FlashBake® Model VFB12
Light Wave Oven

Product Evaluation

FSTC Report 5011.99.67

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Acknowledgments

The establishment of a Food Service Technology Center reflects Pacific Gas and Electric Company's commitment to the food service industry. The goal of the research project is to provide Pacific Gas and Electric Company's customers with information to help them evaluate technically innovative food service equipment and systems, and make informed equipment purchases regarding advanced technologies and energy sources. The project was the result of many people and departments working together within Pacific Gas and Electric Company and the overwhelming support of the commercial equipment manufacturers who supplied the cooking appliances for testing.

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Specific appreciation is extended to Quadlux, Inc. and Vulcan for supplying the Food Service Technology Center with the FlashBake® Model VFB12 oven for controlled testing in the appliance laboratory.

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Contents

List of Tables and Figures

Figures

Page

Tables

Page

Executive Summary

As food service operators look to fill the needs of their "on-the-go" customers who want high food quality without the long wait, equipment manufacturers are taking advantage of new technologies to produce appliances that will provide a high quality food product in the shortest amount of time. Quadlux, Inc. has developed just such an appliance in their Flashbake® oven. The FlashBake is a countertop oven that incorporates quartz halogen lamps as the heat source to cook the food product. The high powered lamps use a combination of intense visible light and infrared energy to cook food. This cooking process produces both the browning of a conventional oven and the short cook times of a microwave oven.

The Food Service Technology Center (FSTC) tested the Flashbake oven using modified American Society for Testing and Materials' (ASTM) test methods. Since the Flashbake oven does not fall within a specific appliance category for which an ASTM standard test method exists, the test procedures were derived from existing ASTM standard test methods developed at the Food Service Technology Center[1,2,3]. The specifics of each procedure are outlined in the Methods section and numerical results of the testing are included in the Results section.

The Flashbake oven's performance is characterized by cooking energy efficiency, production capacity, and cooking energy rate. A summary of the test results is presented in Table ES-1. Figure ES-1 illustrates the Flashbake oven's energy efficiencies for both single and barreling loads. The production capacities are shown in Figure ES-2.

Executive Summary

Table ES-1. Summary of Performance: FlashBake Oven, Model VFB12.

Single Load Pizza Tests	
Cook Time (min)	2.5
Cooking Energy Efficiency (%)	17.7 ± 0.7
Cooking Energy Rate (kW)	7.2
Barreling Load Pizza Test	
Test Time (min)	22.1
Peak Cooking Energy Efficiency (%)	24.5
Cooking Energy Rate (kW)	4.8
Production Capacity (Pizzas/h)	21.7
Production Capacity (lb/h)	31.0
Single Load Chicken Tests	
Cook Time (min)	4.5
Cooking-Load Energy Efficiency (%)	20.0 ± 0.8
Product Shrinkage (%)	19.5
Cooking Energy Rate (kW)	11.1
Barreling Load Chicken Test	
Test Time (min)	37.9
Peak Cooking-Load Energy Efficiency (%)	26.9
Cooking Energy Rate (kW)	8.8
Product Shrinkage (%)	23.3
Production Capacity (lb/h)	18.0
Single Load Hamburger Patty Tests	
Cook Time (min)	3.8
Cooking-Load Energy Efficiency (%)	22.1 ± 0.5
Cooking Energy Rate (kW)	11.0
Barreling Load Hamburger Patty Test	
Test Time (min)	24.3
Peak Cooking-Load Energy Efficiency (%)	25.9
Cooking Energy Rate (kW)	9.1
Production Capacity (lb/h)	14.9

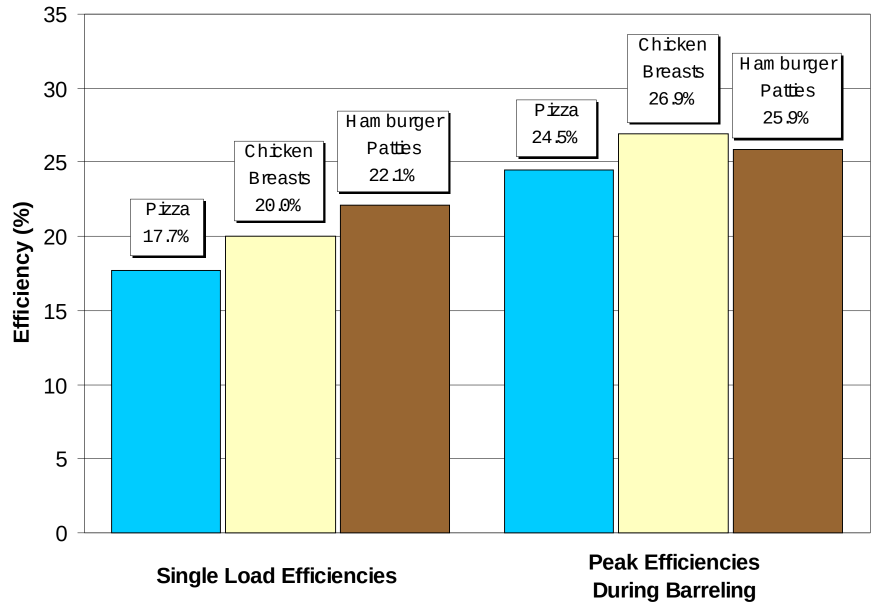

Figure ES-1.
Cooking Energy Efficiencies for Single and Barreling Loads.

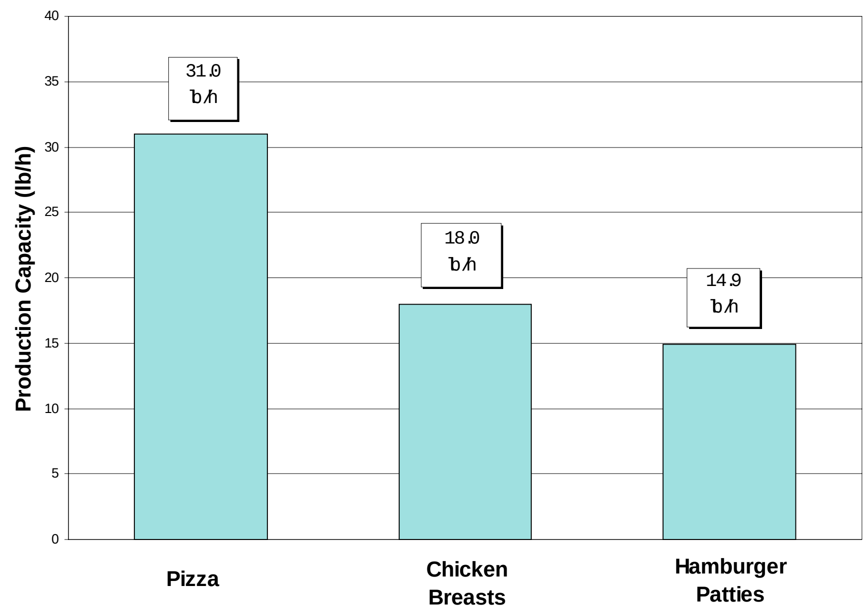

Figure ES-2.
Production Capacities for Barreling Loads.

Executive Summary

During testing at the Food Service Technology Center, the FlashBake oven demonstrated it’s proficiency at cooking a variety of food products quickly and easily. The oven’s small countertop size and ability to operate without an exhaust hood make it well suited for a wide range of applications within the food service industry. The programmable controls with memory function make the FlashBake capable of cooking menus with a variety of items, and adapting to menus that are constantly changing. Since the oven requires no preheat time, it can handle situations where use is intermittent or unpredictable, while also eliminating idle energy costs.

Speed is also a prominent feature, as the FlashBake oven cooked test pizzas in just 2.5 minutes, compared with 5 minutes for a countertop deck oven and 10.7 minutes for a countertop conveyor oven. Chicken breasts and hamburger patties were also prepared quickly, with cook times of 4 minutes 30 seconds, and 3 minutes 50 seconds, respectively.

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1 Introduction

High performance countertop ovens have been carving out a niche in today's fast-paced culinary world. With the food service industry expanding to advance the "on-the-go" market segment, equipment manufacturers are designing appliances to meet the needs of time-conscious operators and consumers. Operators and consumers alike are looking for a variety of quality food product to be available at different food service locations, for example pubs, kiosks, quick-service restaurants, delicatessens, hotels and movie theaters.

The market opportunities for these high performance countertop ovens have opened the door to using new and innovative technologies. The FlashBake® oven, developed by Quadlux, Inc., and manufactured by PMI-FEG, incorporates quartz halogen lamps as the heat source to cook the food product. The high powered lamps use a combination of intense visible light and infrared energy to rapidly cook food. This technique produces the browning of a conventional oven, but with the short cooking times typically associated with a microwave oven.

The FlashBake oven does not need preheating, so it is ready to go on command. Unlike conventional commercial ovens which are often left idling to maintain oven temperature, the Flashbake oven is "on" only when actual cooking is taking place. This translates to virtually zero energy consumption when the oven is not in use and greater energy savings over the course of the production day.

The FlashBake oven was tested using modified ASTM procedures, and this report documents the results. The glossary in Appendix A provides a quick reference to the terms used in this report.

Introduction

The objective of this report is to examine the operation and performance of the FlashBake oven, model VFB12 during testing under controlled conditions based on the ASTM Standard Test Methods. 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 cooking energy efficiency under 6 cooking scenarios: single-load pizza, barreling-load pizza, single-load chicken , barreling-load chicken, single-load hamburger patties and barreling-load hamburger patties.
3. Determine the production capacity of the oven for each barreling load scenario.

The FlashBake VFB12 is a stainless-steel, high-performance electric countertop oven. Food is placed in the FlashBake oven on a special pyroceram dish, called Flashware®, which sits on a rotating grill during cooking. High intensity quartz halogen lamps are positioned above and below the grill, at both center and outer positions. The center lamps are located above and below the center of the grill, and the outer lamps are above and below the rear of the grill. There is one top center lamp and one bottom center lamp. The top outer position has three lamps and the bottom outer position has two lamps. The rotating grill moves the food through these lamp zones, which is where actual cooking occurs.

Each zone, identified as top center , bottom center, top outer and bottom outer, can be programmed for a specific light intensity over the time of the cook cycle using the oven's micro-processor control. Program times and light intensities can be stored in the oven controller's memory as a recipe. The oven can store up to twenty recipes, which can be any of three different cook modes. The standard cook mode runs each of the four lamp zones at a specified intensity over the length of the cook cycle. The intensities can be different for the top and bottom zones, but each respective intensity remains constant. The Two-Step cook mode runs all four lamp zones at maximum intensity to begin the cook cycle, then switches to a second step which allows you to program the four different lamp zones at intensities independent of each other. This helps speed up the cooking of certain foods that could not be cooked entirely at 100% intensity. The Thermopulse cook mode is for cooking thicker foods such as lasagna, thick meats and filled pastries. In this mode, the lamps pulse to slowly drive energy into the food. Other features include a browning level adjustment for consistent product appearance, an “Add Time” button that extends the length of the cooking event by 20 seconds without altering the recipe, and a “Pause” button that interrupts cooking if necessary.

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

Table 1-1. Appliance Specifications.

Manufacturer	Vulcan
Model	VFB12
Generic Appliance Type	High Performance Countertop Oven
Rated Input	11.9 kW
Technology	High Intensity Quartz-Halogen Lamps
Construction	Stainless-steel exterior, aluminum interior
Controls	Programmable micro-processor controlled electronic keypad
Dimensions	27 ½" x 21'' x 19 ½"

2 Methods

Set Up and Instrumentation

The oven was installed in accordance with the manufacturer's instruction on a 3-foot-tall stainless steel table 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. The ventilation hood was used with this appliance during testing in order to maintain the proper ambient temperature as specified by ASTM standards[1,2,3]. The researchers acknowledge that in many instances this appliance can be operated in a restaurant without a ventilation hood.

Power and energy were measured with a watt/watt-hour transducer that generated an analog signal for instantaneous power and a pulse for every 10 Wh. The transducer and thermocouple probes were connected to a computerized data acquisition unit that recorded data every 5 seconds. A voltage regulator was connected to the oven to maintain a constant voltage for all tests. Figure 2-1 shows the FlashBake instrumented with the data acquisition system and voltage regulator.

Figure 2-1.
The FlashBake Oven instrumented for testing.

Methods

Measured Energy Input Rate

The energy input rate is the maximum rate at which the oven will consume energy. Since the Flashbake oven has a sensor which cycles off the cooking lights if the cavity temperature is too high, it is not possible to run the oven without a food load present for any considerable period of time. Therefore, the energy input rate was measured during a 4.5 minute chicken test. The chicken test, being performed at 100% cooking intensity, provided the best opportunity to measure maximum energy consumption for the longest period of time. The maximum power draw during this period was reported as the measured energy input rate.

Pizza- Single Load Cooking Energy Efficiency Tests

The ingredients used for the test pizzas, the preparation of the test pizzas, and the criteria for pizza doneness were identical to those described in Sections 7.1 - 7.4 of ASTM designation F 1817-97, *Standard Test Method for the Performance of Conveyor Ovens*[1].

Pizza crusts were 12-inch diameter, par-baked crusts weighing 0.9 ± 0.2 lb with a moisture content of 36 ± 3% by weight. Pizza sauce was a simple, tomato based sauce with a moisture content of 86 ± 2% by weight. Pizza cheese was part-skim, low moisture, shredded mozzarella cheese with a moisture content of 50 ± 2% by weight. All ingredients were verified for proper moisture content by gravimetric moisture analysis.

The pizzas were comprised of a pizza crust, pizza sauce and pizza cheese according to the following: 0.25 lb of pizza sauce spread uniformly on top of a pizza crust to within 0.5 inch of the edge of the crust, and 0.375 lb of pizza cheese spread uniformly over the pizza sauce. The pizzas were then placed on sheet pans and covered with plastic wrap. The pizzas were stabilized in a refrigerator for a minimum of 18 hours before testing to ensure temperature uniformity of 39 ± 1°F.

Pizza doneness, as outlined by ASTM standards[1], requires a final pizza temperature of 195 ± 3°F. The final pizza temperature was measured by placing six hypodermic-style thermocouple probes on the surface of the pizza, located 3 inches from the center of the pizza and equidistant from each other, for a period of 60 seconds. The probes were allowed to penetrate the cheese and rest in the crust-sauce interface. The highest average temperature of the six probes during the 60 second period was the final pizza temperature. For consistency of the temperature readings, the probes were attached to a lightweight plastic disc which held the relative position of each probe constant from pizza to pizza. A picture of the thermocouple probe structure is shown in Fig 2-2.

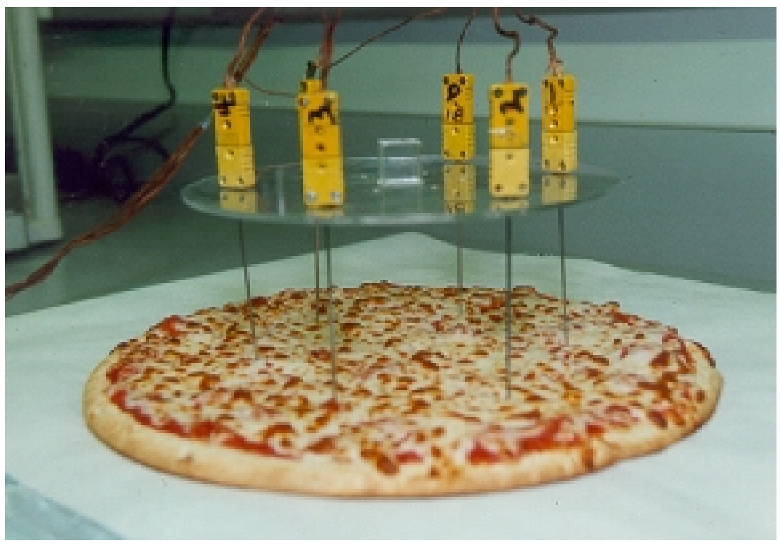


Figure 2-2. Thermocouple Probe Structure.

A recipe was determined to achieve both the desired final pizza temperature and the best food quality. The recipe was a 2.5 minute "Two Step" program. The full power step was a period of 20 seconds, and the second step was a period of 2 minutes 10 seconds with the following light intensities: Top Inner and Top Outer set at 20%, Bottom Inner set at 80%, and Bottom Outer set at 100%.

After the recipe was determined, the single run pizza tests were conducted. A single pizza was weighed and then placed directly on the rotating grill inside the oven. No more than 1 minute was allowed to elapse from the time the pizza was removed from the refrigerator to the beginning of the cook cycle. After cooking, the pizza was removed from the grill and placed on a two inch thick square of polystyrene insulation that prevented heat loss into the table surface during temperature measurement. After the final temperature was determined, the pizza was weighed again so weight loss during cooking could be calculated. The test was performed three times, allowing at least 10 minutes between tests to allow the oven to cool, so no accumulated heat from the prior test would impact the following one. Using three test runs ensured that the cooking energy efficiency could be reported with an uncertainty of less than ±10%.

Pizza- Barreling and Production Capacity Test

A barreling test is a cooking scenario where the oven is required to perform numerous cook cycles, one right after another. When one pizza is finished cooking, it is removed from the oven and another pizza is immediately loaded so the cooking cycle can be started again as quickly as possible.

The barreling test was performed for two reasons. First, to provide the information necessary for the calculation of production capacity. The second reason was to calculate cooking energy efficiency for each individual pizza as the barreling test progressed. Since the oven compensates for high cavity temperature by cycling the lights off momentarily, it was expected that subsequent loads would be cooked using less energy.

Chicken- Single Load Cooking Energy Efficiency Tests

The chicken breasts used, and the criteria for chicken doneness were the same as outlined in ASTM designation F1639-95, *Standard Test Method for the Performance of Combination Ovens*[2]. Chicken breasts were 5-oz, boneless, skinless, butterfly-cut, whole meat, chicken breasts. The raw chicken breasts were placed on a wire rack which sat on a sheet pan to catch any drippings. The breasts were arranged in a single layer and covered with plastic wrap. The wrapped chicken was stabilized in a refrigerator for a minimum of 24 hours before testing to ensure temperature uniformity of 37 ± 2°F.

The number of chicken breasts used for each test run was determined by the size of the Flashware dish supplied with the oven. The breasts were placed on the dish in a manner which covered as much area of the dish as possible, without having any part of two adjacent breasts overlap. This resulted in 5 breasts being used for each load.

Chicken doneness, as outlined by ASTM standards[2], requires internal chicken temperature to reach at least 170°F. Since it is not possible to thermocouple the chicken breasts while they are in the oven, the temperature of the thickest part of each breast was measured with a hypodermic-style thermocouple probe after cooking. The breasts were monitored for 60 seconds, and the highest average temperature recorded during this time was the final chicken temperature.

The recipe required to achieve a final average chicken temperature of 170 ± 3°F was as follows: “Standard” cook mode, 4.5 minutes at 100% light intensity for all areas.

After recipe determination, three single run chicken tests were conducted. Five chicken breasts were arranged on the baking dish and weighed, with the dish, before cooking. No more than 1 minute was allowed to elapse between removal from the refrigerator and the beginning of the cook cycle. Immediately after cooking, the breasts were again weighed with the dish and the juices from cooking. The breasts were then transferred to a wire drip rack, where they were probed for a period of 60 seconds to determine the final chicken temperature. Immediately following the temperature measurement, the breasts were weighed a final time, without the cooking dish or juices.

Chicken- Barreling and Production Capacity Test

A barreling test was also conducted using the chicken, with a new test load beginning immediately after removal of the previous load. This allowed the calculation of the cooking energy efficiencies for each load and the calculation of production capacity.

Hamburger Patties-Single Load Cooking Energy Efficiency Tests

The hamburger patties used, and the criteria for hamburger patty doneness were the same as in ASTM designation F1275-95, *Standard Test Method for Performance of Griddles*[3]. The hamburgers were ¼ lb. pre-frozen, machine prepared, 3/8 in. thick patties with a moisture content of 60 ± 2% by weight. Hamburger patties were verified for proper moisture content by gravimetric moisture analysis.

The frozen hamburger patties were placed on sheet pans lined with cooking paper and covered with plastic wrap. The wrapped patties were stabilized in a freezer for a period of at least 24 hours before testing to ensure temperature uniformity of 0 ± 5°F.

Three hamburger patties were used for each test run- the largest number that would fit on the Flashware without overlapping adjacent patties.

Hamburger doneness, as outlined by ASTM standards[3], requires an internal temperature of 163°F. Research conducted at the FSTC has demonstrated that the internal temperature of cooked hamburger patties is directly related to the weight loss of the patties during cooking. The final temperature of 163°F can be attained by cooking the patties to a 35% weight loss.

The recipe used to achieve a weight loss of 35% was as follows: “Standard” cook mode, 3 minutes, 50 seconds at 100% light intensity for all areas.

After recipe determination, three single run hamburger patty tests were conducted. Three pre-weighed frozen hamburger patties were arranged on the Flashware which was then placed in the oven to cook. No more than 30 seconds were allowed to elapse between the time the patties were removed from the freezer and the beginning of the cook cycle.

After cooking, the patties were transferred to a wire drip rack. The patties were allowed to drip for a period of 1 minute on each side, then removed from the rack and weighed.

One patty from each load was reserved for the purpose of moisture analysis.

Hamburger Patties-Barreling and Production Capacity Test

A barreling test was also conducted using the hamburger patties, with a new test load beginning immediately after removal of the previous load. This allowed the calculation of the cooking energy efficiencies for each load and the calculation of production capacity.

During both the single load chicken tests and the single load hamburger patty tests the oven uses energy to not only cook the food product, but also to heat the baking dish from room temperature to a temperature of several hundred degrees. If this temperature is measured, then the cooking-load energy efficiency can be determined. The cooking-load energy efficiency accounts for both the energy used to cook the food product and the energy used to heat the baking dish.

The temperature of the baking dish was measured during the single load chicken tests and the single load hamburger patty tests with a hand-held surface temperature probe, and it was determined that the average final temperature of the baking dish was 450°F.

The ASTM results reporting sheets for the cooking tests appear in Appendix C, and the cooking energy efficiency data sheets appear in Appendix D.

3 Results

Energy Input Rate

The energy input rate was measured and compared with the manufacturer's nameplate value prior to any testing to ensure that the oven was operating properly. The maximum energy input rate was measured as 11.4 kW, 4.2% lower than the nameplate rate of 11.9 kW, but within the 5% tolerance of ASTM standards[1,2,3].

Cooking Tests

The oven was tested with three food products under both single load and barreling test scenarios. Each single load test was performed in triplicate, while each barreling test was performed once. The order of testing was as follows: single load pizza tests, barreling pizza test, single load chicken tests, barreling chicken test, single load hamburger tests, barreling hamburger test. The energy consumption, elapsed cook time and ambient temperature were monitored for the duration of each cooking cycle at five second intervals. After each cooking cycle, final product temperature was determined using the method prescribed for the particular food product.

Single Load Pizza Tests

The FlashBake oven cooked each pizza to an average final temperature of 195.5°F with a cook time of 2.5 minutes, while delivering 17.7% cooking energy efficiency at a cooking energy rate of 7.2 kW.

Pizza Barreling Test

The Flashbake oven required 22.1 minutes to cook 8 consecutive pizzas to an average final temperature of 193.3°F. The test time included 15 seconds between each load for unloading and reloading. The cooking energy rate during the barreling test steadily declined from 7.2 kW for the first pizza to 4.8 kW for the sixth and each subsequent pizza. Therefore, the first pizza was cooked with a cooking energy efficiency of 17.4%, and the sixth, seventh and eighth pizzas were cooked with an average cooking energy efficiency of 24.3%. The production capacity for the barreling test was 21.7 Pizzas/h. Figure 3-1 shows the cooking energy rate and cooking energy efficiency of each load during the barreling test.

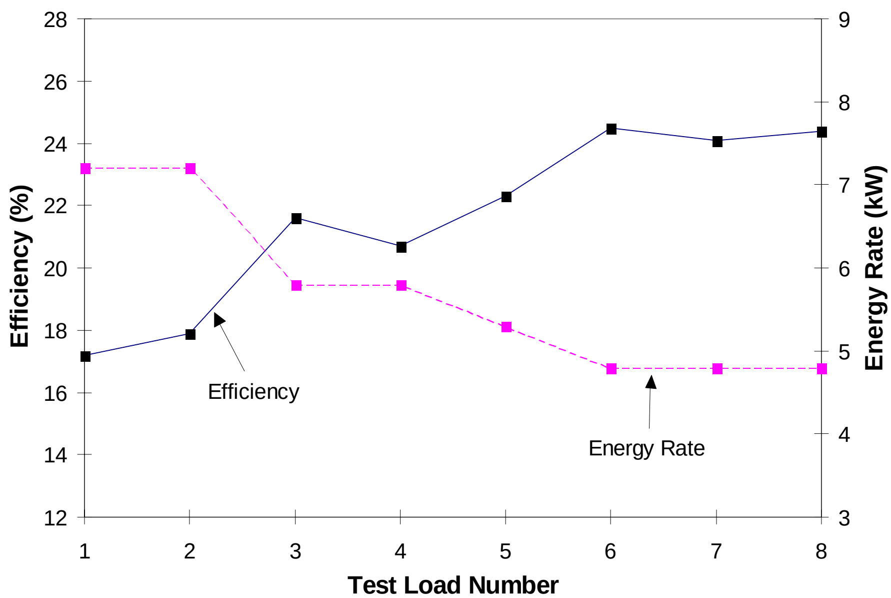


Figure 3-1. Cooking Energy Rates and Cooking Energy Efficiencies for Pizza Barreling Test.

Single Load Chicken Tests

The oven cooked the chicken breasts to a final average internal temperature of 170.8°F with a cook time of 4 minutes 30 seconds while delivering 20.0% cooking-load energy efficiency at a cooking energy rate of 11.1 kW.

Results

Chicken Barreling Test

The Flashbake required 37.9 minutes to cook 8 consecutive chicken breast loads to an average final temperature of 173.5°F. The test time included 15 seconds between each load for unloading and reloading. The cooking energy rate during the barreling test steadily declined from 11.2 kW for the first load to 8.8 kW for the fifth and each subsequent load. Therefore, the first load was cooked with a cooking-load energy efficiency of 19.9%, and the fifth, sixth, seventh and eighth loads were cooked with an average cooking-load energy efficiency of 26.4%. The production capacity for the barreling test was 18.0 lb/h. Figure 3-2 shows the cooking energy rate and cooking-load energy efficiency of each test load during the chicken barreling test.

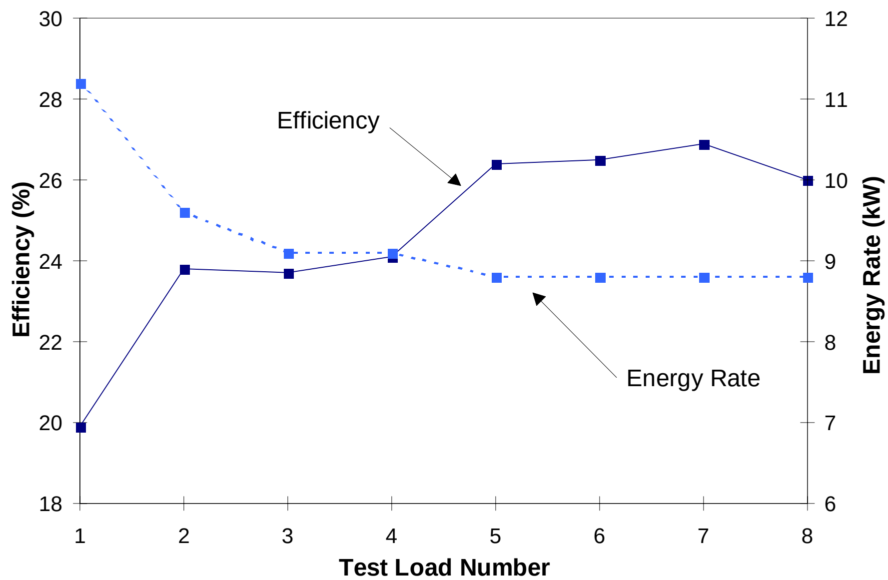


Figure 3-2.
Cooking Energy Rates And Cooking-load Energy Efficiencies For Chicken Barreling Test.

Single Load Hamburger Tests

The Flashbake cooked the hamburger patties to a final average weight loss of 34.6%, which equals a final average temperature of 161.9°F. The cook time was 3 minutes 50 seconds, which delivered 22.1% cooking-load energy efficiency at a cooking energy rate of 11.0 kW.

Hamburger Barreling Test

The oven required 24.3 minutes to cook 6 consecutive loads of hamburger patties to a final average weight loss of 32.8%, which equals a final average temperature of 157.0°F. The test time included 15 seconds between each load for unloading and reloading. The cooking energy rate during the barreling test steadily decreased form 11.3 kW for the first load to 9.1 kW for the third and each subsequent load. Therefore, the first load was cooked with a cooking-load energy efficiency of 21.9%, and the third, fourth, fifth, and sixth loads were cooked with an average cooking-load energy efficiency of 25.7%. The production capacity for the barreling test was 14.9 lb/h. Figure 3-3 shows the cooking energy rate and cooking-load energy efficiency of each test load during the hamburger patty barreling test.

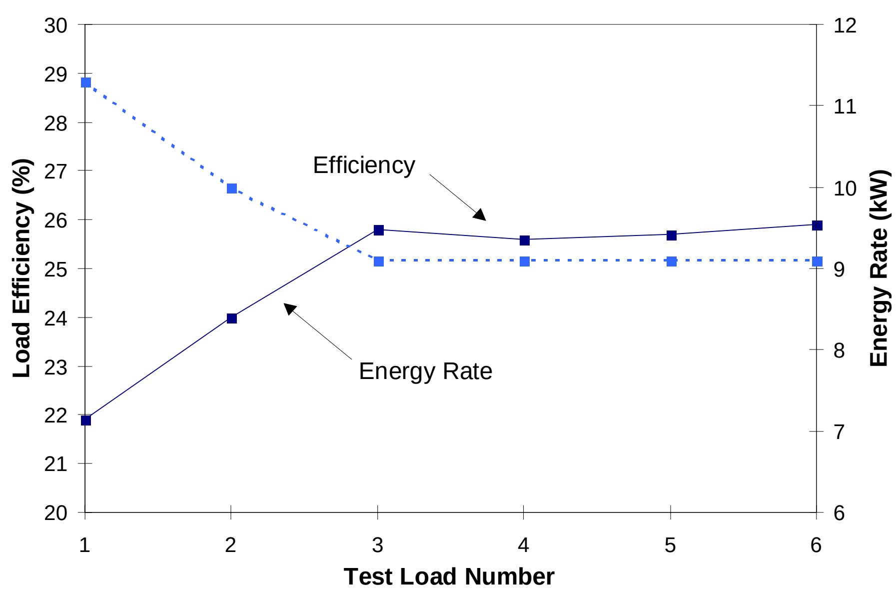


Figure 3-3.
Cooking Energy Rates And Cooking-load Energy Efficiencies For Hamburger Patty Barreling Test.

Test Results

Cooking energy efficiency is defined as the quantity of energy consumed by the food expressed as a percentage of energy consumed by the oven during the cooking event. The mathematical expression is therefore:

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

During pizza testing, energy is used for both heating the pizzas, and for evaporating some of the water present in the various ingredients. The energy consumed by the pizzas is calculated by determining the amount of heat gained by the pizzas while being heated from their initial temperature to their final temperature, and how much energy was necessary to evaporate the water which was lost during the cooking process. The energy consumption is expressed mathematically as:

$$E_{pizza} = E_{(heat\ pizza)} + E_{(evaporate\ water)}$$

Chicken energy consumption is also defined as the energy required to heat the chicken breasts from their initial temperature to their final temperature, and to evaporate the water lost during the cooking process:

$$E_{chicken} = E_{(heat\ chicken\ breasts)} + E_{(evaporate\ water)}$$

Cooking hamburger patties from a frozen state requires that energy be imparted to not only cook the patties and evaporate water, but also to melt the frozen water present in the patties. Therefore, the energy consumption of hamburger patties is defined as:

$$E_{hamburgers} = E_{(heat\ hamburgers)} + E_{(evaporate\ water)} + E_{(melt\ ice)}$$

Cooking-load energy efficiency accounts for both the energy required to cook the food product and the energy imparted to the Flashware during cooking. Since the chicken breasts and the hamburger patties must be cooked on the Flashware baking dish, the energy required to heat the dish during cooking is factored into the energy equation for these two food products. The mathematical expression is:

$$\text{Cooking-load Energy Efficiency \%} = \frac{E_{food} + E_{dish}}{E_{oven}} \times 100\%$$

Using the detailed equations provided in Section 11 of each respective ASTM Standard Test Method, the cooking energy efficiencies can be readily calculated[1,2,3].

Tables 3-1 and 3-2 summarize the Flashbake oven's performance for the three food products. Figures 3-4 and 3-5 illustrate these results in a graphical format.

Results

Table 3-1. Single Run Test Results- Cooking Energy Efficiency

	Pizza	Chicken Breasts	Hamburger Patties
Cook Time (min)	2.5	4.5	3.8
Cooking Energy Rate (kW)	7.2	11.1	11.0
Cooking Energy Efficiency (%)	17.7	20.0*	22.1*

* Load Efficiencies

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

	Pizza	Chicken Breasts	Hamburger Patties
Peak Cooking Energy Efficiency (%)	24.5	26.9*	25.9*
Cooking Energy Rate (kW)	4.8	8.8	9.1
Production Capacity (lb/h)	31.0	18.0	14.9
Production Capacity (pizzas/h)	21.7	-	-

* Load Efficiencies

Results

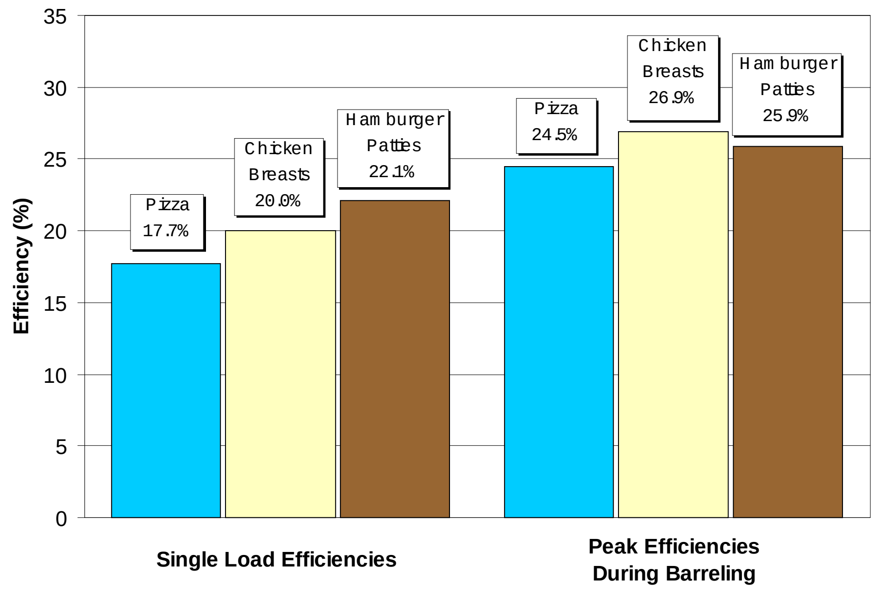


Figure 3-4.

Cooking Energy Efficiencies for Single Runs and Peak Cooking Energy Efficiencies during Barreling Runs.

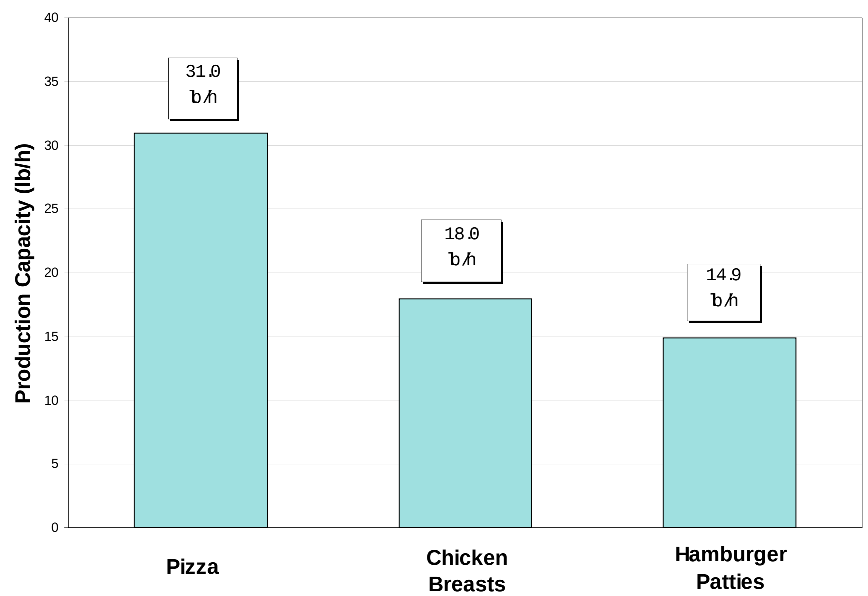


Figure 3-5.

Production Capacity Test Results.

4 Conclusions

The high-intensity quartz halogen lamps cooked food very quickly, and the oven's programming flexibility allowed it to cook a variety of food items.

In the emerging market segment of high performance countertop ovens, the Flashbake oven, model VFB12 proved a worthy performer. With it's no-idle, instant-on operation, the Flashbake oven is especially well suited for applications where demand is intermittent or unpredictable, such as schools, movie theaters, or hotel room service. The oven's small size and ability to operate without an exhaust hood make it easily usable in locations where space is a premium, as in bars, delicatessens or kiosks.

Operation of the Flashbake oven was simple, with the recipe storage feature eliminating the need to remember cook times and intensity settings for different types of foods. Pressing the recipe number and then the start button was all that was necessary to start the cooking process.

The high-intensity quartz halogen lamps cooked food very quickly, and the oven's programming flexibility allowed it to cook a variety of food items. Using the modified ASTM procedures, pizzas were cooked in only 2.5 minutes in the Flashbake oven , compared with 5.0 minutes for a countertop deck oven and 10.7 minutes for a countertop conveyor oven. Chicken breasts and hamburger patties were also prepared quickly, with cook times of 4 minutes 30 seconds, and 3 minutes 50 seconds, respectively.

With it's countertop size, adjustable programming, and fast cook times, the Flashbake oven is adaptable to fit a wide range of food service situations and menus. It would be a great selection for any operator looking for a step up in cooking speed or menu flexibility, or for various small locations where full size equipment or exhaust hoods are impractical or impossible.

5 References

1. American Society for Testing and Materials. 1997. *Standard Test Method for the Performance of Conveyor Ovens.* ASTM Designation F 1817-97, in *Annual Book of ASTM Standards,* Philadelphia: American Society for Testing and Materials.

2. American Society for Testing and Materials. 1995. *Standard Test Method for the Performance of Combination Ovens.* ASTM Designation F 1639-95, in *Annual Book of ASTM Standards,* Philadelphia: American Society for Testing and Materials.

3. American Society for Testing and Materials. 1995. *Standard Test Method for the Performance of Griddles.* ASTM Designation F 1275-95, in *Annual Book of ASTM Standards,* Philadelphia: American Society for Testing and Materials.

Appendices

A Glossary

Combination Oven
A device that combines the function of hot air convection or saturated and superheated steam heating, or both, to perform steaming, baking, roasting, rethermalizing, and proofing of various food products. In general, the term combination oven is used to describe this type of equipment, which is self contained. The combination oven is also referred to as a combination oven/steamer.

Conveyor Oven
An appliance that carries the food product on a moving conveyor into and through a heated chamber. The chamber may be heated by gas or electric forced convection, radiants, or quartz tubes. Top and bottom heat may be independently controlled.

Cooking Energy Efficiency
Energy Efficiency
Quantity of energy imparted to the specified food product expressed as a percentage of energy consumed by the oven during the cooking event.

Cooking-load Energy Efficiency
Quantity of energy imparted to the specific food product and the pot or pan containing the food product, expressed as a percentage of energy consumed by the oven during the cooking event

Cooking Energy Rate
Cooking Energy Consumption Rate
Average rate of energy consumption (Btu/h or kW) during the cooking energy efficiency test. Refers to all loading scenarios (heavy,light).

Energy Input Rate
Rate at which an oven consumes energy (Btu/h or kW).

Griddle
A device for cooking food in oil or it's own juices by direct contact with a hot surface

Idle Energy Rate
Idle Rate
The oven's rate of energy consumption (kW or Btu/h), when empty, required to maintain it's cavity temperature at the specified thermostat set point.

Maximum Energy Input Rate
Measured Energy Input
Measured Peak Energy Input Rate
Peak Rate of Energy Input
Peak rate at which an oven consumes energy (Btu/h or kW).

Oven Cavity
That portion of the oven in which food products are heated or cooked.

Pilot Energy Rate
Rate of energy consumption (Btu/h) by an oven's continuous pilot (if applicable).

Glossary

Preheat Energy
Amount of energy consumed (Btu/h or kWh) by the oven while preheating it's cavity from ambient temperature to the specified thermostat set point.

Preheat Time
Time (min.) required for the oven cavity to preheat from ambient temperature to the specified thermostat set point.

Production Capacity
Maximum rate (lb(kg)/h) at which an oven can bring the specified food product to a specified "cooked" condition.

Production Rate
Rate (lb(kg)/h) at which an oven can bring the specified food product to a specified "cooked" condition.

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.

Uncertainty
Measure of systematic and precision errors in specified instrumentation or measure of repeatability of a reported test result.

B Appliance Specifications

Appendix B includes the product literature for the Flashbake VFB12 oven.

VULCAN

Item # ____________________

C.S.I. Section 11420

MODEL VFB12

COUNTER ELECTRIC FLASHBAKE® OVEN

STANDARD FEATURES

- Stainless steel front, sides and top.
- Stainless steel door with window.
- 4" legs.
- Alanod oven interior measures 18"w x 18"d x 7¾"h.
- 16" diameter carousel cooking grill.
- Seven 2,000 watt quartz halogen lamps, four on the top and three on the bottom. No pre-heat time required.
- Electronic digital controls accept 10 recipe programs.
- 208 or 240 volt, 60 Hz, 1 or 3 phase. 11.9 KW maximum draw.
- One year limited parts and labor warranty.

OPTIONS

- ☐ 72" cord and plug.
- ☐ Second year extended limited parts and labor warranty.

ACCESSORIES

- ☐ 16" diameter grill.
- ☐ 12" diameter silverstone non-stick pan.
- ☐ 6", 7", 10", 12", 14" and 16" diameter black pans for fresh dough pizzas.
- ☐ 12" diameter Flashware cooking dish.

CLASSIFIED UL EPH

ANSI/NSF Standard #4

UL LISTED

C UL LISTED

SPECIFICATIONS:

Counter electric FlashBake® Oven, Vulcan Model No. VFB12. Front, sides, top and oven door constructed of 304 series stainless steel. Observation window is #5 welders glass. Reflective Alanod oven interior measures 18"w x 18"d x 7¾"h. 16" diameter carousel cooking grill. Seven 2,000 watt quartz halogen lamps, four on the top and three on the bottom. No pre-heat time required. Electronic digital controls accept 10 recipe programs. 208 or 240 volt, 60 Hz, 1 or 3 phase.

Exterior dimensions: 27⅜"w x 28⅞"d x 19½"h on 4" legs.

Classified by U L to NSF Std. #4. U L listed. U L listed to Canadian safety standards.

VULCAN

UL REGISTERED FIRM A2780 ISO9001 Vulcan-Hart Co.

MODEL: VFB12 Counter Electric FlashBake® Oven

VULCAN-HART COMPANY, P.O. BOX 696, LOUISVILLE, KY 40201, TEL. 1-800-814-2028
502-778-2791 QUOTE & ORDER FAX: 1-800-444-0602

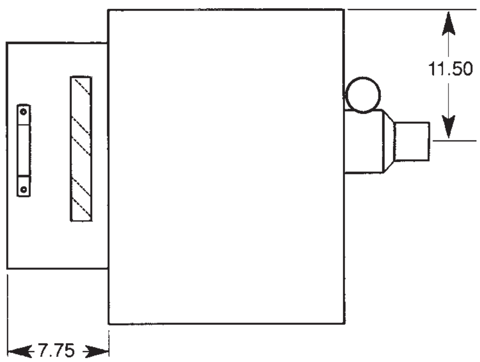
F-32270 (12-01)

MODEL VFB12

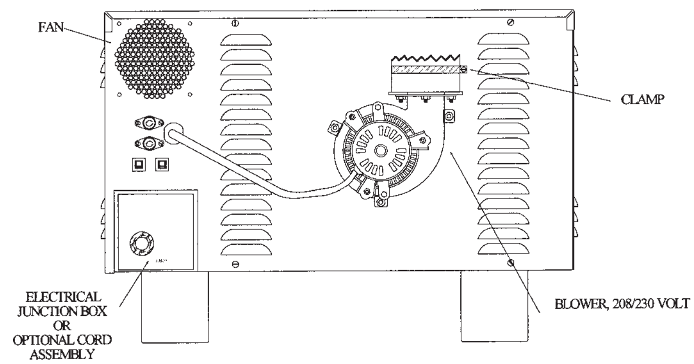
COUNTER ELECTRIC FLASHBAKE® OVEN

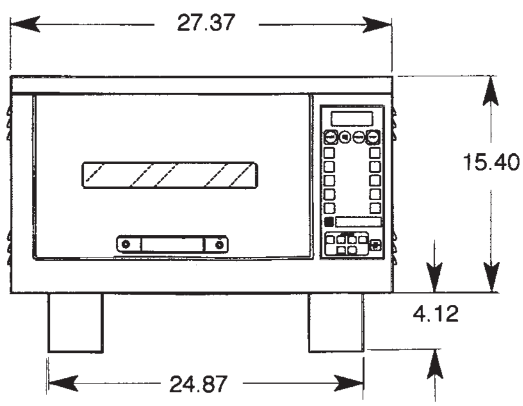
IMPORTANT

1. This appliance must be installed with 6" clearance at both sides and 1" clearance at the rear adjacent to both combustible and non-combustible construction.
2. This appliance is manufactured for commercial installation only and is not intended for domestic/household installation.

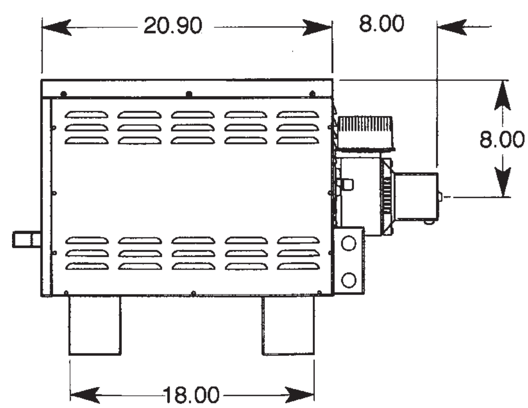


TOP VIEW





FRONT VIEW



SIDE VIEW

PHYSICAL SPECIFICATIONS								
Length	Depth	Height	Weight	Ship Wt.	Ship Size	Construction	Cooking Cavity	Cooking Surface
27 3/8"	28 7/8"	19 1/2"	100 lbs.	150 lbs.	34.5" x 33" x 28" = 18.45 sq. ft.	Stainless Steel	18" x 18" x 7 3/4"	16" diameter

ELECTRICAL SPECIFICATIONS									
				Maximum		Typical		Breaker	NEMA
Model[1]	Voltage	Phase	Cycles	Power	Current	Power	Current	Size	Receptacle
VFB12	208/240	1	60	11.9 KW	56 A	9 KW	43 A	60 A	14-60R
	208/240	3	60	11.9 KW	35 A	9 KW	27 A	40A[2]	15-50R

1 Plug and cord optional, for additional cost.

2 50A if cord connected.

NOTE: In line with its policy to continually improve its products, Vulcan-Hart Company reserves the right to change materials and specifications without notice.

VULCAN-HART COMPANY, P.O. BOX 696, LOUISVILLE, KY 40201, TEL. 1-800-814-2028
502-778-2791 QUOTE & ORDER FAX: 1-800-444-0602

F-32270 (12-01)

Printed On Recycled Paper

C Results Reporting Sheets

Manufacturer	Vulcan
Model	VFB12
Date:	September, 98

Section 11.1 Test Oven

Description of operational characteristics: The oven uses high intensity quartz halogen lamps to cook product which is placed on a rotating grill during cooking. The oven uses programmable microprocessor control with memory function.

Section 11.2 Apparatus

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

Deviations: None

Section 11.4 Energy Input Rate

Test Voltage	208 V
Gas Heating Value	N/A
Rated	11.9 kW
Measured	11.4 kW
Percent Difference between Measured and Rated	4.2 %
Fan / Control Energy Rate (Gas Ovens Only)	N/A

Results Reporting Sheets

Section 11.5 Preheat Energy and Time

Test Voltage	N/A
Gas Heating Value	N/A
Energy Consumption	N/A

Section 11.6 Idle Energy Rate

Test Voltage	N/A
Gas Heating Value	N/A
Idle Energy Rate	N/A

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

Pizza Testing:

Test Voltage	208 V
Cook Time	2.5 min
Cooking Energy Efficiency	17.7 ± 0.7 %
Cooking Energy Rate	7.2 kW
Production Capacity	21.7 Pizzas/h

Chicken Testing:

Test Voltage	208 V
Cook Time	4.5 min
Cooking Energy Efficiency	12.9 ± 0.8 %
Cooking-Load Energy Efficiency	20.0 ± 0.9 %
Electric Cooking Energy Rate	11.1 kW
Product Shrinkage	19.5%
Production Capacity	18.0 lb/h

Results Reporting Sheets

Hamburger Patty Testing:

Test Voltage	208 V
Cooking Time	3.83 min
Cooking Energy Efficiency	13.6 ± 0.5 %
Cooking-Load Energy Efficiency	22.1 ± 0.4 %
Electric Cooking Energy Rate	11.0 kW
Energy per Pound of Food Cooked	3191 Btu/lb
Energy to Food	433 Btu/lb
Production Capacity	14.9 lb/h

D Cooking Energy Efficiency Data

Table D-1. Physical Properties.

Specific Heat (Btu/lb °F)	
Ice	0.50
Pizza	0.593
Chicken	0.800
Hamburger Patty	0.72
Baking Dish	0.20
Latent Heat (Btu/lb)	
Vaporization, Water at 212°F	970
Vaporization, Water at 170°F	996
Fusion, Water at 32°F	144

Cooking Energy Efficiency Data

Table D-2. Pizza- Single Load Test Data.

Measured Values	Repetition #1	Repetition #2	Repetition #3
Total Energy (Wh)	300	300	300
Cook Time (min)	2.5	2.5	2.5
Initial Weight (lb)	1.412	1.416	1.422
Final Weight (lb)	1.359	1.368	1.368
Initial Temperature (°F)	40	40	40
Final Temperature (°F)	198.0	196.2	192.4
Calculated Values			
Sensible to Solids (Btu)	132	131	129
Latent - Water Vaporization (Btu)	51	47	52
Total Energy to Food (Btu)	184	178	181
Energy to Food (Btu/lb)	**130**	**126**	**127**
Total Energy to Oven (Btu)	1024	1024	1024
Energy to Oven (Btu/lb)	**725**	**723**	**720**
Cooking Energy Efficiency (%)	**17.9**	**17.4**	**17.7**
Cooking Energy Rate (kW)	**7.2**	**7.2**	**7.2**

Cooking Energy Efficiency Data

Table D-3. Pizza Barreling Test Data.

Measured Values	Pizza #1	Pizza #2	Pizza #3
Total Energy (Wh)	300	300	240
Cook Time (min)	2.5	2.5	2.5
Initial Weight (lb)	1.410	1.437	1.440
Final Weight (lb)	1.362	1.385	1.393
Initial Temperature (°F)	40	40	40
Final Temperature (°F)	196.3	195.5	192.7
Calculated Values			
Sensible to Solids (Btu)	131	133	130
Latent - Water Vaporization (Btu)	47	51	46
Total Energy to Food (Btu)	178	184	176
Energy to Food (Btu/lb)	**126**	**128**	**123**
Total Energy to Oven (Btu)	1024	1024	819
Energy to Oven (Btu/lb)	**726**	**713**	**569**
Cooking Energy Efficiency (%)	**17.4**	**17.9**	**21.6**
Cooking Energy Rate (kW)	**7.2**	**7.2**	**5.8**
Production Capacity (pizzas/hr)	**21.7**	**21.7**	**21.7**
Production Rate (lb/h)	**31.0**	**31.0**	**31.0**

Table D-3 (continued). Pizza Barreling Test Data.

Measured Values	Pizza #4	Pizza #5	Pizza #6
Electric Energy (Wh)	240	220	200
Cook Time (min)	2.5	2.5	2.5
Initial Weight (lb)	1.399	1.417	1.452
Final Weight (lb)	1.356	1.376	1.414
Initial Temperature (°F)	40	40	40
Final Temperature (°F)	193.5	191.0	190.7
Calculated Values			
Sensible to Solids (Btu)	127	127	130
Latent - Water Vaporization (Btu)	42	40	37
Total Energy to Food (Btu)	169	167	167
Energy to Food (Btu/lb)	**121**	**118**	**115**
Total Energy to Oven (Btu)	819	751	683
Energy to Oven (Btu/lb)	**586**	**530**	**470**
Cooking Energy Efficiency (%)	**20.7**	**22.3**	**24.5**
Cooking Energy Rate (kW)	**5.8**	**5.3**	**4.8**
Production Capacity (pizzas/hr)	**21.7**	**21.7**	**21.7**
Production Rate (lb/h)	**31.0**	**31.0**	**31.0**

Table D-3 (continued). Pizza Barreling Test Data.

Measured Values	Pizza #7	Pizza #8
Total Energy (Wh)	200	200
Cook Time (min)	2.5	2.5
Initial Weight (lb)	1.429	1.452
Final Weight (lb)	1.395	1.416
Initial Temperature (°F)	40	40
Final Temperature (°F)	194.6	192.3
Calculated Values		
Sensible to Solids (Btu)	131	131
Latent - Water Vaporization (Btu)	33	35
Total Energy to Food (Btu)	164	166
Energy to Food (Btu/lb)	**115**	**115**
Total Energy to Oven (Btu)	683	683
Energy to Oven (Btu/lb)	**478**	**470**
Cooking Energy Efficiency (%)	**24.1**	**24.4**
Cooking Energy Rate (kW)	**4.8**	**4.8**
Production Capacity (pizzas/hr)	**21.7**	**21.7**
Production Capacity (lb/h)	**31.0**	**31.0**

Table D-4. Single Load Chicken Test Data.

Measured Values	Repetition #1	Repetition #2	Repetition #3
Total Energy (Wh)	820	840	840
Cook Time (min)	4.5	4.5	4.5
Number of Breasts	5	5	5
Initial Weight (lb)	1.494	1.536	1.525
After-Cook Weight (lb)	1.288	1.335	1.309
Final Weight (lb)	1.191	1.251	1.224
Initial Temperature (°F)	40	40	40
Final Average Temperature (°F)	170.3	169.4	172.6
Weight of Baking Dish (lb)	2.710	2.710	2.710
Initial Baking Dish Temperature (°F)	75	75	75
Final Baking Dish Temperature (°F)	450	450	450
Calculated Values			
Sensible to Solids (Btu)	156	159	162
Latent- Water Vaporization (Btu)	205	200	215
Total Energy to Food (Btu)	361	359	377
Energy to Food (Btu/lb)	**242**	**234**	**247**
Energy to Baking Dish (Btu)	203	203	203
Total Energy to Food and Dish (Btu)	564	562	580
Total Energy to Oven (Btu)	2799	2867	2867
Energy to Oven (Btu/lb)	**1873**	**1866**	**1880**
Cooking Energy Efficiency (%)	**12.9**	**12.5**	**13.1**
Cooking-Load Energy Efficiency (%)	**20.2**	**19.6**	**20.2**
Cooking Energy Rate (kW)	**10.9**	**11.2**	**11.2**
Product Shrinkage (%)	**20.3**	**18.6**	**19.7**

Table D-5. Chicken Barreling Test Data.

Measured Values	Load #1	Load #2	Load #3
Total Energy (Wh)	840	720	680
Cook Time (min)	4.5	4.5	4.5
Number of Breasts	5	5	5
Initial Weight (lb)	1.448	1.321	1.351
After-Cook Weight (lb)	1.230	1.083	1.142
Final Weight (lb)	1.141	0.995	1.040
Initial Temperature (°F)	40	40	40
Final Average Temperature (°F)	169.3	175.8	167.9
Weight of Baking Dish (lb)	2.710	2.710	2.710
Initial Baking Dish Temperature (°F)	75	75	75
Final Baking Dish Temperature (°F)	450	450	450
Calculated Values			
Sensible to Solids (Btu)	150	144	138
Latent- Water Vaporization (Btu)	217	237	208
Total Energy to Food (Btu)	367	381	346
Energy to Food (Btu/lb)	**253**	**288**	**256**
Energy to Baking Dish (Btu)	203	203	203
Total Energy to Food and Dish (Btu)	570	584	550
Total Energy to Oven (Btu)	2867	2457	2321
Energy to Oven (Btu/lb)	**1980**	**1860**	**1718**
Cooking Energy Efficiency (%)	**12.8**	**15.5**	**14.9**
Cooking-Load Energy Efficiency (%)	**19.9**	**23.8**	**23.7**
Cooking Energy Rate (kW)	**11.2**	**9.6**	**9.1**
Production Capacity (lb/hr)	**18.0**	**18.0**	**18.0**
Product Shrinkage (%)	**21.2**	**24.7**	**23.0**

Table D-5 (continued). Chicken Barreling Test Data.

Measured Values	Load #4	Load #5	Load #6
Total Energy (Wh)	680	660	660
Cook Time (min)	4.5	4.5	4.5
Number of Breasts	5	6	6
Initial Weight (lb)	1.292	1.570	1.473
After-Cook Weight (lb)	1.079	1.347	1.236
Final Weight (lb)	0.981	1.243	1.129
Initial Temperature (°F)	40	40	40
Final Average Temperature (°F)	179.6	174.3	173.4
Weight of Baking Dish (lb)	2.710	2.710	2.710
Initial Baking Dish Temperature (°F)	75	75	75
Final Baking Dish Temperature (°F)	450	450	450
Calculated Values			
Sensible to Solids (Btu)	144	169	157
Latent- Water Vaporization (Btu)	212	222	236
Total Energy to Food (Btu)	356	391	393
Energy to Food (Btu/lb)	**276**	**249**	**267**
Energy to Baking Dish (Btu)	203	203	203
Total Energy to Food and Dish (Btu)	560	594	597
Total Energy to Oven (Btu)	2321	2253	2253
Energy to Oven (Btu/lb)	**1796**	**1435**	**1529**
Cooking Energy Efficiency (%)	**15.4**	**17.4**	**17.5**
Cooking-Load Energy Efficiency (%)	**24.1**	**26.4**	**26.5**
Cooking Energy Rate (kW)	**9.1**	**8.8**	**8.8**
Production Capacity (lb/hr)	**18.0**	**18.0**	**18.0**
Product Shrinkage (%)	**24.1**	**20.8**	**23.4**

Table D-5 (continued). Chicken Barreling Test Data.

Measured Values	Load #7	Load #8
Total Energy (Wh)	660	660
Cook Time (min)	4.5	4.5
Number of Breasts	6	6
Initial Weight (lb)	1.390	1.582
After-Cook Weight (lb)	1.143	1.360
Final Weight (lb)	1.020	1.219
Initial Temperature (°F)	40	40
Final Average Temperature (°F)	180.9	166.7
Weight of Baking Dish (lb)	2.710	2.710
Initial Baking Dish Temperature (°F)	75	75
Final Baking Dish Temperature (°F)	450	450
Calculated Values		
Sensible to Solids (Btu)	157	160
Latent- Water Vaporization (Btu)	246	221
Total Energy to Food (Btu)	403	381
Energy to Food (Btu/lb)	**290**	**241**
Energy to Baking Dish (Btu)	203	203
Total Energy to Food and Dish (Btu)	606	585
Total Energy to Oven (Btu)	2253	2253
Energy to Oven (Btu/lb)	**1621**	**1424**
Cooking Energy Efficiency (%)	**17.9**	**16.9**
Cooking-Load Energy Efficiency (%)	**26.9**	**26.0**
Cooking Energy Rate (kW)	**8.80**	**8.80**
Production Capacity (lb/hr)	**18.0**	**18.0**
Product Shrinkage (%)	**26.6**	**22.9**

Table D-6. Single Load Hamburger Test Data.

Measured Values	Repetition #1	Repetition #2	Repetition #3
Number of Hamburger Patties	3	3	3
Total Energy (Wh)	700	700	700
Cook Time (min)	3.8	3.8	3.8
Weight Loss (%)	35.5	33.6	34.8
Initial Weight (lb)	0.747	0.749	0.750
Final Weight (lb)	0.482	0.497	0.489
Initial Moisture Content (%)	59.7	59.7	59.7
Final Moisture Content (%)	55.0	55.0	55.0
Initial Temperature(°F)	0	0	0
Final Average Temperature (°F)	164.0	159.3	162.3
Weight of Baking Dish (lb)	2.710	2.710	2.710
Initial Baking Dish Temperature (°F)	75	75	75
Final Baking Dish Temperature (°F)	450	450	450
Calculated Values			
Initial Weight of Water (lb)	0.446	0.447	0.448
Final Weight of Water (lb)	0.265	0.273	0.269
Weight of Solids (lb)	0.301	0.302	0.302
Sensible to Food (Btu)	88	86	88
Latent - Water Fusion (Btu)	64	64	64
Latent - Water Vaporization (Btu)	175	169	173
Total Energy to Food (Btu)	328	319	326
Energy to Food (Btu/lb)	**439**	**426**	**434**
Energy to Baking Dish (Btu)	203	203	203
Total Energy Consumed by Food and Dish (Btu)	531	522	529
Total Energy to Oven (Btu)	2389	2389	2389
Energy to Oven (Btu/lb)	**3198**	**3190**	**3185**
Cooking Energy Efficiency (%)	**13.7**	**13.3**	**13.6**
Cooking-Load Energy Efficiency (%)	**22.2**	**21.9**	**22.1**
Cooking Energy Rate (kW)	**11.0**	**11.0**	**11.0**

Cooking Energy Efficiency Data

Table D-7. Hamburger Barreling Test Data.

Measured Values	Load #1	Load #2	Load #3
Number of Hamburger Patties	3	3	3
Total Energy (Wh)	720	640	580
Cook Time (min)	3.8	3.8	3.8
Weight Loss (%)	36.4	34.3	31.9
Initial Weight (lb)	0.749	0.747	0.742
Final Weight (lb)	0.476	0.491	0.505
Initial Moisture Content (%)	59.7	59.7	59.7
Final Moisture Content (%)	55.0	55.0	55.0
Initial Temperature(°F)	0	0	0
Final Average Temperature (°F)	166.6	160.9	154.9
Weight of Baking Dish (lb)	2.710	2.710	2.710
Initial Baking Dish Temperature (°F)	75	75	75
Final Baking Dish Temperature (°F)	450	450	450
Calculated Values			
Initial Weight of Water (lb)	0.447	0.446	0.443
Final Weight of Water (lb)	0.262	0.270	0.278
Weight of Solids (lb)	.302	.301	.299
Sensible to Food (Btu)	90	87	83
Latent - Water Fusion (Btu)	64	64	64
Latent - Water Vaporization (Btu)	180	171	160
Total Energy to Food (Btu)	334	321	307
Energy to Food (Btu/lb)	**446**	**430**	**413**
Energy to Baking Dish (Btu)	203	203	203
Total Energy Consumed by Food and Dish (Btu)	537	525	510
Total Energy to Oven (Btu)	2457	2184	1980
Energy to Oven (Btu/lb)	**3281**	**2924**	**2668**
Cooking Energy Efficiency (%)	**13.6**	**14.7**	**15.5**
Cooking-Load Energy Efficiency (%)	**21.9**	**24.0**	**25.8**
Cooking Energy Rate (kW)	**11.3**	**10.0**	**9.1**
Production Capacity (lb/hr)	**14.9**	**14.9**	**14.9**

Table D-7 (continued). Hamburger Barreling Test Data.

Measured Values	Load #4	Load #5	Load #6
Number of Hamburger Patties	3	3	3
Total Energy (Wh)	580	580	580
Cook Time (min)	3.8	3.8	3.8
Weight Loss (%)	31.0	31.2	31.8
Initial Weight (lb)	0.748	0.747	0.749
Final Weight (lb)	0.516	0.514	0.511
Initial Moisture Content (%)	59.7	59.7	59.7
Final Moisture Content (%)	55.0	55.0	55.0
Initial Temperature(°F)	0	0	0
Final Average Temperature (°F)	152.5	152.9	154.4
Weight of Baking Dish (lb)	2.710	2.710	2.710
Initial Baking Dish Temperature (°F)	75	75	75
Final Baking Dish Temperature (°F)	450	450	450
Calculated Values			
Initial Weight of Water (lb)	0.447	0.446	0.447
Final Weight of Water (lb)	0.284	0.283	0.281
Weight of Solids (lb)	.302	.301	.302
Sensible to Food (Btu)	82	82	83
Latent - Water Fusion (Btu)	64	64	64
Latent - Water Vaporization (Btu)	158	158	161
Total Energy to Food (Btu)	304	305	309
Energy to Food (Btu/lb)	**407**	**408**	**412**
Energy to Baking Dish (Btu)	203	203	203
Total Energy Consumed by Food and Dish (Btu)	508	508	512
Total Energy to Oven (Btu)	1980	1980	1980
Energy to Oven (Btu/lb)	**2646**	**2650**	**2643**
Cooking Energy Efficiency (%)	**15.4**	**15.4**	**15.6**
Cooking-Load Energy Efficiency (%)	**25.6**	**25.7**	**25.9**
Cooking Energy Rate (kW)	**9.1**	**9.1**	**9.1**
Production Capacity (lb/hr)	**14.9**	**14.9**	**14.9**

Table D-8. Single Load Cooking Energy Efficiency Statistics.

	Cooking Energy Efficiency		
	Pizza	**Chicken***	**Hamburgers***
Replicate #1	17.9	20.2	22.2
Replicate #2	17.4	19.6	21.9
Replicate #3	17.7	20.2	22.1
Average	**17.7**	**20.0**	**22.1**
Standard Deviation	0.29	0.34	0.20
Absolute Uncertainty	0.73	0.83	0.50
Percent Uncertainty	4.1	4.2	2.2

* Load Efficiencies