Cuppone, Model Max 18.35
Deck Oven Performance Test

Application of ASTM Standard Test Method F 1965-99

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Executive Summary

The Cuppone Max 18.35 electric deck oven is a stackable unit capable of personalized cooking. The oven's internal cavity is square-shaped equipped with a stone deck and programmable thermostat. The oven's electric heating elements are located both below the stone and near the ceiling of the cooking compartment. The oven is rated at 13 kW per deck.

The Cuppone Max 18.35 deck oven was tested at the Food Service Technology Center Laboratory located in San Ramon, California. The objective of this testing was to examine the operation and performance of the Cuppone electric deck oven, model Max 18.35, under controlled conditions. The oven was tested during idle and cooking conditions, using the American Society for Testing Materials (ASTM) Standard F1965-99 *Standard Test Method for the Performance of Deck Ovens.* Oven performance is characterized by preheat energy consumption and duration, idle energy rate, cooking-energy efficiency and production capacity.

The ASTM test method specifies a 475°F cavity temperature for all tests. Due to the versatility of the Max 18.35's thermostat controls, the oven underwent multiple testing arrangements regarding ceiling-to-deck heating element ratios, and upper and lower cavity configurations. However, for cooking par-baked crust pizza, Cuppone recommends the ceiling heating elements be set to 80% capacity and the deck to be set to 10% capacity (80:10). For all testing, the temperature sensor installed in the center of the cooking chamber by lab technicians indicated a stabilized operating temperature of 475°F. Since the objective of the preheat test is to determine the time and energy required to reach a ready-to-cook condition, the oven was considered preheated when the cavity temperature reached 97.9% of its stabilized operating temperature (or 465°F). With only the upper cavity activated, this temperature was satisfied in 28.58 minutes consuming 2.76 kWh. With only the lower cavity activated, this temperature was satisfied in 33.00 minutes consuming 3.27 kWh. All testing was subsequently performed with the oven's operational setting at 475°F. The oven was placed under a 10-foot by

5-foot wall-mounted canopy hood. The hood was 78 inches above the floor, centered left-to-right over the oven, with a 9-inch front overhang.

Cooking-energy efficiency and production capacity results were obtained from cooking 12″ cheese test pizzas under heavy load testing scenarios in the upper cavity with the lower cavity in the off position. The Max 18.35 exhibited a production capacity of 67.5 pizzas per hour per deck. The test setup is shown in Figure ES-1and the test data is summarized in Table ES-1.

Table ES-1. Summary of Performance: Cuppone Max 18.35 Deck Oven.

Rated Energy Input Rate (kW)	13.0
Measured Energy Input Rate (kW)	13.4
Preheat and Idle Rate Tests (Upper Cavity)	
Preheat Time (minutes)	28.58
Preheat Electric Energy (kWh)	2.76
Idle Energy Rate (kW)	5.8
12-inch Pizza (Heavy Load) Cooking Tests (Upper Cavity)	
Electric Cooking Energy Rate (kW)	4.13
Energy Efficiency (%)	81.5
Production Capacity (Pizzas/h)	67.5

The oven’s heating element system was equipped to operate at various combinations and still maintain a pre-set temperature (475°F). Researchers increased the oven controls to achieve a (100:100) heating element ratio only to find that the increase in energy consumption only slightly improved the cook time, thus resulting in a less-efficient operating procedure. When tested with the manufacturer recommended (80:10) ratio, the oven exhibited an 81.5% cooking efficiency. Researchers noted that this may not have fully represented the oven’s maximum performance. When researchers tested the oven with the (100:100) ratio, the oven’s cooking efficiency reduced to 62.8%.

As researchers anticipated; however, when both cavities were tested simultaneously with the (80:10) ratio, the oven showed a greater efficiency and faster recovery time. The dual cavity test increased the average cooking efficiency to 83.8%.

1 Introduction

Background

Dedicated to the advancement of the food service industry, the Food Service Technology Center (FSTC) has focused on the development of standard test methods for commercial food service equipment since 1987. 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. ASTM F1965, *Standard Test Method for the Performance of Deck Ovens,* was originally approved by ASTM in 1999. [1]

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.

Controlled testing of the Cuppone Max 18.35 deck oven was performed according to the ASTM deck oven test method. The test data provides key information to determine the cost of operation and the percentage of total kitchen productivity a single appliance can deliver. Better-informed decisions can then be made for equipment purchases, kitchen layout, energy demand of the kitchen, and appliance capacity during peak demand. Improved kitchen strategies can be implemented using the test information to reduce energy costs while still maintaining optimal cooking production. Information about preheat time can be used to schedule start up of an appliance when it is needed, which can reduce the amount of appliance idle time.

Other Food Service Technology Center reports document results of applying the ASTM test method for deck ovens to different models.[2,3] The glossary in Appendix A provides a quick reference to the terms used in this report.

Objective

The objective of this report is to examine the operation and performance of the Cuppone electric deck oven, model Max 18.35, under the controlled conditions of the ASTM Standard Test Methods. The scope of this testing is as follows:

- Energy input rate is determined to confirm that the oven is operating within 5% of the nameplate energy input rate.
- The amount of time and energy required to preheat the oven to a ready-to-bake state are determined.
- Idle energy rate is measured with the oven maintaining a ready-to-bake state while not baking.
- Evaluate the energy-saving idle modes.
- Cooking-energy efficiency and production rate are determined during heavy load cooking tests using standard cheese pizza as the food product.
- The maximum production capacity of the appliance is determined during heavy load cook testing.

Appliance Description

The Cuppone Max 18.35 is an electric deck oven with a unique electronic temperature control system allowing the operator to manage the cooking-phase of the food product. The electric heating elements on the deck of the oven are covered by stone and successions of electric heating elements are arranged just below the ceiling of the oven, as to simultaneously transmit heat to the top and bottom of the food product. The oven contains 4 electronically adjustable vents on the back wall of the oven for cooking steam-exhaust.

The Max 18.35 has a rated electric input rate of 13 kW and may be stacked up to two decks high. Appliance specifications are listed in Table 1-1, and the manufacturer's literature is included in Appendix B.

Figure 1-1. The Cuppone Max 18.35 deck oven.

Table 1-1. Appliance Specifications.

Manufacturer	Cuppone
Model	Max 18.35
Generic Appliance Type	Deck Oven
Rated Input	13 kW per deck
Technology	Heat Regeneration System
Construction	Stainless Steel Exterior
Controls	Digital
Dimensions	1060 x 1060 x 160 (mm)

2 Methods

Setup and Instrumentation

The Max 18.35 deck oven was installed in accordance with the ASTM *Standard Test Method for Deck Ovens.*[1] The oven was positioned under a 10-foot by 5-foot wall mounted canopy hood, with the lower edge of the hood mounted at 78 inches above the floor. The exhaust ventilation operated at a nominal rate of 3,000 CFM, or 300 CFM per linear foot of hood.

Power and energy were measured with a watt/watt-hour transducer. Temperature measurement of the cooked pizzas as well as measurement of the oven cavity temperature was accomplished using a data acquisition system that recorded data at 5-second intervals.

Energy Input Rate and Thermostat Calibration

The maximum energy input rate was measured while the oven was preheating from room temperature to a set point of 475°F. Thermostat calibration was verified by installing a thermocouple in the center of the baking chamber, two inches above the deck. The oven was stabilized at the 475°F set point for one hour, and then the temperature was monitored for an additional hour to verify that the average temperature was 475 ± 5°F.

The energy input rate was measured to ensure that the oven was operating according to the manufacturer's specification during testing. The peak input rate was measured at 13.4 kW, 3.2% higher than the rated maximum input rate of 13.0kW.

Preheat Energy Consumption and Idle Energy Rate

The preheat test recorded the time and energy required for the oven to warm from room temperature to a ready-to-cook condition. The oven was considered ready-to-cook when the cavity reached 465°F. After the oven was preheated, it was allowed to stabilize for one hour, and then the idle energy consumption was monitored for a two hour period.

Methods

Cooking-Energy Efficiency and Production Capacity

The heavy-load cooking tests were conducted with the oven operating under full-load conditions with the heating elements set at a (80:10) ratio. Due to the square shape of the oven, the loading sequence went from left to right, back to front to maximize the number of 12-inch pizzas for each test (9).

Heavy-Load Pizza Tests

The pizzas consisted of 12-inch diameter, par-baked crusts, a simple, tomato-based sauce and part-skim, low moisture, shredded mozzarella cheese. The pizzas were refrigerated overnight to ensure a temperature of 39 ± 1°F.

After the oven was preheated and stabilized at 475°F for one hour, the cook time was adjusted until a final average pizza temperature of 195 ± 3°F was obtained.

The pizzas were removed from the refrigerator and weighed just before loading. Upon removing the pizzas from the oven, the final pizza temperature was measured with a six-probe thermocouple rig and then placed on a scale to determine the final cooked weight.

Upon completion of the three test-runs under said conditions, an additional three test-runs were conducted following the same procedure, with the heating element control settings set to a maximum (e.g., 100:100 ratio).

Additionally, researchers stabilized both the upper and lower decks simultaneously to 475°F for one hour. After stabilization, the upper and lower deck underwent a dual cavity, heavy-load scenario which was replicated twice more to achieve the three test-run average. In this scenario, the upper deck cycled off, the door was opened and the pizzas were loaded in, just as in the other heavy-load testing procedures. Once the upper deck door was shut, the bottom deck door was opened and the same loading sequence took place for the lower deck. When the cook time was up, the upper deck was unloaded completely before opening the lower deck for pizza removal.

Light-Load Pizza Tests

Light-load pizza tests are used to calculate cooking-energy efficiency under intermittent loading conditions, such as off-peak hours. The pizzas used for the light load test had the same ingredients and composition as the heavy load test.

All cooking tests were performed in triplicate, minimum, to ensure that the reported cooking-energy efficiency and production capacity 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. Appendix C contains the ASTM results reporting sheets for this oven.

3 Results

Preheat and Idle Rate

When independently preheating from room temperature at (80:10), the upper deck reached 465°F after 28.58 minutes while the oven consumed 2.76 kWh. When independently preheating from room temperature at (80:10), the lower deck reached 465°F after 33.00 minutes while the oven consumed 3.27 kWh. The oven's preheat curve is shown in Figure 3-1.

The oven was stabilized for one hour following the preheat test and then the energy consumption was monitored over a 2-hour period. The upper deck idle energy rate was 1.13 kW. The lower deck idle energy rate was 1.42 kW. The rated energy input, preheat energy, and idle rate test results are summarized in Table 3-1.

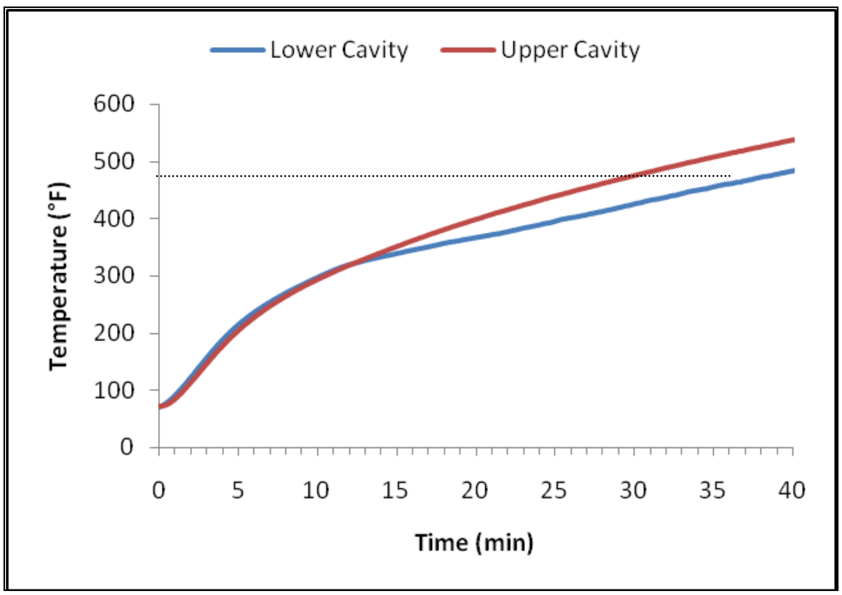


Figure 3-1. Preheat characteristics.

Results

Table 3-1. Input, Preheat, and Idle Rate Test Results at (80:10).

Rated Energy Input Rate (kW)	13.0
Measured Energy Input Rate (kW)	13.4
Preheat and Idle Rate Tests (Upper Deck)	
Preheat Time (minutes)	28.58
Preheat Electric Energy (kWh)	2.76
Idle Energy Rate (kW)	1.13
Preheat and Idle Rate Tests (Lower Deck)	
Preheat Time (minutes)	33.00
Preheat Electric Energy (kWh)	3.27
Idle Energy Rate (kW)	1.42

Uniformity

The uniformity test consisted of 9 steel disks with 6 inch diameters. Each disk had an individual thermocouple tack-welded to the center. The disks were placed in the same formation as a heavy load pizza test in order to represent the center of each pizza being baked during the tests.

The temperature of each disk is reflected by position in Figure 3-2. Position #1 is the front, right side corner of the oven. From there, the positions move front to back, right to left ending with position #9 in the left rear corner.

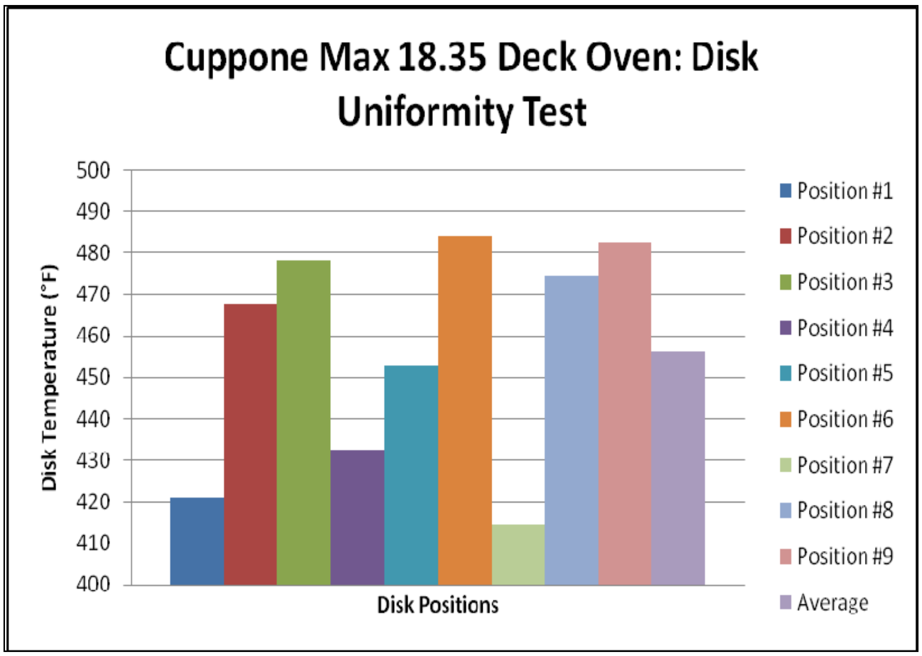


Figure 3-2. Disk Uniformity temperature graph.

Cooking Tests

The ASTM test method specifies 12-inch cheese pizzas as the test product for the cooking energy efficiency tests. Since both decks were equivalent, all cooking tests were conducted on the upper deck with the lower deck cool and turned off. The oven was tested under light (single pizza) and heavy (9 pizzas) load conditions. Each load scenario was replicated a minimum of three times to ensure the repeatability of the final test results.

Light-Load Efficiency Tests

Light load tests are used to determine the oven's energy use under low load conditions, as may be reflected during slow periods. Researchers cooked one pizza at a time in the center of upper deck. Using the manufacturer's recommended settings for par-baked crust pizza (80% top heat, 10% bottom heat), the heavy-load cook time was 6 minutes and 30 seconds. The light-load energy efficiency was 31.0 ± 2.7% and the production rate was 8.7 pizzas per hour.

Heavy-Load Efficiency and Production Capacity Tests

The heavy-load tests represent the maximum loading of the oven. Researchers were able to load 9 pizzas at a time into a single deck. Using the manufacturer's recommended settings for pizza (80% top heat, 10% bottom heat), the heavy-load cook time was 6 minutes and 30 seconds. The energy efficiency was 81.5 ± 4.5% and the production capacity was 75.0 pizzas per hour during the heavy-load cooking tests.

To compare the manufacturer's recommended heater settings with a potential "worst case" scenario, the heavy-load tests were repeated with the heaters set to their maximum levels (100% top and bottom heat). With the additional bottom heat, the cook time was reduced to 5 minutes and 52 seconds. The shorter cook time came with a dramatic increase in energy consumption. The energy efficiency was 62.8 ± 4.3% and the production capacity was 75.6 pizzas per hour.

Figure 3-3. Heavy Load test.

Cooking-energy efficiency is defined as the quantity of energy consumed by the pizzas expressed as a percentage of energy consumed by the oven during the cooking test:

$$\text{Cooking-Energy Efficiency} = \frac{\text{Energy to Food}}{\text{Energy to Appliance}}$$

The energy transferred to the food was calculated using the measured values of initial and final pizza temperature, initial and final pizza weight, the specific heat of the pizza (based on the specified pizza composition), and the heat of vaporization of water. Energy consumed by the oven is the electric energy consumed during the test. Table 3-2 summarizes the Max 18.35-2 oven's performance under the ASTM test method. Appendix D contains a synopsis of test data for each replicate of the cooking tests.

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

	Light Load (80:10)	Heavy Load (80:10)	Heavy Load (100:100)	Dual-Deck (80:10)
Number of pizzas	1	9	9	18
Measured Cook Time (mm:ss)	6:30	6:30	5:52	6:45
Test Time (minutes)	6.92	8.00	7.05	7.96
Cooking Energy Rate (kW)	1.47	4.13	6.13	8.60
Energy Efficiency (%)	31.0 ± 2.7	81.5 ± 4.5	62.8 ± 4.3	83.8 ± 3.6
Production Rate (pizzas/h)	8.7 ± 0.4	67.5 ± 1.7	75.6 ± 1.3	135.9 ± 15.0
Production Rate (lb/h)	12.7 ± 0.9	98.5 ± 4.1	114.1 ± 5.5	207.5 ± 17.9

Table 3-2 illustrates the relationship between cooking-energy efficiency and production rate for the Cuppone Max 18.35 oven when cooking 12-inch pizzas.

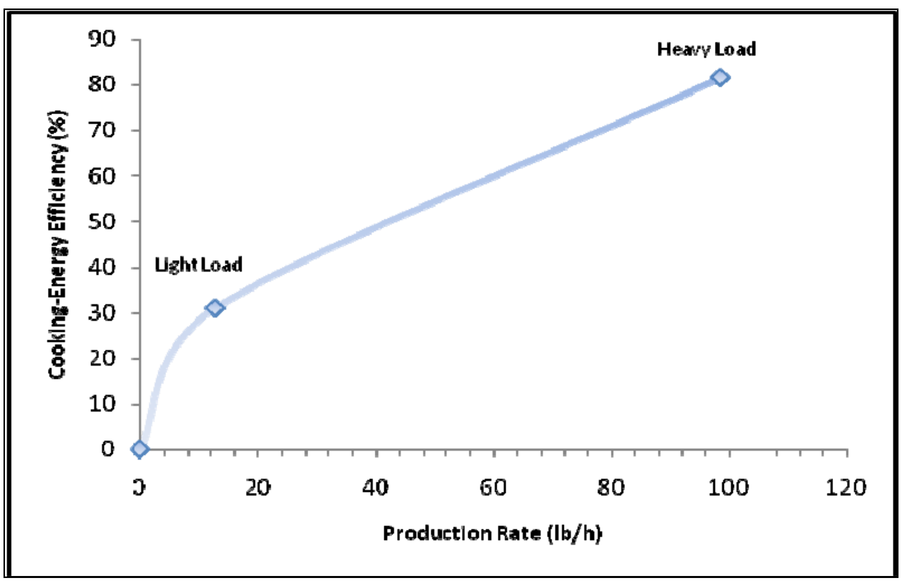
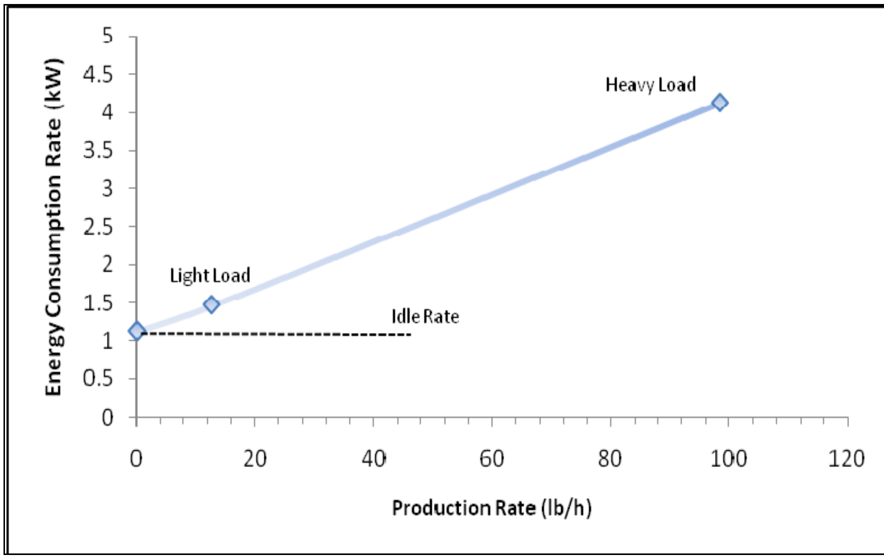


Figure 3-4. Deck oven part load cooking energy efficiency.

Figure 3-4 illustrates the relationship between the oven's average energy consumption rate and the production rate for each deck. This graph can be used as a tool to estimate the daily energy consumption for the deck oven in a real-world operation. Average electric energy consumption rates at 25, 50, 75, and 100 pounds per hour are 1.85 kW, 2.62 kW, 3.40 kW, and 4.17kW, respectively.



F

Figure 3-5. Electric cooking-energy consumption profile.

4 Conclusions

The Max 18.35 was able to cook 67.5 pizzas per hour per deck at the manufacturer's recommended settings while demonstrating a heavy-load cooking-energy efficiency of 81.5%. The double-deck Max 18.35-2 would have an ASTM production capacity of 135 pizzas per hour, with both decks operating at their maximum capacity.

During testing, the oven exhibited a fairly low duty cycle—that is, the percentage of the oven's actual energy consumption rate compared to the 11.2 kW measured energy input rate—was 8.7% during idle conditions and 31.7% during heavy load cooking operation. This additional reserve heat could be useful for baking denser products, such as deep dish pizzas and casseroles.

5 References / Bibliography

1. American Society for Testing and Materials, 2005. *Standard Test Method for Performance of Deck Ovens*. ASTM Designation F1965-99. In Annual Book of ASTM Standards, West Conshohocken, PA.

2. Sorensen, G., Young, R., 1999. *Garland Air Deck™ Model G56PB Deck Oven Performance Test.* Food Service Technology Center Report 5011.99.76, October.

Appendixes

Cook Time (min)

Time required for the deck oven to bring the specified food product to a specified "cooked" condition.

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.

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.

Deck Oven

An appliance that cooks the food product within a heated chamber. The food product can be placed directly on the floor of t he chamber during cooking, and energy may be delivered to the food product convective, conductive and/or radiant heat transfer. The chamber may be heated by gas or electric forced convection, radiants, or quartz tubes. Top and bottom heat may be independently controlled.

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.

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

The deck oven's rate of energy consumption, when empty, required to maintain its cavity temperature at the specified thermostat set point.

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 (%)

Glossary

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").

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 cook zone 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 (pizzas/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.

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 product literature for the Cuppone, Model Max 18.35 Deck Oven

C Results Reporting Sheets

Manufacturer Cuppone

Model Max 18.35

Serial Number N/A

Date: February, 2010

Test Reference Number (optional) ________________

Section 11.1 Apparatus

√ Check if testing apparatus conformed to specifications in section 6.

Deviations:

None

Section 11.2 Energy Input Rate

Test Voltage (V)	208
Gas Heating Value (Btu/ft^3)	N/A
Rated (kW)	13.0
Measured (kW)	13.4
Percent Difference between Measured and Rated (%)	3.1
Fan/Control Energy Rate (kW, Gas Ovens Only)	N/A

Section 11.3 Preheat Energy and Time

Test Voltage (V) 208

Gas Heating Value (Btu/ft³) N/A

Energy Consumption (Btu or kWh) 2.76

Time from 72.4 °F to 465°F (min) 28.58

Preheat Curve

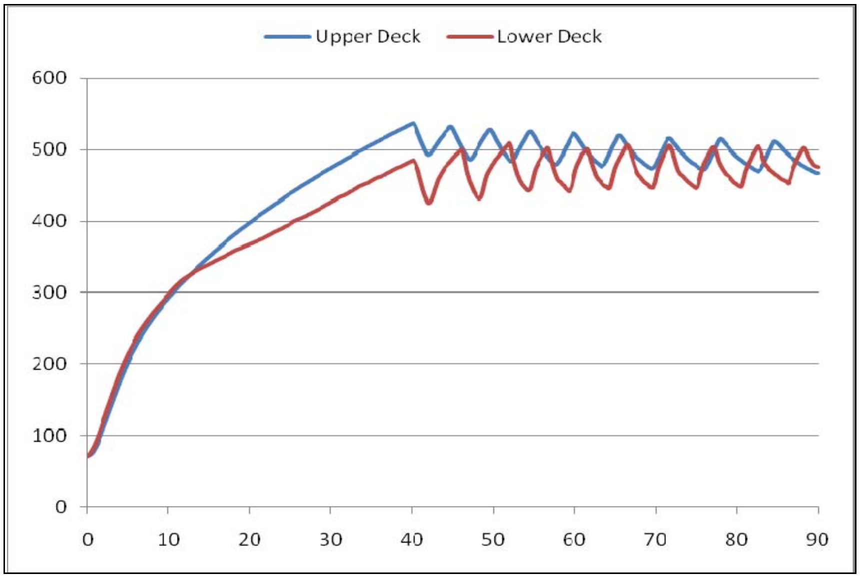


Figure 3-6. Preheat Curve Profile

Section 11.4 Idle Energy Rate

Test Test Voltage (V) 208

Gas Heating Value (Btu/ft³) N/A

Idle Energy Rate (Btu or kW) 1.13

Electric Energy Rate (kW, gas ovens only) N/A

Section 11.5 Pilot Energy Rate

Gas Heating Value (Btu/ft³) N/A

Pilot Energy Rate (Btu/h) N/A

Section 11.6 Cooking Energy Efficiency and Cooking Energy Rate

Cook Time Determination (80:10):

Cook Time: 6:30 min.

Light Load:

Test Test Voltage (V)	208	
Cooking Energy Efficiency (%)		23.0 ± 2.7
Cooking Energy Rate (kW)		1.47
Electric Energy Rate (kW, gas ovens only)		N/A

Heavy Load:

Test Test Voltage (V)	208	
Cooking Energy Efficiency (%)		81.5 ± 4.5
Cooking Energy Rate (kW)		4.13
Electric Energy Rate (kW, gas ovens only)		N/A

Dual-Deck Heavy Load:

Test Voltage (V)	208	
Cooking Energy Efficiency (%)		83.8 ± 3.6
Cooking Energy Rate (kW)		8.60
Electric Energy Rate (kW, gas ovens only)		N/A

Cook Time Determination (100:100):

Cook Time: 5:52 min.

Heavy Load:

Test Voltage (V)	208	
Cooking Energy Efficiency (%)		62.8 ± 4.3
Cooking Energy Rate (kW)		6.13
Electric Energy Rate (kW, gas ovens only)		N/A

D Cooking-Energy Efficiency Data

Table D-1. Physical Properties.

Specific Heat (Btu/lb °F)		
	Pizza	0.59
Latent Heat (Btu/lb)		
	Vaporization, Water	970

Cooking-Energy Efficiency Data

Table D-2. Light-Load Pizza Efficiency Test Data at (80:10).

	Repetition #1	Repetition #2	Repetition #3	Repetition #4
Measured Values				
Number of Pizzas	1	1	1	1
Test Voltage (V)	208	208	208	208
Initial Pizza Temperature (°F)	40.0	40.0	40.0	40.0
Final Average Pizza Temperature (°F)	195.0	197.1	197.1	196.1
Total Initial Pizza Weight (lb)	1.43	1.47	1.46	1.45
Total Final Pizza Weight (lb)	1.39	1.42	1.41	1.41
Test Time (min)	7.00	6.83	6.72	6.92
Cook Time (min)	6.50	6.50	6.50	6.50
Electric Energy to Oven (kWh)	0.15	0.18	0.18	0.17
Calculated Values				
Energy Consumed by Pizzas (Btu)	170	180	185	175
Electric Energy Consumed by Oven (Btu)	342	434	429	388
Total Energy Consumed by Oven (Btu)	512	614	614	563
Cooking Energy Efficiency (%)	33.3	29.3	30.0	31.3
Electric Cooking Energy Rate (kW)	1.29	1.58	1.58	1.43
Production Capacity (lbs/h)	12.26	12.87	13.04	12.56
Production Rate (pizzas/h)	8.57	8.78	8.93	8.68

Cooking-Energy Efficiency Data

Table D-3. Heavy-Load Pizza Efficiency Test Data (80:10).

	Repetition #1	Repetition #2	Replication #3
Measured Values			
Number of Pizzas	9	9	9
Test Voltage (V)	208	208	208
Initial Pizza Temperature (°F)	40.0	40.0	40.0
Final Average Pizza Temperature (°F)	194.8	197.9	195.3
Total Initial Pizza Weight (lb)	13.08	13.08	13.24
Total Final Pizza Weight (lb)	12.75	12.75	12.93
Test Time (min)	8.08	8.00	7.92
Cook Time (min)	6.50	6.50	6.50
Electric Energy to Oven (kWh)	0.54	0.57	0.54
Calculated Values			
Energy Consumed by Pizzas (Btu)	1,520	1,545	1,522
Electric Energy Consumed by Oven (Btu)	323	400	321
Total Energy Consumed by Oven (Btu)	1,843	1,945	1,843
Cooking Energy Efficiency (%)	82.5	79.4	82.6
Electric Cooking Energy Rate (kW)	4.01	4.28	4.09
Production Capacity (lbs/h)	97.1	98.1	100.3
Production Rate (pizzas/h)	66.8	67.5	68.2

Cooking-Energy Efficiency Data

Table D-4. Dual-Deck Heavy-Load Pizza Efficiency Test Data (80:10).

	Repetition #1	Repetition #2	Replication #3
Measured Values			
Number of Pizzas	18	18	18
Test Voltage (V)	208	208	208
Initial Pizza Temperature (°F)	40.0	40.0	40.0
Final Average Pizza Temperature (°F)	197.0	192.7	195.4
Total Initial Pizza Weight (lb)	26.86	27.64	28.02
Total Final Pizza Weight (lb)	26.14	26.81	27.31
Test Time (min)	7.80	7.71	8.38
Cook Time (min)	7.00	6.50	6.75
Electric Energy to Oven (kWh)	1.14	1.14	1.14
Calculated Values			
Energy Consumed by Pizzas (Btu)	3,199	3,308	3,276
Electric Energy Consumed by Oven (Btu)	692	583	615
Total Energy Consumed by Oven (Btu)	3,891	3,891	3,891
Cooking Energy Efficiency (%)	82.2	85.0	84.2
Electric Cooking Energy Rate (kW)	8.77	8.87	8.17
Production Capacity (lbs/h)	206.8	215.1	200.7
Production Rate (pizzas/h)	138.6	140.1	129.0

Table D-5. Heavy-Load Pizza Efficiency Test Data (100:100).

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Number of Pizzas	9	9	9
Test Voltage (V)	208	208	208
Initial Pizza Temperature (°F)	40.0	40.0	40.0
Final Average Pizza Temperature (°F)	192.07	195.35	196.90
Total Initial Pizza Weight (lb)	13.28	13.74	13.22
Total Final Pizza Weight (lb)	12.91	13.48	12.89
Test Time (min)	7.00	7.08	7.08
Cook Time (min)	5.75	5.92	5.92
Electric Energy to Oven (kWh)	0.75	0.69	0.72
Calculated Values			
Energy Consumed by Pizzas (Btu)	1,561	1,518	1,545
Electric Energy Consumed by Oven (Btu)	999	837	912
Total Energy Consumed by Oven (Btu)	2,560	2,355	2,457
Cooking Energy Efficiency (%)	61.0	64.4	62.9
Electric Cooking Energy Rate (kW)	6.43	5.85	6.10
Production Capacity (lbs/h)	113.8	116.4	112.0
Production Rate (pizzas/h)	77.1	76.3	76.3

Table D-6. Cooking-Energy Efficiency and Production Capacity Statistics (80:10).

	Cooking-Energy-Efficiency		Production Capacity
	Heavy Load	Light Load	(pizzas/h)
Replicate #1	82.5	33.3	66.8
Replicate #2	79.4	29.3	67.5
Replicate #3	82.6	30.0	68.2
Replicate #4	n/a	31.3	n/a
Average	81.5	31.0	67.5
Standard Deviation	1.82	1.72	0.68
Absolute Uncertainty	4.51	2.74	1.67
Percent Uncertainty	5.54	8.85	2.48