a unique SelfCooking Control mode that automates the cooking process for numerous food products.

Apparatus

The combination oven was installed in accordance with the manufacturer's instructions under a 4-foot-deep canopy hood, with the lower edge of the hood 6 feet, 6 inches above the floor and a minimum of 6 inches inside the vertical front edge of the hood. The exhaust ventilation operated at a nominal rate of 300 cfm per linear foot of hood with the ambient temperature maintained between 75 ± 5°F. All test apparatus were installed in accordance with Section 9 of the ASTM test method.[1]

The combination oven was instrumented using a positive displacement gas meter with a resolution of 0.05 ft^3, and a watt hour transducer with a resolution of 0.00001Wh. A computerized data acquisition system recorded test information at 5-second intervals for the entire test method application. All test apparatus were installed in accordance with Section 9 of the ASTM test method.

Energy Input Rate

Gas Heating Value	1014 Btu/ft^3
Measured	77,870 Btu/h
Rated	75,000 Btu/h
Percent Difference between Measured and Rated	3.8%
Electric Energy Rate	0.40 kW

Appliance Preheat Energy Consumption and Duration- Manual Mode

Oven Setting	Manual Mode, 340°F
Gas Heating Value	1017 Btu/ft^3
Energy Consumption	8,022 Btu
Duration	6.3 min

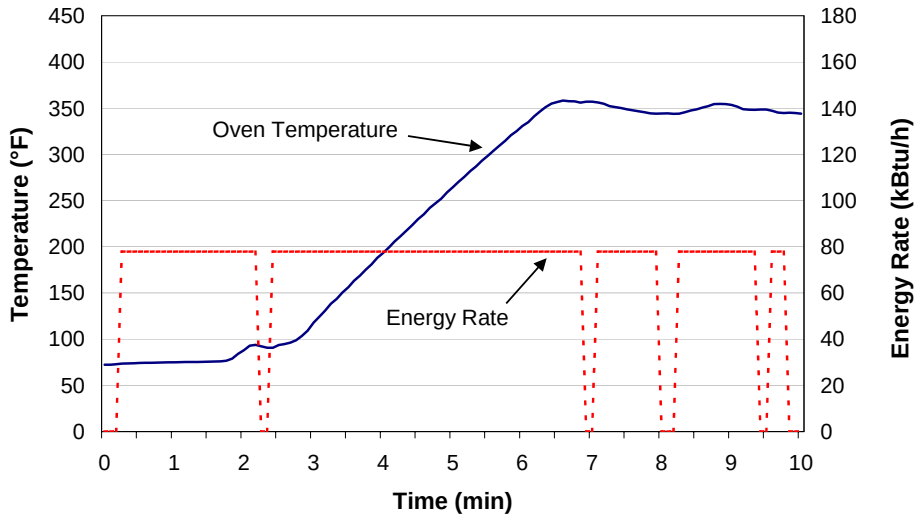


Figure C-1. Preheat Curve in Manual Mode

Appliance Preheat Energy Consumption and Duration- Self Cooking Control Mode

Oven Setting	Roasted Chicken, Medium Dark
Gas Heating Value	1014 Btu/ft^3
Energy Consumption	10,900 Btu
Duration	8.7 min

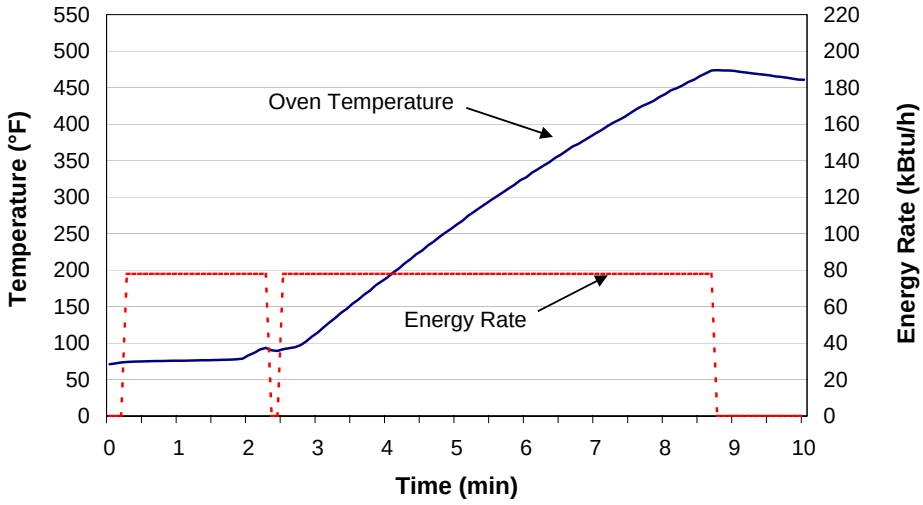


Figure C-2. Preheat Curve in SelfCooking Control Mode

Appliance Idle Energy Rate- Manual Mode

Oven Setting	Manual Mode, 340°F
Gas Heating Value	1020 Btu/ft^3
Idle Energy Rate	34,260 Btu/h
Electric Energy Rate	0.24 kW
Idle Water Consumption	25.5 gal/h

Appliance Idle Energy Rate- SelfCooking Control Mode

Oven Setting	SelfCooking Control
Gas Heating Value	N/A
Idle Energy Rate	N/A
Electric Energy Rate	0.06 kW
Idle Water Consumption	N/A

Whole Chicken Cooking Tests:

Heavy-Load- Manual Mode:

Oven Setting	Combination Dry and Moist Heat, 340°F
Gas Heating Value	1022 Btu/ft^3
Number of Chickens	32
Cooking Time	38.0 min
Cooking-Energy Efficiency	58.9 ± 5.5%
Cooking Energy Rate	63,700 Btu/h
Electric Energy Rate	0.28 kW
Production Capacity	131.5 ± 4.1 lb/h
Shrinkage	28.2 %
Water Consumption Rate	20.9 gal/h
Condensate Temperature Maximum	170°F
Condensate Temperature Average	142°F

Heavy-Load- SelfCooking Control Mode:

Oven Setting	Roasted Chicken, Medium Dark
Gas Heating Value	1022 Btu/ft^3
Number of Chickens	32
Cooking Time	38.6 min
Cooking-Energy Efficiency	55.9 ± 3.2%
Cooking Energy Rate	70,380 Btu/h
Electric Energy Rate	0.31 kW
Production Capacity	131.0 ± 11.3 lb/h
Shrinkage	28.2 %

Water Consumption Rate	19.8 gal/h
Condensate Temperature Maximum	179°F
Condensate Temperature Average	143°F

Light-Load- Manual Mode:

Oven Setting	Combination Dry and Moist Heat, 340°F
Gas Heating Value	1019 Btu/ft^3
Number of Chickens	8
Cooking Time	28.7 min
Cooking-Energy Efficiency	33.5 ± 1.7%
Cooking Energy Rate	37,410 Btu/h
Electric Energy Rate	0.24 kW
Production Rate	41.5 ± 2.5 lb/h
Shrinkage	28.6%
Water Consumption Rate	24.7 gal/h
Condensate Temperature Maximum	158°F
Condensate Temperature Average	136°F

Light-Load- SelfCooking Control Mode:

Oven Setting	Roasted Chicken, Medium Dark
Gas Heating Value	1018 Btu/ft^3
Number of Chickens	8
Cooking Time	28.0 min
Cooking-Energy Efficiency	34.6 ± 1.5%
Cooking Energy Rate	47,680 Btu/h
Electric Energy Rate	0.26 kW
Production Rate	43.6 ± 4.2 lb/h
Shrinkage	30.9%
Water Consumption Rate	19.7 gal/h
Condensate Temperature Maximum	156°F
Condensate Temperature Average	135°F

Ice-Loads

Cooking Time, Temperature Uniformity

Oven Setting		Manual Steam Mode, 212°F
Test Voltage		N/A
Cooking Time		39.3 min
Initial Average Temperature		4.3°F
Final Average Temperature		173.4°F
Average Final Ice Load Temperatures	Pan 1 (Top Front)	172.7°F
	Pan 2	174.3°F
	Pan 3	171.6°F
	Pan 4	173.4°F
	Pan 5	172.6°F
	Pan 6	170.4°F
	Pan 7	173.0°F
	Pan 8	175.3°F
	Pan 9	172.1°F
	Pan 10	176.2°F
	Pan 11	173.8°F
	Pan 12 (Bottom Rear)	175.3°F
Maximum Temperature Difference		5.8°F
Maximum Time Delay		1.5 min

D Cooking-Energy Efficiency Data

Table D-1. Specific Heat and Latent Heat.

Specific Heat (Btu/lb, °F)	
Whole Chickens	0.80
Stainless Steel (Racks)	0.11
Latent Heat (Btu/lb)	
Vaporization, Water	970

Cooking-Energy Efficiency Data

Table D-2. Heavy-Load Whole Chicken Data, Manual Mode

	Replication 1	Replication 2	Replication 3
Measured Values			
Number of Chickens	32	32	32
Cook Time (min)	38.3	38.0	37.7
Oven Energy Consumption (Btu)	40,790	40,615	41,398
Temperature of Raw Chickens (°F)	40.7	38.1	38.3
Temperature of Cooked Chickens (°F)	200.0	200.0	200.1
Weight of Pans (lb)	19.01	19.01	19.01
Initial Weight of Raw Chickens (lb)	84.527	83.875	81.426
Final Weight of Cooked Chickens, including liquid (lb)	70.289	70.753	68.458
Net Weight of Cooked Chickens (lb)	59.970	59.284	60.147
Maximum Condensate Temperature (°F)	169.9	171.1	169.0
Average Condensate Temperature (°F)	143.9	141.7	140.4
Water Consumption (gal)	15.2	12.9	11.6
Calculated Values			
Sensible Heat (Btu)	10,772	10,863	10,540
Latent – Heat of Vaporization (Btu)	13,811	12,728	12,579
Total Energy to Food (Btu)	24,583	23,592	23,119
Energy to Food (Btu/lb)	291	281	284
Energy to Pans (Btu)	333	339	338
Energy Consumed by the Combination Oven (Btu)	40,790	40,615	41,398
Energy to Oven (Btu/lb of food cooked)	483	484	508
Results			
Cooking Energy Rate (Btu/h)	62,970	63,190	64,930
Cooking-Energy Efficiency (%)	61.1	58.9	56.7
Production Capacity (lb/h)	132.4	132.4	129.6
Product Shrinkage (%)	29.1	29.3	26.1
Water Consumption (gal/h)	23.8	20.4	18.5

Cooking-Energy Efficiency Data

Table D-3. Heavy-Load Whole Chicken Data, SelfCooking Control Mode

	Replication 1	Replication 2	Replication 3
Measured Values			
Number of Chickens	32	32	32
Cook Time (min)	36.8	38.1	40.9
Oven Energy Consumption (Btu)	40,367	47,195	50,566
Temperature of Raw Chickens (°F)	39.2	38.5	38.4
Temperature of Cooked Chickens (°F)	198.2	201.7	202.9
Weight of Pans (lb)	19.01	19.01	19.01
Initial Weight of Raw Chickens (lb)	82.277	84.490	85.717
Final Weight of Cooked Chickens, including liquid (lb)	70.422	69.399	67.786
Net Weight of Cooked Chickens (lb)	61.743	61.121	58.348
Maximum Condensate Temperature (°F)	181.5	178.6	176.5
Average Condensate Temperature (°F)	142.2	144.5	140.8
Water Consumption (gal)	12.1	12.9	13.2
Calculated Values			
Sensible Heat (Btu)	10,466	11,031	11,280
Latent – Heat of Vaporization (Btu)	11,499	14,638	17,393
Total Energy to Food (Btu)	21,965	25,669	28.673
Energy to Food (Btu/lb)	267	304	335
Energy to Pans (Btu)	333	341	344
Energy Consumed by the Combination Oven (Btu)	40,367	47,195	50,566
Energy to Oven (Btu/lb of food cooked)	491	559	590
Results			
Cooking Energy Rate (Btu/h)	64,750	73,270	73,130
Cooking-Energy Efficiency (%)	55.2	55.1	57.4
Production Capacity (lb/h)	134.1	133.1	125.7
Product Shrinkage (%)	25.0	27.7	31.9
Water Consumption (gal/h)	19.7	20.2	19.4

Cooking-Energy Efficiency Data

Table D-4. Light-Load Whole Chicken Data, Manual Mode

	Replication 1	Replication 2	Replication 3
Measured Values			
Number of Chickens	8	8	8
Cook Time (min)	29.8	27.8	28.6
Oven Energy Consumption (Btu)	19,247	18,943	16,720
Temperature of Raw Chickens (°F)	39.2	38.7	38.3
Temperature of Cooked Chickens (°F)	200.0	200.0	200.0
Weight of Pans (lb)	6.12	6.12	6.12
Initial Weight of Raw Chickens (lb)	20.158	19.738	19.670
Final Weight of Cooked Chickens, including liquid (lb)	16.363	16.034	16.504
Net Weight of Cooked Chickens (lb)	14.652	13.511	14.343
Maximum Condensate Temperature (°F)	160.6	162.5	150.2
Average Condensate Temperature (°F)	136.0	141.4	129.6
Water Consumption (gal)	12.8	11.4	11.3
Calculated Values			
Sensible Heat (Btu)	2593	2547	2545
Latent – Heat of Vaporization (Btu)	3681	3593	3071
Total Energy to Food (Btu)	6274	6140	5616
Energy to Food (Btu/lb)	311	311	285
Energy to Pans (Btu)	108	109	109
Energy Consumed by the Combination Oven (Btu)	19,247	18,943	16,720
Energy to Oven (Btu/lb of food cooked)	955	960	850
Results			
Cooking Energy Rate (Btu/h)	37,907	40,060	34,268
Cooking-Energy Efficiency (%)	33.2	33.0	34.2
Production Rate (lb/h)	40.6	42.6	41.3
Product Shrinkage (%)	27.3	31.5	27.1
Water Consumption (gal/h)	25.8	24.6	23.7

Cooking-Energy Efficiency Data

Table D-5. Light-Load Whole Chicken Data, SelfCooking Control Mode

	Replication 1	Replication 2	Replication 3
Measured Values			
Number of Chickens	8	8	8
Cook Time (min)	27.6	29.2	27.3
Oven Energy Consumption (Btu)	21,959	23,913	22,204
Temperature of Raw Chickens (°F)	39.4	38.0	39.2
Temperature of Cooked Chickens (°F)	193.0	195.4	196.1
Weight of Pans (lb)	6.05	6.12	6.06
Initial Weight of Raw Chickens (lb)	20.327	20.267	20.412
Final Weight of Cooked Chickens, including liquid (lb)	15.056	14.632	15.201
Net Weight of Cooked Chickens (lb)	14.141	13.70	14.332
Maximum Condensate Temperature (°F)	158.5	153.1	155.8
Average Condensate Temperature (°F)	132.5	136.9	134.7
Water Consumption (gal)	8.46	9.79	9.38
Calculated Values			
Sensible Heat (Btu)	2498	2552	2562
Latent – Heat of Vaporization (Btu)	5113	5466	5055
Total Energy to Food (Btu)	7611	8018	7617
Energy to Food (Btu/lb)	374	396	373
Energy to Pans (Btu)	102	106	105
Energy Consumed by the Combination Oven (Btu)	21,959	23,913	22,204
Energy to Oven (Btu/lb of food cooked)	1080	1180	1088
Results			
Cooking Energy Rate (Btu/h)	46,900	48,245	47,910
Cooking-Energy Efficiency (%)	35.1	34.0	34.8
Production Rate (lb/h)	44.2	41.6	44.9
Product Shrinkage (%)	30.4	32.4	29.8
Water Consumption (gal/h)	18.4	20.1	20.6

Cooking-Energy Efficiency Data

Table D-6. Whole Chickens Cooking-Energy Efficiency and Production Capacity Statistics, Manual Mode.

	Cooking-Energy Efficiency		
	Heavy-Load	Light-Load	Production Capacity
Replicate #1	61.1	33.2	132.4
Replicate #2	58.9	33.0	132.4
Replicate #3	56.7	34.2	129.6
Average	58.9	33.5	131.5
Standard Deviation	2.21	0.68	1.64
Absolute Uncertainty	5.5	1.7	4.1
Percent Uncertainty	9.3	5.0	3.1

Table D-7. Whole Chickens Cooking-Energy Efficiency and Production Capacity Statistics, Self Cooking Control.

	Cooking-Energy Efficiency		
	Heavy-Load	Light-Load	Production Capacity
Replicate #1	55.2	35.1	134.1
Replicate #2	55.1	34.0	133.1
Replicate #3	57.4	34.8	125.7
Average	55.9	34.6	131.0
Standard Deviation	1.28	0.59	4.6
Absolute Uncertainty	3.2	1.5	11.3
Percent Uncertainty	5.7	4.2	8.7

E Energy Cost Model

Procedure for Calculating the Energy Consumption of a Combination Oven Based on Reported Test Results.

Appliance test results are useful not only for benchmarking appliance performance, but also for estimating appliance energy consumption. The following procedure is a guideline for estimating combination oven energy consumption based on data obtained from applying the appropriate test method.

The intent of this Appendix is to present a standard method for estimating oven energy consumption based on ASTM performance test results. The examples contained herein are for informational purposes only, and should not be considered an absolute. To obtain an accurate estimate of energy consumption for a particular operation, parameters specific to that operation should be used (for example, operating time and amount of food cooked under heavy and light loads).

The calculation will proceed as follows: First, determine the appliance operating time and total number of preheats. Then estimate the quantity of food cooked and establish the breakdown among heavy (fully loaded oven), and light (single-rack) loads. For example, an oven operating for 12 h a day with two preheats cooked 200 lb of food: 80% of the food was cooked under heavy-load conditions and 20% was cooked under light-load conditions. Calculate the energy due to cooking heavy- and light-load cooking rates, and then calculate the idle energy consumption. The total daily energy is the sum of the components plus the preheat energy. For simplicity, assume that subsequent preheats require the same time and energy as the first preheat of the day.

For the Rational SCC 62G oven, the model was applied to the results obtained in both SelfCooking Control and manual modes. When in SelfCooking Control mode, the oven does not maintain the oven temperature while idling (standby). Because the oven must preheat before each cooking event, the number of preheats in the cost model is 6, equal to the number of loads required to cook the specified amount of chicken. In Self-Cooking Control mode, the chickens were cooked using the Roasted Chicken, Medium Dark settings, which produced the 200°F average final chicken temperature specified by the Test Method.

The application of the test method to the SCC 62G gas combination oven in SelfCooking Control Mode yielded the following results:

Table E-1: Gas Oven Test Results in SelfCooking Control Mode.

Test	Result
Preheat Time	8.7 min
Preheat Energy, Gas	10,900 Btu
Preheat Energy, Electric	0.056 kWh
Idle Energy Rate, Gas*	0.0 Btu/h
Idle Energy Rate, Electric	0.06 kW
Heavy-load Cooking Energy Rate, Gas	70,380 Btu/h
Heavy-load Cooking Energy Rate, Electric	0.31 kW
Light-load Cooking Energy Rate, Gas	47,680 Btu/h
Light-load Cooking Energy Rate, Electric	0.26 kW
Production Capacity	131.0 lb/h
Light-load Production Rate	43.6 lb/h

*Note: Oven does not maintain temperature during idle and therefore does not consume gas.

***Step 1*—The operation being modeled has the following parameters.**

Table E-2: Oven Operation Assumptions.

Operating Time per Day	12 h
Operating Days per Year	365 d
Number of Preheats per Day*	6
Total Amount of Food Cooked per Day	200 lb
Percentage of Food Cooked Under Heavy-load Conditions	80 %
Percentage of Food Cooked Under Light-load Conditions	20 %

* Since the oven does not maintain temperature, it needs to preheat before each cooking event.

***Step 2*—Calculate the total heavy-load energy.**

The total time cooking heavy loads is as follows:

$$t_h = \frac{\%h \times W}{PC},$$

$$t_h = \frac{80\% \times 200\,lb}{131.0\ lb/h},$$

$$t_h = 1.22\,h$$

The total heavy-load energy consumption is then calculated as follows:

$$E_{gas,h} = q_{gas,h} \times t_h,$$

$$E_{gas,h} = 70{,}380\ Btu/h \times 1.22\ h,$$

$$E_{gas,h} = 85{,}864\ Btu$$

$$E_{elec,h} = q_{elec,h} \times t_h,$$

$$E_{elec,h} = 0.31\ kW \times 1.22\ h,$$

$$E_{gas,h} = 0.38\ kWh$$

***Step 3*—Calculate the total light-load energy.**

The total time cooking light loads is as follows:

$$t_l = \frac{\%l \times W}{PR_l},$$

$$t_l = \frac{20\% \times 200\,lb}{43.6\ lb/h},$$

$$t_l = 0.92\,h$$

The total light-load energy consumption is then calculated as follows:

$$E_{gas,l} = q_{gas,l} \times t_l,$$

$$E_{gas,l} = 47{,}680\ Btu/h \times 0.92\ h,$$

$$E_{gas,l} = 43{,}866\ Btu$$

$$E_{elec,l} = q_{elec,l} \times t_l,$$

$$E_{elec,l} = 0.26\ kW \times 0.92\ h,$$

$$E_{elec,l} = 0.24\ kWh$$

***Step 4*—Calculate the total idle time and energy consumption.**

The total idle time is as follows:

$$t_i = t_{on} - t_h - t_l - \frac{n_p \times t_p}{60},$$

$$t_i = 12\ h - 1.22\ h - 0.92\ h - \frac{6\ preheats \times 8.7\ \text{min}}{60},$$

$$t_i = 8.99\ h$$

The idle energy consumption is then calculated as follows:

$$E_{gas,i} = q_{gas,i} \times t_i,$$

$$E_{elec,i} = q_{elec,i} \times t_i,$$

$$E_{gas,i} = 0.0\ Btu/h \times 8.99\ h,$$

$$E_{gas,i} = 0.0\ Btu$$

$$E_{elec,i} = 0.06\ kW \times 8.99\ h,$$

$$E_{elec,i} = 0.54\ kWh$$

***Step 5*—Calculate the total daily energy consumption as follows:**

$$E_{gas,daily} = E_{gas,h} + E_{gas,l} + E_{gas,i} + (n_p \times E_{gas,p})$$

$$E_{gas,daily} = 85{,}864\ Btu + 43{,}866\ Btu + 0.0\ Btu + (6\ preheats \times 10{,}900\ Btu)$$

$$E_{gas,daily} = 195{,}130\ Btu/day$$

$$E_{elec,daily} = E_{elec,h} + E_{elec,l} + E_{elec,i} + (n_p \times E_{elec,p})$$

$$E_{elec,daily} = 0.38\ kWh + 0.24\ kWh + 0.54\ kWh + (6\ preheats \times 0.056\ kWh)$$

$$E_{gelec,daily} = 1.50\ kWh/day$$

***Step 6*—Determine the estimated annual appliance energy cost as follows:**

$$C_{gas,annual} = r_{gas} \times \frac{E_{gas,daily}}{100{,}000\ Btu/Therm} \times d_{op}$$

$$C_{gas,annual} = \$1.20/Therm \times \frac{195{,}130\ Btu/day}{100{,}000\ Btu/Therm} \times 365\ days$$

$$C_{gas,annual} = \$855/year$$

$$C_{elec,annual} = r_{elec} \times E_{elec,daily} \times d_{op}$$

$$C_{elec,annual} = \$0.15/kWh \times 1.50\ kWh \times 365\ days$$

$$C_{elec,annual} = \$82/year$$

***Step 7*—Apply the cost model to the results obtained while operating in Manual Mode:**

The assumptions remained the same as those used in the example for the SelfCooking Control Mode, with the exception of the number of preheats. Because the oven is maintaining a cavity temperature of 350°F during idle, the standard number of preheats (2) is used in this estimate. Table E-3 shows the assumptions for the cost model, and Table E-4 shows the results from the oven tests in manual mode.

Table E-3: Oven Operation Assumptions.

Operating Time per Day	12 h
Operating Days per Year	365 d
Number of Preheats per Day	2
Total Amount of Food Cooked per Day	200 lb
Percentage of Food Cooked Under Heavy-load Conditions	80 %
Percentage of Food Cooked Under Light-load Conditions	20 %

Table E-4: Gas Oven Test Results.

Test	Result
Preheat Time	6.3 min
Preheat Energy, Gas	8,022 Btu
Preheat Energy, Electric	0.038 kWh
Idle Energy Rate, Gas	34,260 Btu/h
Idle Energy Rate, Electric	0.23 kW
Heavy-load Cooking Energy Rate, Gas	63,700 Btu/h
Heavy-load Cooking Energy Rate, Electric	0.28 kW
Light-load Cooking Energy Rate, Gas	37,410 Btu/h
Light-load Cooking Energy Rate, Electric	0.24 kW
Production Capacity	131.5 lb/h
Light-load Production Rate	41.5 lb/h

Estimated annual appliance energy cost :

$C_{gas,annual} = \$2{,}010/year$ $C_{elec,annual} = \$157/year$