Rational ClimaPlus Combi® Model CPC 61
Combination Oven Performance Test

Application of ASTM Standard
Test Method F 1639-95

FSTC Report 5011.03.10

Food Service Technology Center
Final Report, January 2003

Prepared by:

Greg Sorensen
Fisher-Nickel, Inc.

Contributor:
Richard Young
Fisher-Nickel, Inc.

The information in this report is based on data generated at the Food Service Technology Center.

Acknowledgments

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Specific appreciation is extended to Rational, for supplying the Food Service Technology Center with the CPC 61 Half-Size Combination Oven for controlled testing in the appliance laboratory.

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Executive Summary

The Rational model CPC 61 oven is an electric, half-size, combination oven with a 10.0 kW energy input rate and 6 sheet pan capacity. The CPC 61 oven includes Rational's patented ClimaPlus Control®, which allows the operator to continuously measure and adjust the humidity level in the oven. The oven also includes a fully programmable electronic control panel.

The Food Service Technology Center (FSTC) tested the CPC 61 oven under the tightly controlled conditions of the American Society for Testing and Materials' (ASTM) Standard Test Method.[1] Oven performance is characterized by preheat energy consumption and duration, idle energy rate, cooking energy efficiency and production capacity.

Application of the ASTM Test Method to the Rational combination oven included a modification to the test procedure which takes into account the time and energy required for the oven to fully recover after a test load. The oven was tested using this modified procedure in anticipation of the planned revision of the Standard Test Method to incorporate this extra procedure.

The Rational CPC 61 was set up and operated in accordance with the manufacturer's specifications. The oven operated consistently and reliably in all phases of the testing process.

Cooking energy efficiency and production capacity results are obtained from the cooking of 5-oz whole-meat chicken breasts under light–load, medium–load, and heavy–load testing scenarios. A summary of the test results is presented in Table ES-1.

Table ES-1. Summary of Performance: Rational ClimaPlus Combi Half-Size Combination Oven, Model CPC 61.

Preheat and Idle Rate Tests	
Rated Energy Input Rate (kW)	10.0
Measured Energy Input Rate (kW)	9.6
Percentage Difference From Rated (%)	4.0
Preheat Time (min)	16.3
Preheat Energy (kWh)	1.96
Idle Energy Rate (kW)	4.0
Light–Load Efficiency Tests	
Number of Pans	1
Cook Time (min)	9.3
Test Time (min)	11.3
Cooking Energy Rate (kW)	5.1
Cooking Energy Efficiency (%)	20.1 ± 1.1
Production Rate (lb/h)	15.6
Product Shrinkage (%)	20.7
Water Consumption Rate (gal/h)	21.2
Medium–Load Efficiency Tests	
Number of Pans	3
Cook Time (min)	10.6
Test Time (min)	14.4
Cooking Energy Rate (kW)	6.9
Cooking Energy Efficiency (%)	36.8 ± 1.8
Production Rate (lb/h)	39.6
Product Shrinkage (%)	23.4
Water Consumption Rate (gal/h)	23.9

Table ES-1 (continued). Summary of Performance: Rational ClimaPlus Combi Half-Size Combination Oven, Model CPC 61.

Heavy–Load Efficiency and Production Capacity Tests	
Number of Pans	6
Cook Time (min)	12.0
Test Time (min)	16.4
Cooking Energy Rate (kW)	7.6
Cooking Energy Efficiency (%)	58.2 ± 0.9
Production Capacity (lb/h)	72.5
Product Shrinkage (%)	25.6
Water Consumption Rate (gal/h)	22.0

Executive Summary

Performance tests on the CPC 61 oven show a preheat time of 16.3 minutes and an idle energy rate of 4.0 kW. Chicken breasts were cooked in 9.3 minutes and 10.6 minutes during light– and medium–load testing, with cooking–load energy efficiencies of 21.6% and 39.7% respectively. Chicken breasts were cooked in 12.0 minutes during heavy–load testing with a cooking–load energy efficiency of 62.7%, and a production capacity of 72.5 lb/h.

1 Introduction

Background

Combination ovens are widely used in the food service industry to provide a variety of cooking functions in a single appliance. 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.

Rational has expanded on the original combination oven/steamer philosophy by designing an oven that controls the amount of moisture in the oven while cooking in combination mode. The patented ClimaPlus Control® allows chefs to precisely monitor and control the humidity in the oven over a scale from 0% to 100%. The programmability of the Rational oven also allows foods 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.

While initial capital cost is a determining factor in the selection of new food service equipment, appliances can also be evaluated with regard to long-term operational cost and performance as characterized by cooking energy efficiency, idle energy consumption and production capacity.

With support from the Electric Power Research Institute (EPRI) and the Gas Technology Institute (GTI), the Food Service Technology Center (FSTC) developed a uniform testing procedure to evaluate the performance of gas and electric combination ovens. This test procedure 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 using whole chickens is documented in the FSTC report *Delicatessen Appliance Performance Testing*, where the energy performance of three ovens is determined while operating in both convection and combination modes.[2]

Objective

The objective of this report is to examine the operation and performance of the Rational ClimaPlus Combi electric combination oven, model CPC 61, under the controlled conditions of the ASTM Standard Test Method. Application of the ASTM test method to the Rational combination oven included a modification to the test procedure which takes into account the time and energy required for the oven to fully recover after a test load. The oven was tested using this modified procedure in anticipation of the planned revision of the Standard Test Method to incorporate this extra procedure. The scope of this testing is as follows:

1. Thermostat accuracy is checked at a setting of 350°F and the thermostat is adjusted if necessary.
2. Energy input rate is determined to confirm that the oven is operating within 5% of the nameplate energy input rate.
3. Preheat energy and time are determined.
4. Idle energy rate is determined at a thermostat set point of 350°F.
5. Cooking energy efficiency, cooking–load energy efficiency and production rate are determined during light–, medium–, and heavy– load cooking tests using chicken breasts as a food product.

Appliance Description

The Rational ClimaPlus Combi combination oven, model CPC 61, is an electric, half-size combination oven with a total input rate of 10.0 kW, which includes 3 kW for the steam generator and 7 kW for convection. The oven cavity measures 17 1/2-inches wide, 19 1/2-inches tall and 25-inches deep. Both exterior and interior surfaces are stainless steel. When running in combination mode, the oven draws heated air and steam through a fan which forces it into the oven cavity. The fan reverses direction every two minutes in order to better distribute the heat throughout the oven cavity. In addition to combination mode, the Rational ClimaPlus Combi can also run in convection (no moisture) and steam (no dry heat) modes. The oven features a programmable electronic control panel for all oven functions. This allows the oven to be programmed to cook various foods in steps (up to 9) that can combine combi, convection, and steam all in one program. The programs can be stored for later use.

Appliance specifications are listed in Table 1-1, and the manufacturer's literature is included in Appendix B.

Table 1-1. Appliance Specifications.

Manufacturer	Rational
Model	CPC 61
Generic Appliance Type	Combination Oven
Rated Energy Input Rate	10.0 kW
Technology	Combination dry heat and steam
Construction	Stainless Steel Exterior Stainless Steel Interior
Controls	Programmable electronic
Cavity Size	17 1/2" Wide × 19 1/2" Tall × 25" Deep
Pan Capacity	6 Half-Size Sheet Pans
Dimensions (w/o stand)	36" Wide × 33" Tall × 31" Deep
Dimensions (w stand)	36" Wide × 61" Tall × 31" Deep

2 Methods

Setup and Instrumentation

The CPC 61 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.

During all phases of testing, the oven was set to combination mode with 100% humidity, and a thermostat set point of 355°F.

Power and energy were measured with a watt/watt-hour transducer that generated a pulse for each 10 Wh used. 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 identical 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 CPC 61 instrumented with the data acquisition system.

Figure 2-1.
The CPC 61 Oven Instrumented for Testing.

Energy Input Rate and Thermostat Calibration

The energy input rate was determined by turning the oven on and measuring the energy consumed from the time the oven first began operating until the time when the elements or steam generator 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 a period of thirty minutes. If the average oven temperature during the thirty minutes was more than 355°F or less than 345°F, the controls were adjusted, the oven was allowed to re-stabilize at the new temperature for a period of one hour, and the cavity temperature was again monitored for a period of thirty minutes. This process was repeated until the oven temperature was within the 350 ± 5°F bandwidth.

Preheat and Idle Rate Tests

Preheat tests recorded the time and energy required for the oven, in combi mode, 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.

After the oven was preheated, it was allowed to stabilize for one hour, and then idle energy and water consumption, in combi mode, were monitored for a 3-hour period.

Cooking Tests

Light–Load Efficiency Tests

Light–load cooking tests were used to calculate the cooking energy efficiency of the oven under minimum loading conditions.

The tests were performed with 5-oz, boneless, skinless, butterfly-cut, whole-meat, chicken breasts. Raw chicken breasts were arranged on a half-size sheet pan, such that eight chicken breasts weighing a total of 2.4 ± 0.1 lb were used. Two of the breasts near the center of the pan were instrumented using a type K thermopile, which averages the temperatures of the two breasts. The thermopile wires were inserted into the thickest part of each breast, from the side, and at an angle as close to horizontal as possible.

The entire pan was then covered with plastic wrap and was stabilized in a refrigerator for a minimum of 18 hours before testing to ensure a uniform 37 ± 2°F starting temperature.

For each light–load test run, a single pan of chicken breasts was placed in the oven, centered in the oven cavity. No more than 1 minute elapsed between removal from the refrigerator and the closing of the oven door to begin the cooking process. The thermopile was used to verify that the starting temperature of the chicken breasts was 40 ± 2°F. Cook time and test time monitoring began when the oven door was closed. The chicken breasts were removed from the oven when the thermopile indicated the average temperature of the chicken breasts had reached 170°F, signaling the end of the cook time. The oven door was immediately re-closed and test time and energy consumption continued to be monitored until the oven cavity had recovered to a temperature of 348°F.

It should be noted that the original published version of the ASTM test method did not take into account the time and energy required for the oven to recover once the cooked food was removed. However, subsequent testing on a variety of combination ovens revealed that the recovery energy could represent a significant component of the energy balance. Therefore, this oven was tested taking into account the recovery period in anticipation of the revision of the original standard test method.

The pan, with chicken breasts, was weighed immediately after removal from the oven to determine the amount of moisture lost by the chicken breasts through evaporation during cooking. The chicken breasts were then removed from the pan, leaving the drippings and juices behind, and re-weighed to determine the net weight of the cooked breasts.

Medium–Load Efficiency Tests

The medium–load tests were used to calculate cooking energy efficiency under partial loading conditions. This loading scenario represents a situation where the oven is cooking at less than its maximum capacity.

The medium–load tests required preparation of 3 pans of chicken breasts for each test run. The breasts were prepared, instrumented and stabilized as in the light–load tests. The pans were loaded in the oven from bottom to top, with a pan in the bottom, a pan in the center, and a pan in the top of the oven rack.

After cooking, the pans were removed from top to bottom, weighed, and the recovery time and energy determined as in the light–load tests.

Heavy–Load Efficiency and Production Capacity Tests

The heavy–load tests were used to calculate cooking energy efficiency and production capacity when the oven was under maximum loading conditions.

The heavy–load tests required preparation of 6 pans of chicken breasts for each test run. The chickens were prepared and stabilized as in the light– and medium–load tests, however, only 4 pans were instrumented with thermopiles. These instrumented pans were loaded on the bottom, the center, just above center and top rack positions during cooking.

After cooking, the pans were removed from top to bottom, weighed, and the recovery time and energy determined as in the light– and medium–load tests.

Each test load scenario– light–, medium– and heavy–, was applied in triplicate and a statistical analysis of the results was performed to ensure that the reported cooking energy efficiency and production capacity results had an uncertainty of less than 10%. Application of the statistical analysis is detailed in Annex A1 of the ASTM Standard Test Method.

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 energy input rate was measured and compared with the manufacturer's nameplate value to ensure the oven was operating within its specified parameters. The maximum energy input rate was 9.6 kW, 4.0% lower than the nameplate rate of 10.0 kW, but within the 5% tolerance of the ASTM standard. The oven cavity temperature was monitored to verify that the oven was operating at 350 ± 5°F. At the thermostat set point of 350°F the oven cavity temperature averaged 344.5°F, which is below the operating window. The thermostat was adjusted to 355°F, which gave an average oven cavity temperature of 350.7°F. The 355°F setting was used for all tests.

Preheat and Idle Rate Tests

Preheat Energy and Time

The preheat and idle rate tests were performed with the oven in combi mode. Time and energy were monitored starting from the time the oven was first turned on. Any time that elapsed before the energizing of the elements was included in the test time. The preheat test ended at the specified temperature of 348°F, and consumed 1.96 kWh over a period of 16.3 min.

Idle Energy Rate

The oven was allowed to stabilize for one hour following the preheat test with the thermostat set to 355°F which held the average oven temperature at 350 ± 5°F. After this stabilization, the energy consumption was monitored over a 3-hour period. The idle energy rate was calculated to be 4.0 kW, which is 41.7% of the oven's measured input.

Test Results

The oven's preheat curve is shown in Figure 3-1. The measured energy input rate, preheat, and idle energy rate test results are summarized in Table 3-1.

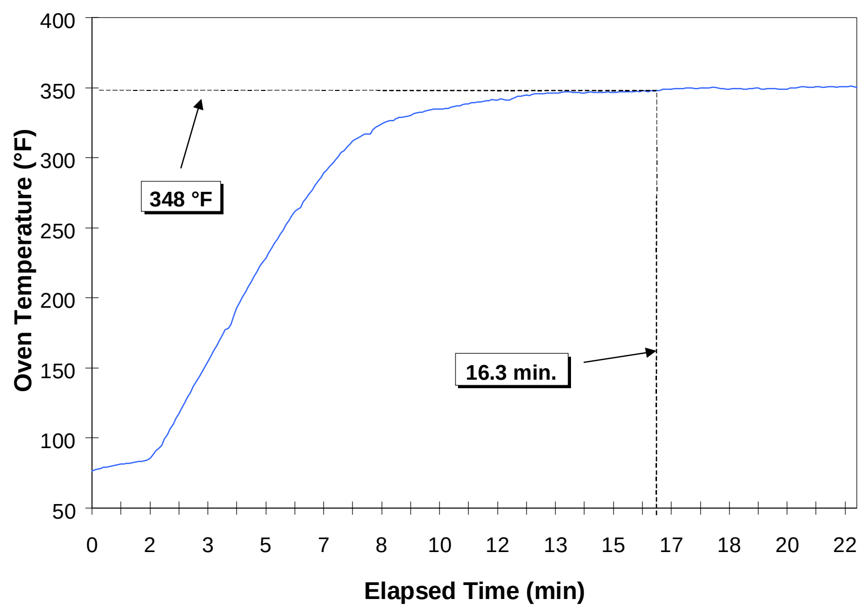


Figure 3-1.
Preheat Characteristics.

Table 3-1. Input, Preheat, and Idle Rate Test Results in Combi Mode.

Rated Energy Input Rate (kW)	10.0
Measured Energy Input Rate (kW)	9.6
Percentage Difference From Rated (%)	4.0
Preheat	
Time (min)	16.3
Energy (kWh)	1.96
Idle Energy Rate	
Energy Rate (kW)	4.0
Percentage of Measured Energy Input Rate (%)	41.7

Results

Cooking Tests

Light–, medium–, and heavy–load cooking tests were applied to the oven to determine cooking energy efficiency and production capacity. All monitored temperatures, as well as the readings of the temperature probes inserted into the chicken breasts, were recorded at five second intervals.

Light–Load Efficiency Tests

The light–load tests were used to determine the oven's performance while cooking a single pan of chicken breasts. The cook time was 9.3 minutes, and the CPC 61 oven completed the entire test, including recovery, in 11.3 minutes, while delivering 20.1% cooking energy efficiency, and 21.6% cooking–load energy efficiency at a production rate of 15.6 lb/h. The cooking energy efficiency includes only the energy imparted to the chicken breasts during the test, while the cooking–load energy efficiency includes the energy imparted to both the chicken breasts and the sheet pans they are placed upon. During the test, the oven used 3.3 gallons of water, which equals a rate of 21.2 gal/h.

Medium–Load Efficiency Tests

The medium–load tests were conducted to determine the oven's performance under partial load conditions. The cook time was 10.6 minutes, and the CPC 61 oven completed the entire test, including recovery, in an average time of 14.4 minutes, while delivering 36.8% cooking energy efficiency, and 39.7% cooking–load energy efficiency at a production rate of 39.6 lb/h. The oven used 4.2 gallons of water, which equals a rate of 23.9 gal/h.

Heavy–Load Efficiency and Production Capacity Tests

The heavy–load tests were used to determine the oven's performance when operating the oven at its maximum capacity. The cook time was 12.0 minutes, and the CPC 61 oven completed the entire test, including recovery, in an average of 16.4 minutes, while delivering 58.2% cooking energy efficiency, and 62.7% cooking–load energy efficiency at a production capacity of 72.5 lb/h. The oven used 4.4 gallons of water, which equals a rate of 22.0 gal/h.

Test Results

Cooking energy efficiency is defined as the quantity of energy consumed by the chicken breasts expressed as a percentage of energy consumed by the oven during the cooking test. The mathematical expression is:

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

Cooking–load energy efficiency is defined as the quantity of energy consumed by the chicken breasts plus the energy imparted to the sheet pans expressed as a percentage of energy consumed by the oven during the cooking test. The mathematical expression is:

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

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 sheet pans is calculated using the measured values of initial and final temperature of the pans, weight of the pans, and the specific heat of aluminum. Energy consumed by the test oven is determined by measuring electric energy use during the test. Appendix D lists the physical properties and measured values of all the test variables for each test run. Using the detailed equations provided in Section 11 of the combination oven ASTM Standard Test Method, the cooking energy efficiencies can be readily calculated. Table 3-2 summarizes the cooking energy efficiency and production capacity test results for the CPC 61 oven.

Table 3-2. Cooking Energy Efficiency and Production Capacity Test Results.

	Light Load	Medium Load	Heavy Load
Number of Pans	1	3	6
Number of Chicken Breasts	8	24	48
Cook Time (min)	9.3	10.6	12.0
Test Time (min)	11.3	14.4	16.4
Cooking Energy Rate (kW)	5.1	6.9	7.6
Cooking Energy Efficiency (%)	20.1	36.8	58.2
Cooking–Load Energy Efficiency (%)	21.6	39.7	62.7
Production Rate (lb/h)	15.6	39.6	72.5
Product Shrinkage (%)	20.7	23.4	25.6
Water Consumption Rate (gal/h)	21.2	23.9	22.0
Condensate Temperature Max. (°F)	136	134	134
Condensate Temperature Average (°F)	119	122	125

4 Conclusions

The Rational CPC 61 oven was designed with a high level of operator control in mind. The patented ClimaPlus Control allows continuous monitoring and adjustment of the moisture level in the oven, providing a high level of flexibility for cooking various food products. The electronic control panel and extensive programmability make it easy to obtain consistent results from one oven operator to the next, even during multiple-stage cooking events. After pushing the buttons to start a cook cycle, the oven will automatically adjust itself as required. And, if no special cooking recipe is needed, the oven will also run normally without any programming.

During testing, the ClimaPlus Combi oven, in combi mode, preheated to 350°F in 16.3 minutes while consuming 1.96 kWh of energy. The idle energy rate, in combi mode, was 4.0 kW, which is 41.7% of its measured input. Test chicken breasts were cooked in 9.3 minutes for the light–load tests, 10.6 minutes for the medium–load tests, and in 12.0 minutes for the heavy–load tests. Test times were 11.3 minutes for the light–load tests, 13.2 minutes for the medium–load tests, and 16.4 minutes for the heavy–load tests. Cooking energy efficiencies were 20.1% for the light loads, 36.8% for the medium loads, and 58.2% for the heavy loads. Cooking–load energy efficiencies were 21.6% for the light loads, 39.7% for the medium loads, and 62.7% for the heavy loads. Production rates during light– and medium– load tests were 15.6 lb/h and 39.6 lb/h, respectively, and production capacity during the heavy–load tests was 72.5 lb/h.

With its ClimaPlus Control and high level of programmability, the Rational CPC 61 oven would be a valuable addition to any kitchen considering a half-size combination type oven.

5 References

1. American Society for Testing and Materials, 2000. *Standard Test Method for Performance of Combination Ovens.* ASTM Designation F1639-95. In Annual Book of ASTM Standards, West Conshohocken, PA.

2. Zabrowski, D., Young, R., Ardley, S., Knapp, S., Selden, S., 1995. *Delicatessen Appliance Performance Testing.* Food Service Technology Center Report 5016.95.23. October.

Appendixes

A Glossary

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 Btu/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-, medium-, 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 Btu/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.

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 at a specified control setting.

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.

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

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 (Btu/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 oven cavity heats during a preheat.

Preheat Time (minute)
Preheat Period

The time required for an appliance to "preheat" 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)
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.

Recovery Time (minute, second)

The time from the removal of the food product from the oven until the oven cavity is within 10°F of the calibrated thermostat set point.

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.

B Appliance Specifications

Appendix B includes the manufacturer's product literature for the Rational ClimaPlus Combi electric combination oven, model CPC 61.

C Results Reporting Sheets

Manufacturer Rational

Model CPC 61

Serial # E61CA98079079

Date: September, 2002

Test Reference Number
(optional) N/A

Section 11.1 Test Oven

Description of operational characteristics:

The oven draws heated air through a fan which forces it into the oven cavity, while moisture is created by a steam generator. The oven features a programmable electronic control panel for all oven functions.

Physical Dimensions

Size of Oven: 61 H × 36 W × 33 D inches

Number of Racks: 6

Space Between Racks: 2.75 in.

ASTM Classification:

Type I — Table Top _______ Type II — Floor √

Class A — Half Size √ Class B — Full Size _______

Section 11.2 Apparatus

√ Check if testing apparatus conformed to specifications in section 5.

Deviations:

None.

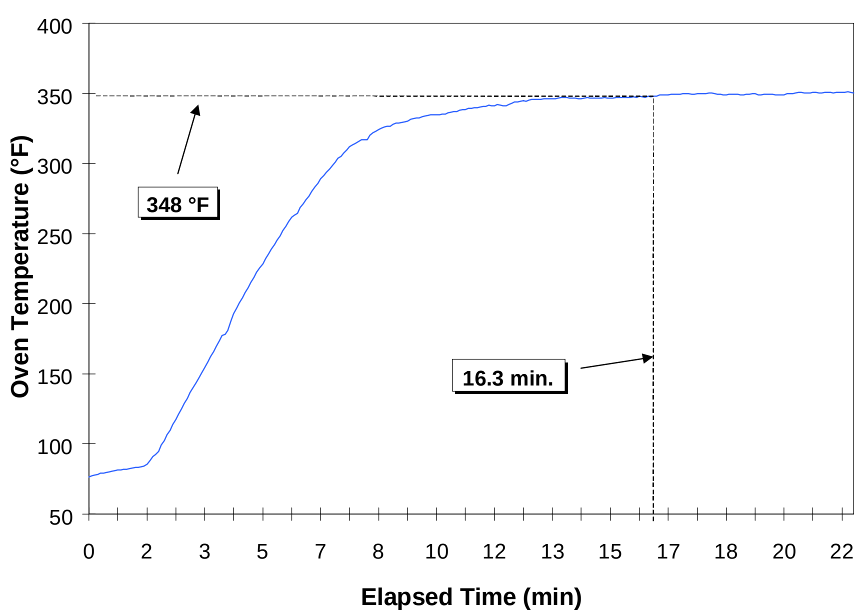
Section 11.4 Energy Input Rate

Test Voltage (V)	208
Gas Heating Value (Btu/ft³)	N/A
Rated (Btu/h or kW)	10.0
Measured (Btu/h or kW)	9.6
Percent Difference between Measured and Rated (%)	4.0
Fan / Control Energy Rate (kW, gas ovens only)	N/A

Section 11.5 Preheat Energy and Time

Test Voltage (V)	208
Gas Heating Value (Btu/ft³)	N/A
Energy Consumption (Btu or kWh)	1.96
Time from 76.5 °F to 348°F (min)	16.3

Preheat Characteristics



Section 11.6 Idle Energy Rate

Test Voltage (V)	208
Gas Heating Value (Btu/ft^3)	N/A
Idle Energy Rate (Btu/h or kW)	4.0

Section 11.7 Pilot Energy Rate

Gas Heating Value	N/A
Pilot Energy Rate	N/A

Section 11.8 Cooking Energy Efficiency and Cooking Energy Rate

Light Load:

Test Voltage (V)	208
Gas Heating Value (Btu/ft^3)	N/A
Cooking Energy Efficiency (%)	20.1 ± 1.1
Cooking–Load Energy Efficiency (%)	21.6 ± 1.2
Production Rate (lb/h)	15.6
Cooking Energy Rate (Btu/h or kW)	5.1
Electric Energy Rate (kW, gas ovens only)	N/A
Cooking Time (min)	9.3
Test Time (min)	11.3
Shrinkage (%)	20.7
Water Consumption (gal/h)	21.2
Condensate Temperature Max. (°F)	136
Condensate Temperature Average (°F)	119

Medium Load:

Test Voltage (V)	208
Gas Heating Value (Btu/ft^3)	N/A
Cooking Energy Efficiency (%)	36.8 ± 1.8

Cooking–Load Energy Efficiency (%)	39.7 ± 1.7
Production Rate (lb/h)	39.6
Cooking Energy Rate (Btu/h or kW)	6.9
Electric Energy Rate (kW, gas ovens only)	N/A
Cooking Time (min)	10.6
Test Time (min)	14.4
Shrinkage (%)	23.4
Water Consumption (gal/h)	23.9
Condensate Temperature Max. (°F)	134
Condensate Temperature Average (°F)	122

Heavy Load:

Test Voltage (V)	208
Gas Heating Value (Btu/ft[3])	N/A
Cooking Energy Efficiency (%)	58.2 ± 0.9
Cooking–Load Energy Efficiency (%)	62.7 ± 1.0
Production Capacity (lb/h)	72.5
Cooking Energy Rate (Btu/h or kW)	7.6
Electric Energy Rate (kW, gas ovens only)	N/A
Cooking Time (min)	12.0
Test Time (min)	16.4
Shrinkage (%)	25.6
Water Consumption (gal/h)	22.0
Condensate Temperature Max. (°F)	134
Condensate Temperature Average (°F)	125

D Cooking Energy Efficiency Data

Table D-1. Physical Properties.

Specific Heat (Btu/lb °F)	
Chicken	0.8
Latent Heat (Btu/lb)	
Vaporization, Water	970

Cooking Energy Efficiency Data

Table D-2. Light–Load Efficiency Test Data.

Measured Values	Repetition #1	Repetition #2	Repetition #3
Number of Pans	1	1	1
Number of Chicken Breasts	8	8	8
Initial Chicken Temperature (°F)	40.3	39.8	39.8
Final Average Chicken Temperature (°F)	170.6	171.4	170.7
Initial Chicken Weight (lb)	2.403	2.417	2.421
After-Cook Chicken Weight (lb)	1.996	1.975	2.003
Final Dripped Chicken Weight (lb)	1.905	1.912	1.923
Pan Weight (lb)	1.844	1.842	1.871
Cook Time (min)	9.2	9.5	9.2
Test Time (min)	11.0	11.7	11.3
Electric Energy (Wh)	960	1000	940
Water Consumption (gal)	3.3	3.5	3.1
Calculated Values			
Energy Consumed by Chicken (Btu)	650	680	660
Energy to Food (Btu/lb)	270	280	270
Energy to Sheet Pans (Btu)	51	51	52
Energy Consumed by Oven(Btu)	3280	3410	3200
Energy to Oven (Btu/lb)	1360	1410	1330
Cooking Energy Efficiency (%)	19.7	20.0	20.5
Cooking–Load Energy Efficiency (%)	21.3	21.5	22.2
Production Rate (lb/h)	15.7	15.3	15.8
Cooking Energy Rate (kW)	5.2	5.1	5.0
Shrinkage (%)	20.7	20.9	20.6
Water Consumption (gal/h)	21.7	22.1	19.9

Cooking Energy Efficiency Data

Table D-3. Medium–Load Efficiency Test Data.

Measured Values	Repetition #1	Repetition #2	Repetition #3
Number of Pans	3	3	3
Number of Chicken Breasts	24	24	24
Initial Chicken Temperature (°F)	38.4	38.3	38.1
Final Average Chicken Temperature (°F)	170.7	170.5	170.3
Initial Chicken Weight (lb)	7.054	7.027	6.914
After-Cook Chicken Weight (lb)	5.621	5.644	5.591
Final Dripped Chicken Weight (lb)	5.355	5.349	5.375
Pan Weight (lb)	5.568	5.662	5.683
Cook Time (min)	10.7	10.9	10.2
Test Time (min)	14.3	14.6	14.2
Electric Energy (Wh)	1680	1640	1640
Water Consumption (gal)	4.6	4.0	4.1
Calculated Values			
Energy Consumed by Chicken (Btu)	2140	2090	2020
Energy to Food (Btu/lb)	303	297	290
Energy to Sheet Pans (Btu)	157	160	160
Energy Consumed by Oven(Btu)	5730	5600	5600
Energy to Oven (Btu/lb)	810	800	810
Cooking Energy Efficiency (%)	37.3	37.3	36.0
Cooking–Load Energy Efficiency (%)	40.0	40.1	38.9
Production Rate (lb/h)	39.6	38.7	40.7
Cooking Energy Rate (kW)	7.0	6.7	6.9
Shrinkage (%)	24.1	23.9	22.3
Water Consumption (gal/h)	25.9	22.0	23.9

Cooking Energy Efficiency Data

Table D-4. Heavy–Load Efficiency Test Data.

Measured Values	Repetition #1	Repetition #2	Repetition #3
Number of Pans	6	6	6
Number of Chicken Breasts	48	48	48
Initial Chicken Temperature (°F)	38.2	38.1	38.8
Final Average Chicken Temperature (°F)	170.1	170.2	170.2
Initial Chicken Weight (lb)	14.463	14.443	14.541
After-Cook Chicken Weight (lb)	11.984	11.747	11.791
Final Dripped Chicken Weight (lb)	10.827	10.700	10.817
Pan Weight (lb)	11.229	11.197	11.188
Cook Time (min)	11.6	12.2	12.2
Test Time (min)	15.8	16.5	16.8
Electric Energy (Wh)	1980	2100	2100
Water Consumption (gal)	4.0	4.6	4.6
Calculated Values			
Energy Consumed by Chicken (Btu)	3930	4140	4200
Energy to Food (Btu/lb)	272	287	289
Energy to Sheet Pans (Btu)	317	316	314
Energy Consumed by Oven(Btu)	6760	7170	7170
Energy to Oven (Btu/lb)	467	496	493
Cooking Energy Efficiency (%)	58.2	57.8	58.5
Cooking–Load Energy Efficiency (%)	62.9	62.2	62.9
Production Rate (lb/h)	74.8	71.0	71.5
Cooking Energy Rate (kW)	7.5	7.6	7.5
Shrinkage (%)	25.1	25.9	25.6
Water Consumption (gal/h)	20.8	22.7	22.4

Cooking Energy Efficiency Data

Table D-5. Cooking Energy Efficiency Statistics.

	Light Load	Medium Load	Heavy Load	Production Capacity
Replicate #1	19.7	37.3	58.2	74.8
Replicate #2	20.0	37.3	57.8	71.0
Replicate #3	20.5	36.0	58.5	71.5
Average	20.1	36.8	58.2	72.4
Standard Deviation	0.43	0.73	0.38	2.06
Absolute Uncertainty	1.1	1.8	0.94	5.12
Percent Uncertainty	5.3	4.9	1.6	7.1