

Vulcan-Hart, Model VC4GD Gas Full-Size Convection Oven Performance Test

Application of ASTM Standard
Test Method F 1496-99

FSTC Report 5011.03.08—2nd Edition

**Food Service Technology Center
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Executive Summary

The Vulcan-Hart VC4GD gas convection oven (Figure ES-1) is the first oven tested by the Food Service Technology Center (FSTC) that incorporates a snorkel to drive flue gases into the cooking cavity, thereby placing it into the classification of direct-fired ovens. A two-speed fan, powered by a ½-hp motor, circulates hot air and combustion gases throughout the cavity and solid-state controls maintain oven temperatures selected by a simple dial control. The two-speed fan allows for variable cooking conditions as well as quicker cool down times.

FSTC engineers tested the full-size gas convection oven under the tight specifications of the American Society for Testing and Materials' (ASTM) standard test method.¹ Convection oven performance is characterized by preheat time and energy consumption, idle energy consumption rate, cooking-energy efficiency, production capacity, cooking uniformity, and white sheet cake browning uniformity.

Cooking performance was determined by baking 100-count russet potatoes under three different loading scenarios (heavy—5 full-size sheet pans, medium—3 full-size sheet pans, and light—1 full-size sheet pan). The cook times for the three loading scenarios were 54.2 minutes for the heavy-load test, 45.9 minutes for the medium-load test, and 44.9 minutes for the light-load test.

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

¹ American Society for Testing and Materials. 1999. *Standard Test Method for the Performance of Convection Ovens*. ASTM Designation F 1496-99, in *Annual Book of ASTM Standards*, Philadelphia.

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

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

Table ES-1. Summary of ASTM Convection Oven Performance Results.

Rated Energy Input Rate (Btu/h)	44,000
Measured Energy Input Rate (Btu/h)	45,330
Fan/Control Energy Rate (kW)	0.53
Preheat Time to 350°F (min) ^a	13.0
Preheat Energy to 350°F (Btu) ^a	9,800
Idle Energy Rate @ 350°F (Btu/h) ^a	11,850
Pilot Energy Rate (Btu/h) ^a	0
Heavy-load Cooking-Energy Efficiency (%)	46.3 ± 1.0 ^b
Medium-Load Cooking-Energy Efficiency (%)	41.3 ± 0.5 ^b
Light-Load Cooking-Energy Efficiency (%)	24.8 ± 0.5 ^b
Production Capacity ^c (lb/h)	80.4 ± 5.1 ^b
Cooking Uniformity Average Rack Temperatures (°F):	
Rack #1 (Top)	170
Rack #2	152
Rack #3	154
Rack #4	173
Rack #5 (Bottom)	185
Maximum Temperature Difference	33

^a This oven was equipped with automatic ignition.

^b This range indicates the experimental uncertainty in the test result based on a minimum of three test runs.

^c Based on the heavy-load cooking test with a 205°F endpoint.

Under the procedures and conditions of the ASTM test method, the heavy-load potato test was evaluated at a 205°F endpoint, instead of a previous accepted 210°F endpoint, due to the fact that research conducted by the FSTC showed that potatoes were sufficiently cooked at this temperature and considered ac-

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ceptable. Furthermore, energy efficiencies and cooking energy rates for both endpoints were very close to one another.

Figure ES-1 illustrates the relationship between cooking-energy efficiency and production rate for this convection oven. Figure ES-2 illustrates the relationship between the convection oven's average energy consumption rate and the production rate. This graph can be used as a tool to estimate the daily energy consumption for the convection oven in a real-world operation. Average energy consumption rates at 15, 30, and 60 pounds per hour are 18,030 Btu/h, 24,060 Btu/h, and 35,520 Btu/h, respectively.

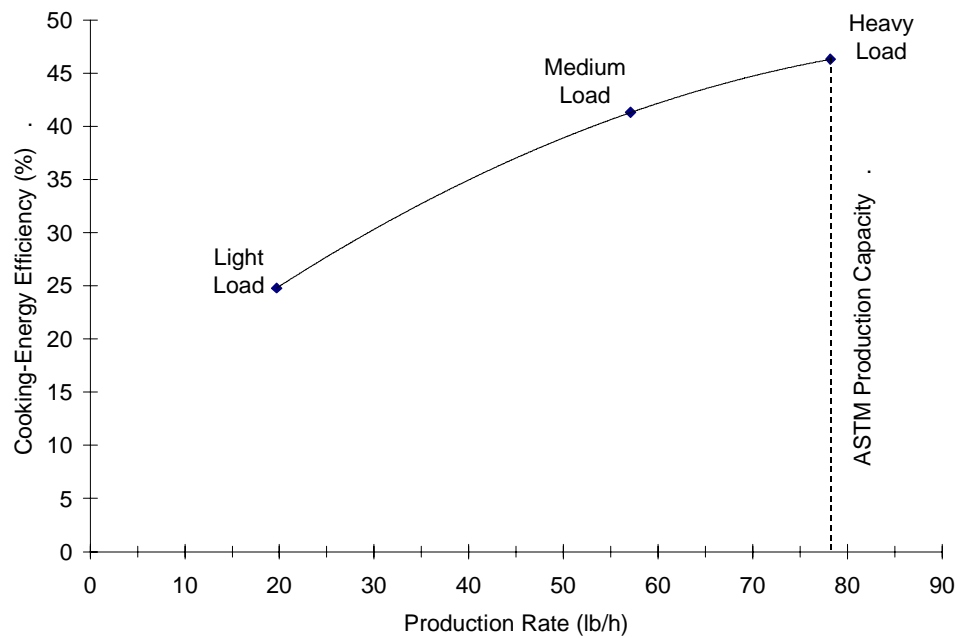
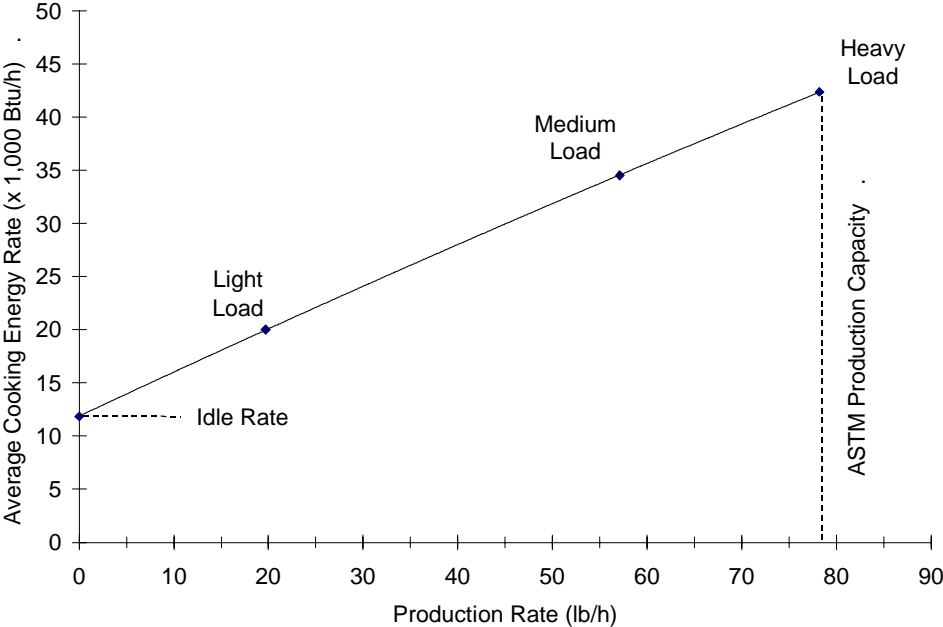


Figure ES-1.
Convection oven part-load cooking-energy efficiency.

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*Figure ES-2.
Convection oven
cooking energy
consumption profile.*



Note: Light-load = 1 pan/load; medium-load = 3 pans/load; heavy-load = 5 pans/load.

1 Introduction

Background

Convection ovens are the most widely used appliances in the food service industry. Operators know that fresh-baked signature desserts, crusty breads, and familiar comfort foods, such as roasted meats and potatoes, are irresistible to their customers. In addition to traditional uses such as roasting and baking, these ovens can be used for nearly all types of food preparation, including foods typically prepared using other types of appliances.

Vulcan-Hart's convection oven incorporates a two-speed fan with a solid-state thermostat, and a zero to 60-minute timer.

With competition rising among equipment manufacturers, new designs that incorporate timesaving features via sophisticated control packages are being introduced. In 1993, the Food Service Technology Center (FSTC) developed a standard test method to quantify the performance of convection ovens. This test method was applicable to both full-size and half-size convection ovens and allowed manufacturers and end users to compare performance indices such as energy efficiency, cooking uniformity, and production capacity.

The draft test procedure was submitted to the American Society for Testing and Materials (ASTM), and in February 1994 was accepted as a standard test method (Designation F 1496-93). Furthermore, this test method was revised in 1999 and now includes new standards in temperature endpoints. The Food Service Technology Center report, *Development and Application of a Uniform Testing Procedure for Convection Ovens* documents the developmental procedures and preliminary test results for four (two gas and two electric) convection ovens.² Other Food Service Technology Center reports document results of applying the ASTM test method to different convection ovens.^{3,4,5}

Vulcan-Hart's gas convection oven incorporates a two-speed, ½-horsepower fan with a solid-state thermostat, and a zero-to-sixty minute timer. The speed selection allows the fan to run at high or low speeds, with the doors open to cool the cooking cavity. The glossary in Appendix A is provided so that the

Introduction

reader has a quick reference to the terms used in this report and Appendix B includes the full specification sheet for this oven.

Objectives

The objective of this report is to examine the operation and performance of the Vulcan-Hart VC4GD gas full-size convection oven under the controlled conditions of the ASTM standard test method. The scope of this testing is as follows:

1. Verify that the appliance is operating at the manufacturer's rated energy input.
2. Determine the time and energy required to preheat the oven from room temperature to 340°F.
3. Characterize the oven's idle energy use with the thermostat set at a calibrated 350°F.
4. Document the cooking energy consumption and efficiency under three different scenarios: heavy (five pans of potatoes), medium (three pans of potatoes), and light (single pan of potatoes).
5. Determine the oven's production capacity when baking potatoes.
6. Document the oven's frozen-load cooking-energy efficiency, production capacity, and cooking uniformity using a representative food product such as macaroni and cheese.
7. Document the oven's browning uniformity using white sheet cakes.

Appliance Description

An atmospheric burner located under the floor of the oven cavity powers the thermostatically controlled convection oven. Heat is transferred to the oven cavity from combustion products as they circulate up through spaces between the sidewalls of the oven cavity (Figure 1-1) and through a rectangular duct ("Snorkel") that directly routes the hot flue gasses into the cooking cavity (Figure 1-2). A ½-horsepower, 2-speed (high or low speed) fan circulates air throughout the oven cavity. This oven was equipped with electronic ignition, thus eliminating the need for a standing pilot.

Introduction

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



Figure 1-1.
VC4GD oven cavity.

Table 1-1. Appliance Specifications.

Manufacturer	Vulcan-Hart
Model	VC4GD
Generic Appliance Type	Full-size gas convection oven
Rated Input	44,000 Btu/h
Dimensions	29" x 22 ¹ / ₈ " x 20"
Oven Cavity Volume	12,832.5 cubic inches
Controls	Single thermostat adjustable from 150 to 500°F, 0 to 60 minute cook timer, and a two-speed fan.

2 Methods

Setup and Instrumentation

FSTC researchers installed the convection oven on a tiled floor under a 4-foot-deep canopy hood that was 6 feet, 6 inches above the floor. The hood operated at a nominal exhaust rate of 300 cfm per linear foot of hood. There was at least 6 inches of clearance between the vertical plane of the convection oven and the edge of the hood. Figure 2-1 illustrates this setup. All test apparatus were installed in accordance with Section 9 of the ASTM test method.¹

Researchers instrumented the convection oven with several thermocouples to measure the temperature of the oven walls and the temperature at the center of the cooking cavity. Natural gas consumption was measured with a positive displacement-type gas meter that generated a pulse for every 0.1 ft³ consumed. Fan and control energy was measured with a Watt-hour transducer

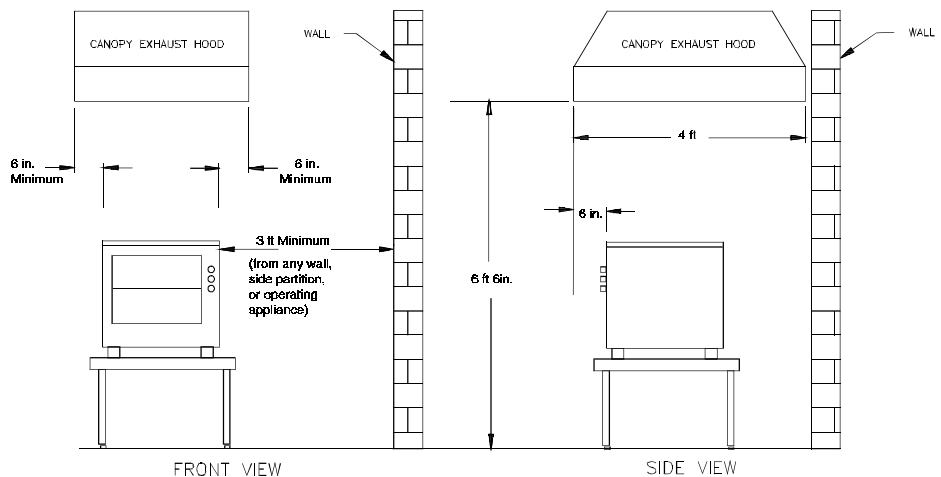


Figure 2-1.
Appliance/hood
configuration.

that generated a pulse for every 0.00001 watt-hours. The gas meter, transducer, and thermocouples were connected to an automated data acquisition

Methods

unit that recorded data every 5 seconds. Energy consumption and input rates were calculated and temperature profiles were generated from this information.

Measured Energy Input Rate

Researchers determined the energy input rate by measuring the energy consumption during a preheat from room temperature. The peak input recorded during this period was reported as the measured energy input rate.

Cooking-Energy Efficiency Tests

The cooking-energy efficiency and production capacity tests consisted of baking 100-count russet potatoes on full-size sheet pans. The cooking-energy efficiency tests were conducted for three distinct loading scenarios: heavy (five sheet pans), medium (three sheet pans) and light (single sheet pan).

Each pan was filled with 30 potatoes that had a combined weight of approximately 14½ pounds. Three potatoes per pan were randomly selected and instrumented with thermocouples for monitoring temperature during the test. The potatoes were then baked from 70°F to an average temperature of 205°F. Each of the three cooking-energy efficiency tests were replicated a minimum of three times to ensure accuracy in the reported results. Production capacity was determined during the heavy-load test.

Cooking Uniformity Tests

The heavy-load cooking uniformity test was designed to reflect how evenly an oven cooks “stubborn” food products. The preheated oven was loaded with 20 quarter-size pans (four per rack) filled with a frozen food product, in this case macaroni and cheese. The temperature of each pan was individually monitored during the course of the test. When the entire quantity of macaroni and cheese trays reached an average temperature of 170°F, the test was complete. By recording the temperatures of the pans, the tester could show how uniformly the oven cooked the frozen food product, especially within each rack and in each corner.

Methods

Browning Uniformity Tests

The oven's browning uniformity was documented while baking white sheet cakes. For this test, the oven was loaded with five full-size sheet pans, each filled with 6 pounds of cake batter. The pans were loaded from the bottom rack to the top rack to minimize the disuniformity between racks. The cakes were considered done when a wood skewer could be inserted into the cakes and removed without any particles adhering to it.

Appendix C contains the ASTM results reporting sheets for this oven.

3 Results

Energy Input Rate

Prior to testing, the energy input rate was measured and compared with the manufacturer's nameplate value. This procedure ensured that the convection oven was operating within its specified parameters. The measured energy input rate was 45,330 Btu/h (a difference of 3.0% from the nameplate rating).

Preheat and Idle Tests

Preheat Energy and Time

The oven was instrumented with thermocouples attached to the geometric center of the cooking cavity. After stabilizing the oven cavity at room temperature ($70 \pm 5^\circ\text{F}$) overnight, the oven was turned on and preheated to 350°F . Elapsed time and energy consumption were recorded during this preheat period. However, for accuracy, preheat energy was recorded from the time the burners were on until the cavity temperature reached 340°F , as specified by the ASTM test method.¹ This ensured that there would be no disruption or premature reduction in burner rate during preheat to the 350°F set-point. Figure 3-1 shows the oven's energy consumption along with the cooking cavity temperature during this preheat test.

Idle Energy Rate

The idle energy rate represents the energy required to maintain the set temperature, or the oven's stand-by losses. After the oven had stabilized at 350°F for at least one hour, researchers monitored oven energy consumption for an additional three hours. The idle energy rate during this period was 11,850 Btu/h, with an additional 530 watts of electricity for the fan and controls.

Results

Test Results

Input, preheat, and idle test results are summarized in Table 3-1.

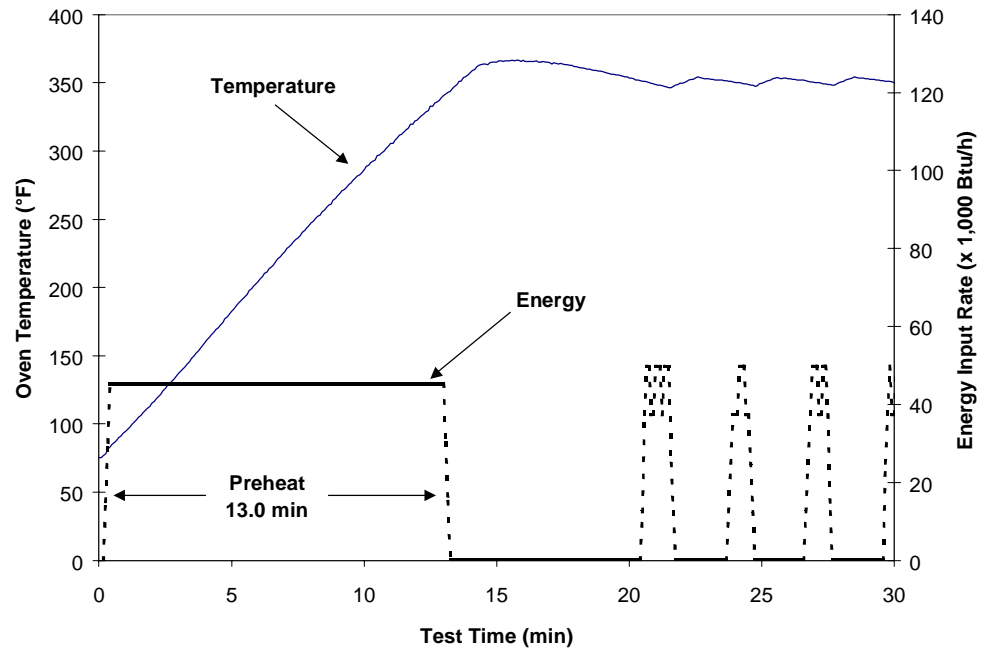


Figure 3-1.
Preheat characteristics.

Table 3-1. Input, Preheat, and Idle Test Results.

Rated Energy Input Rate (Btu/h)	44,000
Measured Energy Input Rate (Btu/h)	45,330
Fan/Control Energy Rate (kW)	0.53
Preheat	
Time to 340°F (min)	13.0
Energy (Btu)	9,800
Rate to 340°F (°F/min)	21
Idle Energy Rate @ 350°F (Btu/h)	11,850

Results

Cooking-Energy Efficiency Tests

The convection oven was used to bake 100-count russet potatoes under three loading scenarios: full (five full-size pans), medium (three full-size pans), and light (single full-size pan). Each pan contained 30 potatoes, with a combined weight of approximately 14½ pounds. Researchers monitored cook time, potato temperature and convection oven energy consumption during these tests.

Heavy-load Tests

The heavy-load cooking tests were designed to reflect an oven’s maximum performance. The oven was used to bake five full-size sheet pans of potatoes from 70°F to an average temperature of 205°F. Three potatoes per pan were randomly selected and instrumented with thermocouples for monitoring temperature. Figure 3-2 shows the average potato temperature during a typical heavy-load test.

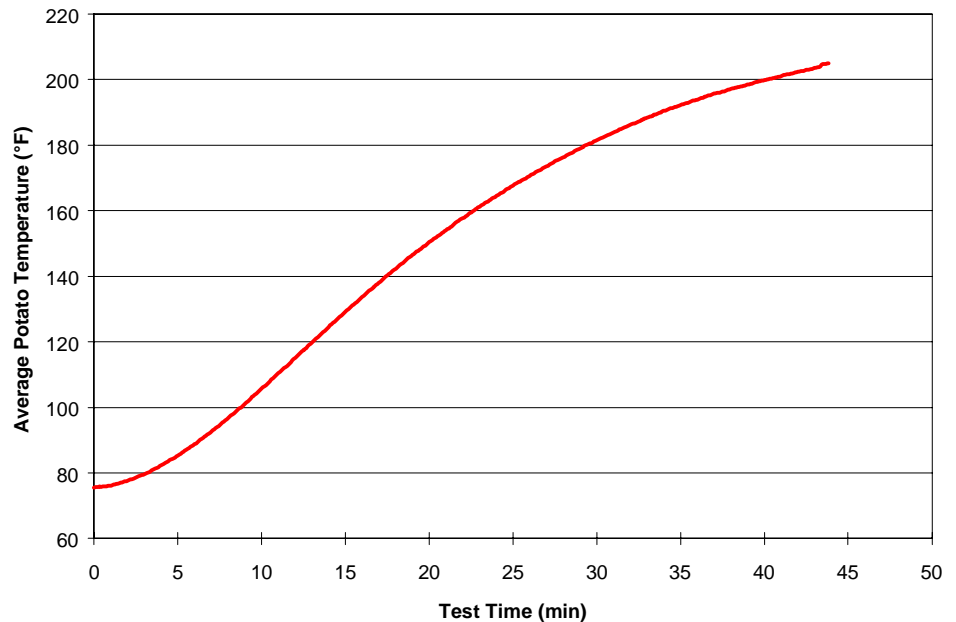


Figure 3-2.
Average potato temperature during a heavy-load test.

Results

Since 210°F is close to the boiling point for water, the temperature curve tends to flatten out as it approaches the specified endpoint. At this point, the potatoes begin to absorb the available heat much more slowly, which may somewhat overstate the required cook time. A 205°F endpoint was considered as an alternative to the previously-specified 210°F endpoint since 205°F was still on the steep portion of the temperature curve. Energy imparted to the potatoes is the sum of the energy required to raise their temperatures from 70°F to the endpoint (sensible energy) and the energy required to vaporize a portion of the water contained in the potatoes (vaporization energy). The oven's cooking-energy efficiency for a given loading scenario is the amount of energy imparted to the potatoes, expressed as a percentage of the amount of energy consumed by the oven during the cooking process.

Medium- and Light-Load Tests

Medium and light load tests determine the oven's performance under partial loading conditions. The medium-load tests were conducted with three full-size sheet pans of potatoes; the light-load tests were conducted with a single pan of potatoes. Since convection ovens may be used to bake less than a full load of product much of the time, these part-load efficiencies can be used to estimate convection oven performance in an actual operation.

Test Results

Cooking-energy efficiency results for the ASTM heavy-load tests were 45.3%, 45.8%, 46.2%, and 47.7%, yielding an uncertainty of 1.0% in the test results. Table 3-2 summarizes the results of the ASTM cooking-energy efficiency and production capacity tests. Figure 3-3 illustrates the relationship between cooking-energy efficiency and production rate for this convection oven. Appendix D contains a synopsis of test data for each replicate of the cooking tests. Figure 3-4 illustrates the relationship between the convection oven's average energy consumption rate and the production rate. This graph can be used as a

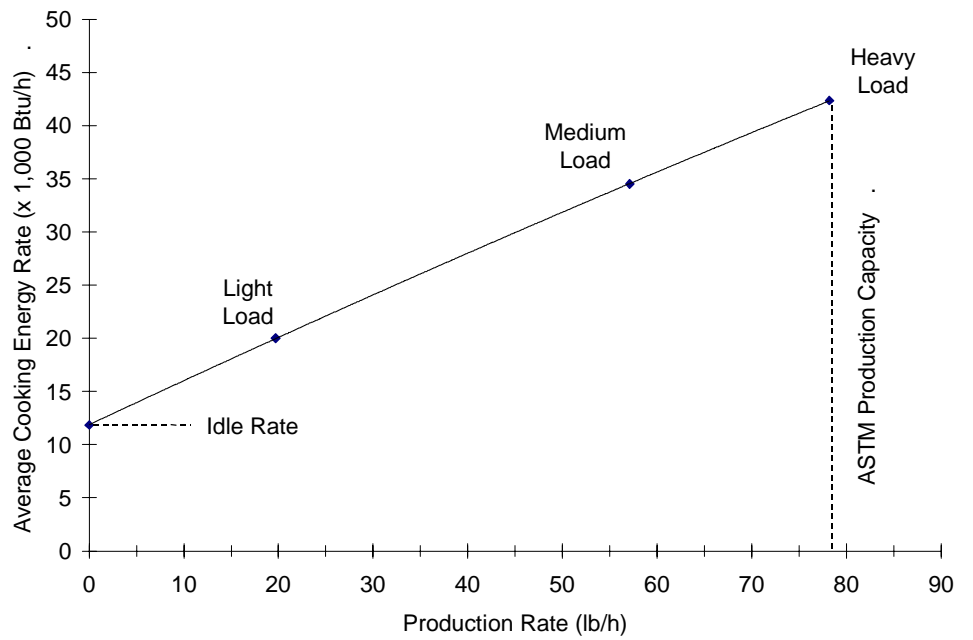
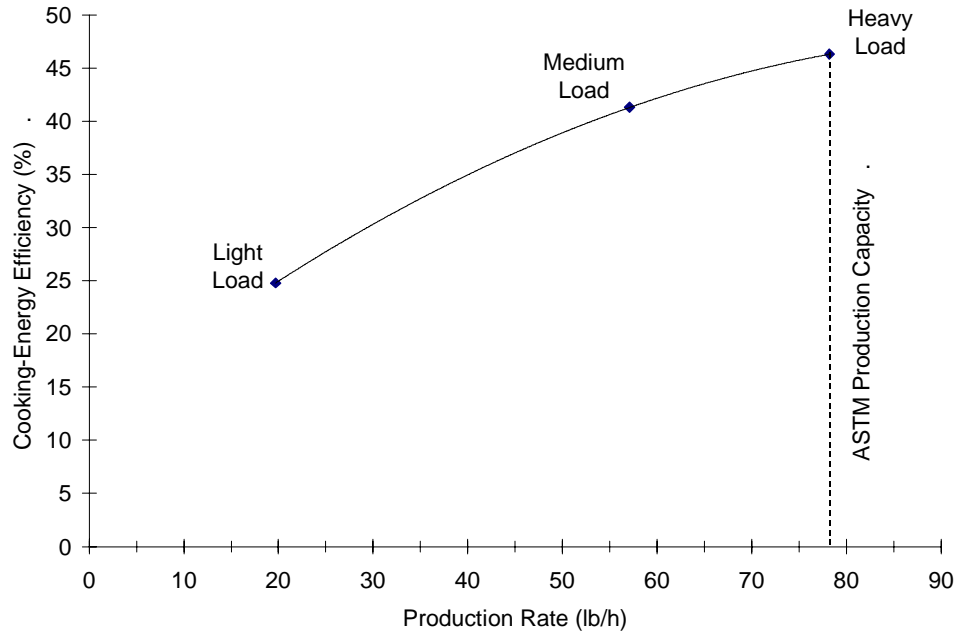
Results

tool to estimate the daily energy consumption for the convection oven in a real-world operation. Average energy consumption rates at 15, 30, and 60 pounds per hour are 21,370 Btu/h, 28,660 Btu/h, and 40,390 Btu/h, respectively.

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

	Heavy-Load	Medium-Load	Light-Load
Endpoint (°F)	205	205	205
Cook Time (min)	54.20	45.86	44.90
Production Rate (lb/h)	80.4 ± 5.1	57.1 ± 2.0	19.7 ± 0.3
Energy to Food (Btu/lb)	244	247	255
Energy Consumption (Btu/lb)	527	604	1,031
Cooking Energy Rate (Btu/h)	42,360	34,500	20,030
Fan/Control Energy Rate (kW)	0.54	0.54	0.53
Cooking-Energy Efficiency (%)	46.3 ± 1.0	41.3 ± 0.5	24.8 ± 0.5

Results



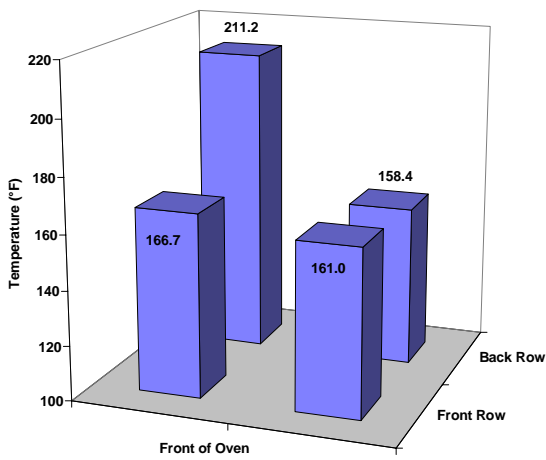
*Figure 3-4.
Convection oven
cooking energy
consumption profile.*

Note: Light-load = 1 pan/load; medium-load = 3 pans/load; heavy-load = 5 pans/load.

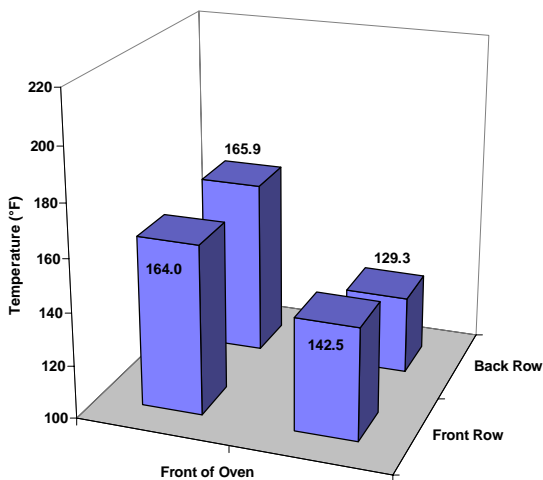
Results

Cooking Uniformity

Individual tray temperatures were monitored to evaluate the oven's cooking uniformity and ability to sufficiently and adequately heat up the macaroni and cheese frozen entrees. Each solid blue bar represents a single tray and its recorded temperature at the moment when the 20 pans reached the ASTM specified average of 170 °F. The oven racks are labeled 1 through 5, and placed from the top of the oven to the bottom.

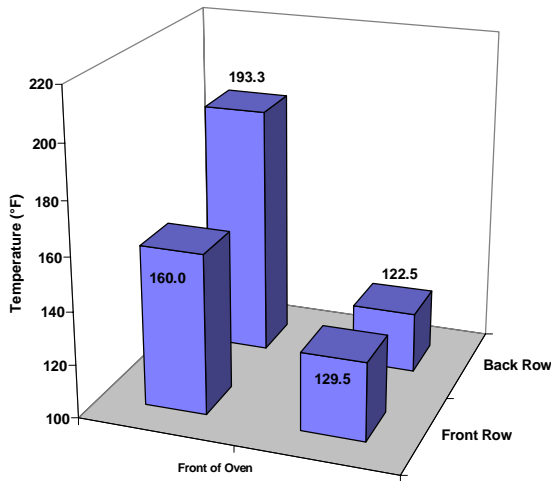


Rack 1. The top rack exhibited one of the highest average temperatures in the oven during the frozen-load tests. While the two trays located at the front of the oven and the tray placed in the right rear corner all assume a close temperature to the endpoint of 170°F, the tray in the left rear corner is significantly hotter than the other three.

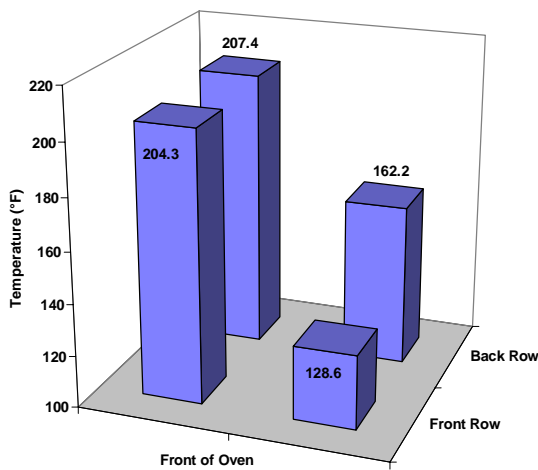


Rack 2. Contrary to the pattern seen in the first rack, Rack 2 (upper middle rack) did not exhibit an extremely high load temperature along the left rear corner and it had even temperatures along the left side, but lower temperatures on the right. Nonetheless, the macaroni and cheese tray in the left rear corner reached the highest temperature on that rack.

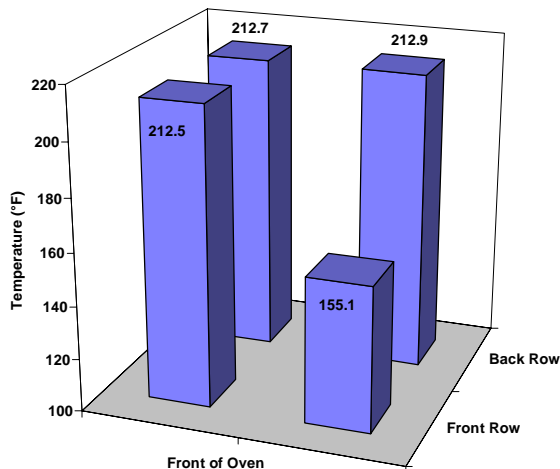
Results



Rack 3. The macaroni and cheese located on Rack 3 (center rack), exhibited a significant discrepancy from the left rear corner to the front right. While the trays on the left both reached the cooking endpoint, the tray on the right did not (each did not surpass 130°F). The difference in temperatures reflects the ovens ability to circulate the heated air around the center rack.



Rack 4. Similar to the center rack, Rack 4 (lower middle rack) also exhibits higher temperatures among the left hand trays to the point where they became overdone in the allotted time to attain an average 20-pan temperature of 170°F. Furthermore, the right-front macaroni and cheese tray was not able to exceed 130°F as seen in the center rack and this is a pattern consistent amongst all racks 2 through 4 and is also exhibited during the browning uniformity tests of sheet cakes.



Rack 5. The temperature profile for Rack 5 reveals that the bottom rack experiences the highest temperatures in the oven. This pattern is consistent with the results obtained during the cooking-energy efficiency tests and the browning uniformity tests. This is due to the fact that rack 5 is closest to the oven's heat source and reflects upon the air circulation at

Results

that location. The right-front tray also experiences the lowest overall temperature of the rack. Table 3-5 summarizes the results of the frozen-load tests.

Table 3-3. Frozen (Macaroni & Cheese) Load Test Results.

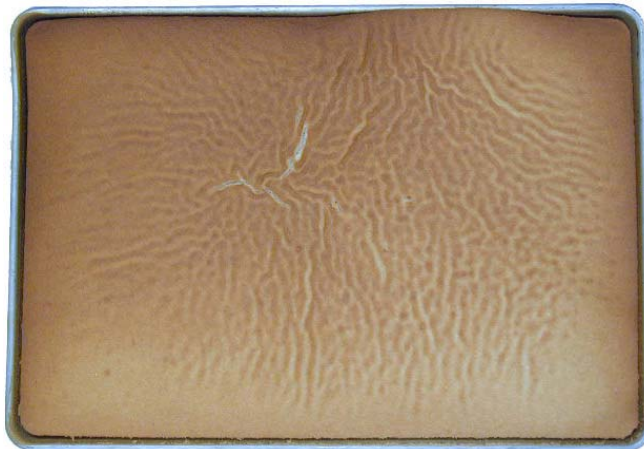
Cook Time (min)	66.9
Production Rate (lb/h)	83.4
Energy to Food (Btu/lb)	268
Energy Consumption (Btu/lb)	520
Cooking Energy Rate (Btu/h)	43,300
Fan/Control Energy Rate (kW)	0.51
Cooking-Energy Efficiency (%)	51.6
Average Rack Temperatures (°F):	
Rack #1	170
Rack #2	152
Rack #3	154
Rack #4	173
Rack #5	185

Browning Uniformity

White sheet cakes provide a visual indication of the temperature uniformity of an oven while baking. The cook time was experimentally determined so that the cakes were uniformly cooked while exhibiting the greatest possible differences in color. The results of the test are described below and visual representations of the browning are shown in Figures 3-6 through 3-10.

Results

Figure 3-5.
Top sheet cake
(rack #1).



Top rack. The surface of this cake had a nice golden brown color and wrinkling was evenly distributed along the surface. The cake located on this rack was also the one to reach doneness first.

Figure 3-6.
Upper middle sheet cake
(rack #2).



Upper middle rack. This cake had a light section along the center of the cake and golden brown patches to either side. The light patch was wider at the front of the cake than at the rear and the left rear is slightly darker than the rest of the cake.

Results

Figure 3-7.
Middle sheet cake
(rack #3).



Middle rack. This cake was somewhat lighter than the rest of the cakes and only the edges exhibited a darker brown surface.

Figure 3-8.
Lower middle sheet cake
(rack #4).



Lower middle rack. This cake showed a nice golden color along most of its surface and a darker edge on the sides and the front.

Results



Figure 3-9.
Bottom sheet cake
(rack #5).

Bottom rack. This cake exhibited darker edges on the left and right, while the rest of the surface remained a golden brown color. Wrinkling was quite even and several remnants of air bubbles in the batter can be seen.

4 Conclusions

The Vulcan-Hart, model VC4GD, full-size gas convection oven performed well under the rigorous conditions of the ASTM test method. It exhibited an impressive, 46% heavy-load efficiency, while out-producing ovens with a much larger rated input.^{2,5} Not only did this Vulcan oven perform well under heavy-load conditions, but its part-load cooking performance was equally impressive. In fact, the VC4GD's 41.3% medium-load efficiency was higher than the heavy-load efficiency for many other gas ovens available on the market.²⁻⁵

This excellent part-load cooking performance was supported by a low, 11,850 Btu/h idle rate and a quick (13 minute) preheat. In addition, the oven cooled down quickly with its dual-speed fan set to high. Since this oven is classified as a direct-fired gas convection oven, it distributes hot flue gases into the cooking cavity for better cooking performance and uniformity. The test results reflect the advantages of using this technology as cooking energy consumption and cook times were minimized. During the heavy-, medium-, and light-load potato tests, the monitored potatoes were sufficiently cooked in a minimal amount of time with little variation in temperature. Furthermore, as indicated by their respective efficiency values, the cooking energy consumption also remained at a minimum.

During the cooking uniformity tests, the oven adequately cooked the frozen macaroni and cheese loads, demonstrating high cooking-energy efficiency (51.6%) at a production rate of 83.4 lb/h. These frozen entrée tests represent a real-world kitchen scenario and shows the strengths and capabilities of this oven.

A more qualitative evaluation of the cooking uniformity of this oven is the browning uniformity tests conducted with white sheet cake. The pictures included in this report show that the oven did a fine job of evenly distributing

Conclusions

heated air to all five sheet cakes. Surface color and texture were acceptable on all the cakes, indicating fairly good baking uniformity.

With its low energy consumption, fast cook times, and high energy efficiency, the Vulcan VC4GD full size gas convection oven proved to be quite versatile and would be an excellent addition to any kitchen.

5 References

1. American Society for Testing and Materials, 1999. *Standard Test Method for Performance of Convection Ovens*. ASTM Designation F1496-99. In Annual Book of ASTM Standards, West Conshohocken, PA.
2. Blessent, J., 1994. *Development and Application of a Uniform Testing Procedure for Convection Ovens*. Pacific Gas and Electric Company Department of Research and Development Report 008.1-94-12, October.
3. Blessent, J., 1996. *Montague Model SEK15AH Electric Convection Oven: Application of ASTM Standard Test Method F1496-93*. Food Service Technology Center Report 5011.95.24, April.
4. Blessent, J., 1996. *Montague Model SE70AH Gas Convection Oven: Application of ASTM Standard Test Method F1496-93*. Food Service Technology Center Report 5011.95.25, April.
5. Zabrowski, D., Cadotte, B., Cowen, D., 1999. *Montague, Model Vectaire HX63A Gas Full-Size Convection Oven Performance Test*. Food Service Technology Center Report 5011.99.79, December.

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 kBtu/h)

The average rate of energy consumption during the cooking period.

Cooking-Energy Efficiency (%)

The quantity of energy input to the food products; expressed as a percentage of the quantity of energy input to the appliance during the heavy-, 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 kBtu/h)

Energy Consumption Rate

Energy Rate

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

Heating Value (Btu/ft³)

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.

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

Glossary

Measured Input Rate (kW or Btu/h)

Measured Energy Input Rate

Measured Peak Energy Input Rate

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

Pilot Energy Rate (kBtu/h)

Pilot Energy Consumption Rate

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

Preheat Energy (kWh or Btu)

Preheat Energy Consumption

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

Preheat Rate (°F/min)

The rate at which the cook zone heats during a preheat.

Preheat Time (minute)

Preheat Period

The time required for an appliance to “preheat” from the ambient room temperature ($75 \pm 5^\circ\text{F}$) to a specified (and calibrated) operating temperature or thermostat set point.

Production Capacity (lb/h)

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

Production Rate (lb/h)

Productivity

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

Rated Energy Input Rate

(kW, W or Btu/h, Btu/h)

Input Rating (ANSI definition)

Nameplate Energy Input Rate

Rated Input

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

Recovery Time (minute, second)

The average time from the removal of the cooked food product from the appliance until the cooking cavity is within 10°F of the thermostat set point and the appliance is ready to be reloaded.

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

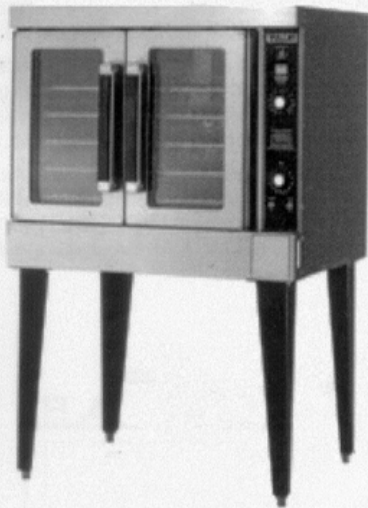
Appendix B includes the product literature for the Vulcan VC4GD gas convection oven.

VULCAN

Item # _____

C.S.I. Section 11420

MODEL VC4GD SINGLE DECK GAS CONVECTION OVEN



SPECIFICATIONS:

Single section gas convection oven, Vulcan-Hart Model No. VC4GD. Stainless steel front, sides and top. Painted legs. Independently operated stainless steel doors with windows open a full 180°. Non-sag insulation applied to the top, rear, sides, bottom and doors. Porcelain enamel on steel oven interior measures 29" w x 22 1/4" d x 20" h. Two interior oven lights. Five nickel plated oven racks measure 28 1/4" x 20 1/2". Eleven position nickel plated rack guides with positive rack stops. One 44,000 BTU/hr. burner. Electronic spark igniter. Furnished with a two speed 1/2 H.P. oven blower-motor. Side mounted solid state temperature control adjusts from 150° to 500°F. 60 minute timer with audible alarm. Oven cool switch for rapid cool down. 115 volt, 60 Hz, 1 ph power supply required. 6' cord and plug. 9 amps total draw.

Exterior dimensions: 40" w x 41 1/2" d x 56 3/4" h on 25 3/4" legs. Depth measurement includes door handles.

CSA design certified. NSF listed.

SPECIFY TYPE OF GAS WHEN ORDERING.

SPECIFY ALTITUDE WHEN ABOVE 2,000 FT.

STANDARD FEATURES

- Stainless steel front, sides and top.
- Painted legs.
- Stainless steel doors with windows.
- 44,000 BTU/hr. burner.
- Electronic spark igniter.
- 1/2 H.P. two speed oven blower-motor. 115/60/1 with 6' cord and plug. 9 amps.
- Solid state temperature control adjusts from 150° to 500°F.
- 60 minute timer with audible alarm.
- Oven cool switch for rapid cool down.
- Porcelain enamel on steel oven interior.
- Five nickel plated oven racks with eleven rack positions.
- 3/4" rear gas connection with gas pressure regulator and manual shut-off valve.
- One year limited parts and labor warranty.

OPTIONS

- Stainless steel legs.
- Five hour timer in place of 60 minute timer.
- Roast & Hold control.
- Stainless steel open stand with storage rack.
- Casters.
- 208V or 240V, 60 Hz, 1 phase two speed blower-motor, 1/2 H.P.
- Second year extended limited parts and labor warranty.

ACCESSORIES

- Stainless steel rear enclosure.
- Extra oven rack(s).
- Stainless steel drip pan.
- Flexible gas hose with quick disconnect and restraining device. Consult price book for available sizes.
- Down draft flue diverter for direct vent connection.
- Stacking kit.

VULCANA2780
ISO9001
Vulcan-Hart Co.**MODEL: VC4GD Single Deck Gas Convection 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

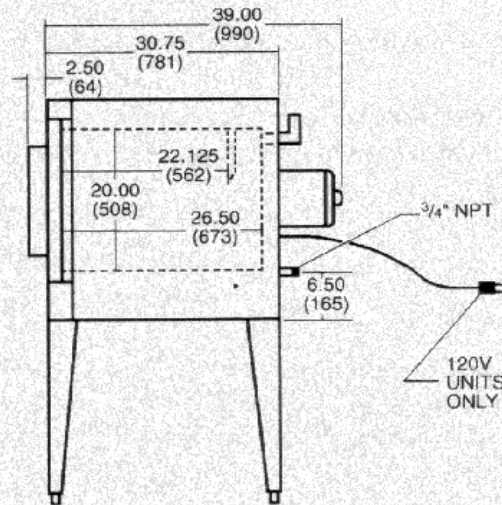
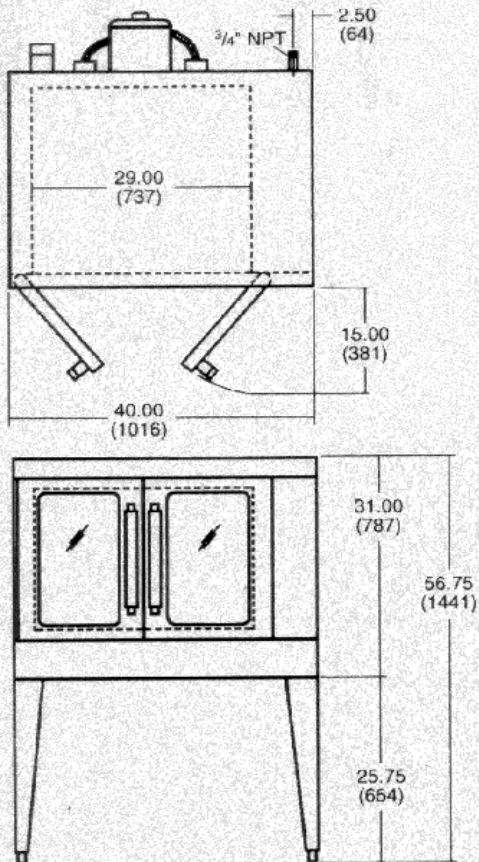
VULCAN

MODEL VC4GD SINGLE DECK GAS CONVECTION OVEN

IMPORTANT

1. A gas pressure regulator for this unit is included. Natural gas 3.5" W.C., propane gas 10.0" W.C.
2. An adequate ventilation system is required for commercial cooking equipment. Information may be obtained by writing to the National Fire Protection Association, Batterymarch Park, Quincy, MA 02289. When writing, refer to NFPA No. 96.
3. These units are manufactured for installation in accordance with ANSZ223.1A (latest edition), National Fuel Gas Code. Copies may be obtained from the American Gas Association, 1515 Wilson Blvd., Arlington, VA 22209.
4. Clearances:

	Combustible	Non-combustible
Rear	6"	6"
Sides	4"	4"
5. This appliance is manufactured for commercial installation only and is not intended for home use.



MODEL NO.	WIDTH	DEPTH (INCLUDES HANDLES)	HEIGHT	BTU/HR. PER OVEN	TOTAL BTU/HR.	ELECTRICAL	APPROX. SHP. WT. LBS.	KG
VC4GD	40"	41½"	56¾"	44,000	44,000	115/60/1	502	228

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

C Results Reporting Sheets

Test Oven Description

Date: June 2002
Manufacturer: Vulcan
Model Number: VC4GD
Serial Number: 481363144 EAA
Fuel Type: Natural gas
Size: Full
Rated Input: 44,000 Btu/h
Oven Cavity Volume: 12,833 cubic inches
Controls: Single thermostat adjustable from 200 to 500°F, 0 to 60 minute cook timer, and a two-speed fan.

Thermostat Accuracy

As-Received Condition:

Center of Oven Temperature: 350°F
Oven Temperature Control Setting: 350°F

As-Adjusted Condition:

Center of Oven Temperature: $350 \pm 5^\circ\text{F}$
Oven Temperature Control Setting: 350°F

Energy Input Rate

Rated Input 44,000 Btu/h
Gas Heating Value 1017.1 Btu/scf
Measured Energy Input Rate: 45,330 Btu/h
Percent Difference between Measured and Rated 3.0%
Fan/Control Energy Rate: 0.53 kW
Pilot Energy Rate: 0 Btu/h*

*This oven was equipped with automatic ignition

Results Reporting Sheets

Preheat Energy and Time

Gas Heating Value	1017.1Btu/scf
Starting Temperature	75°F
Preheat Energy Consumption	9,800 Btu
Preheat Fan/Control Energy	0.53 kW
Preheat Time	13.0 min
Average Preheat Rate	21°F/min

See Fig. 1 for a graphical representation of the preheat period.

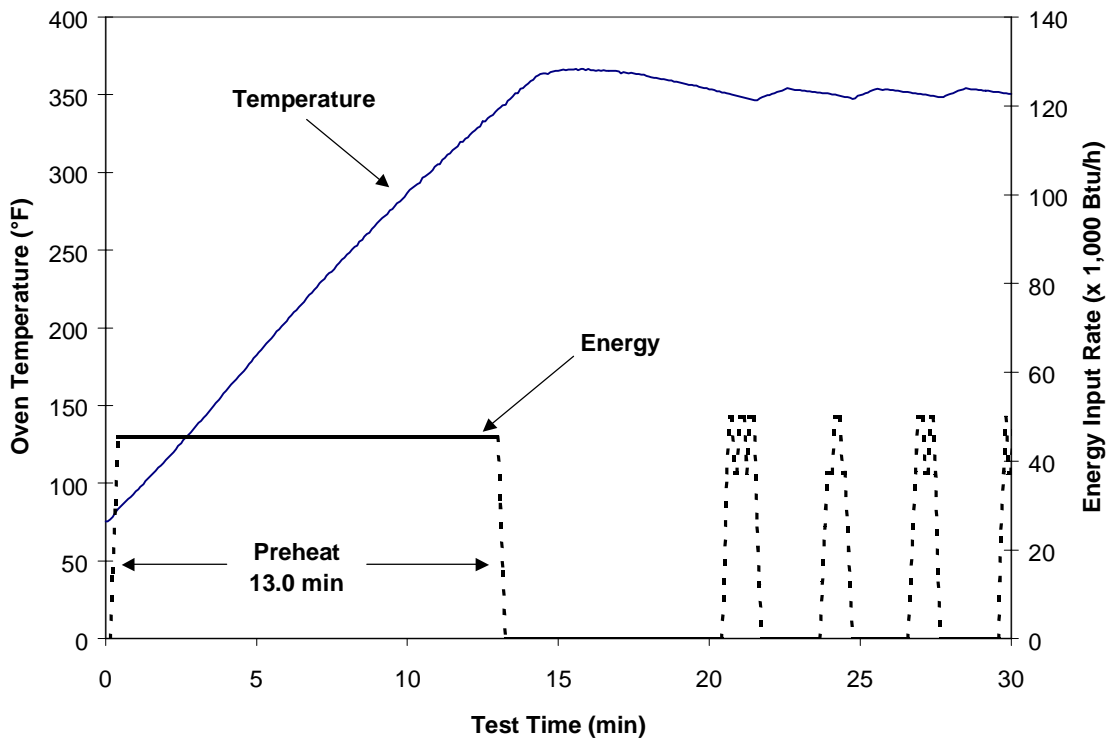


Fig. 1 Preheat and idle characteristics

Results Reporting Sheets

Idle Energy Rate

Gas Heating Value	1031.7 Btu/scf
Center Oven Temperature	350°F
Idle Energy Rate	11,850 Btu/h
Fan/Control Energy Rate	0.53 kW

Cooking-Energy Efficiency

Heavy-Load:

Gas Heating Value	1015.7 Btu/scf
Cook Time	54.20 min
Production Capacity	80.4 ± 5.1 lb/h
Energy to Food	17,690 Btu
Energy to Oven*	38,250 Btu
Energy per Pound of Food Cooked*	548 Btu/lb
Cooking Energy Rate	42,360 ± 570 Btu/h
Fan/Control Energy Rate	0.54 ± 0.01 kW
Cooking-Energy Efficiency*	46.3 ± 1.0 %

*Includes energy consumed by the fan and controls.

Medium-Load:

Gas Heating Value	1018.9 Btu/scf
Cook Time	45.86 min
Production Rate	57.1 ± 2.0 lb/h
Energy to Food	10,790 Btu
Energy to Oven*	26,860 Btu
Energy per Pound of Food Cooked*	635 Btu/lb
Cooking Energy Rate	34,500 ± 270 Btu/h
Fan/Control Energy Rate	0.54 ± 0.01 kW
Cooking-Energy Efficiency*	41.3 ± 0.5 %

*Includes energy consumed by the fan and controls.

Results Reporting Sheets

Light-Load:

Gas Heating Value	1020.8 Btu/scf
Cook Time	44.90 min
Production Rate	19.7 ± 0.3 lb/h
Energy to Food	3,756 Btu
Energy to Oven*	15,170 Btu
Energy per Pound of Food Cooked*	1,117 Btu/lb
Cooking Energy Rate	20,030 ± 300 Btu/h
Fan/Control Energy Rate	0.53 ± 0.01 kW
Cooking-Energy Efficiency*	24.8 ± 0.5 %

*Includes energy consumed by the fan and controls.

Cooking Uniformity

Rack #	Average Temperature
1 (Top)	170°F
2	152°F
3	154°F
4	173°F
5 (Bottom)	185°F

Results Reporting Sheets

Browning Test



Top rack. The surface of this cake had a nice golden brown color and wrinkling was evenly distributed along the surface. The cake located on this rack was also the one to reach doneness first.



Upper middle rack. This cake had a light section along the center of the cake and golden brown patches to either side. The light patch was wider at the front of the cake than at the rear and the left rear is slightly darker than the rest of the cake.



Middle rack. This cake was somewhat lighter than the rest of the cakes and only the edges exhibited a darker brown surface.



Lower middle rack. This cake showed a nice golden color along most of its surface and a darker edge on the sides and the front.



Bottom rack. This cake exhibited darker edges on the left and right, while the rest of the surface remained a golden brown color. Wrinkling was quite even and several remnants of air bubbles in the batter can be seen.

D Cooking-Energy Efficiency Data

Table D-1. Specific Heat and Latent Heat.

Specific Heat (Btu/lb, °F)	
Ice	0.50
Fat	0.40
Solids	0.20
Potatoes	0.84
Macaroni & Cheese	0.70
Latent Heat (Btu/lb)	
Fusion, Water	144
Fusion, Fat	44
Vaporization, Water	970

Cooking-Energy Efficiency Data

Table D-2. Heavy-Load Test Data.

	Rep #1	Rep #2	Rep #3	Rep #4
Measured Values				
Appliance Energy (Btu)	38,660	38,810	38,780	36,730
Fan/Control Energy (Wh)	470	480	480	450
Total Energy (Btu)	40,264	40,448	40,418	38,266
Cook Time (min)	54.3	55.8	55.5	51.3
Initial Weight (lb)	72.66	72.54	72.51	72.6
Final Weight (lb)	62.93	62.50	61.87	63.7
Initial Temperature (°F)	72.7	70.6	71.0	70.3
Final Temperature (°F)	205	205	205	205
Calculated Values				
Sensible (Btu)	8,075	8,187	8,159	8,217
Latent - Water Vaporization (Btu)	9,439	9,739	10,321	8,617
Total Energy to Food (Btu)	17,514	17,926	18,480	16,834
Energy to Food (Btu/lb)	241	247	255	232
Total Energy to Convection Oven	40,264	40,448	40,418	38,266
Energy to Convection Oven (Btu/lb)	554	557	556	527
Cooking-Energy Efficiency (%)	45.3	46.2	47.7	45.8
Cooking Energy Rate (Btu/h)	42,690	41,830	41,930	43,000
Fan Energy Rate (W)	540	540	540	550
Production Rate (lb/h)	80.3	78.0	78.4	85

Cooking-Energy Efficiency Data

Table D-3. Medium-Load Test Data.

	Rep #1	Rep #2	Rep #3	Rep #4
Measured Values				
Appliance Energy (Btu)	25,490	28,230	26,690	26,844
Fan/Control Energy (Wh)	390	420	390	400
Total Energy (Btu)	26,821	29,663	28,021	28,209
Cook Time (min)	46.2	48.6	45.9	46.6
Initial Weight (lb)	43.73	43.66	43.92	43.24
Final Weight (lb)	38.00	37.35	37.86	37.19
Initial Temperature (°F)	70	70	70	70
Final Temperature (°F)	205	205	205	205
Calculated Values				
Sensible (Btu)	4,962	4,952	4,983	4,838
Latent - Water Vaporization (Btu)	5,563	6,116	5,879	5,865
Total Energy to Food (Btu)	10,525	11,068	10,862	10,703
Energy to Food (Btu/lb)	241	254	247	248
Total Energy to Convection Oven	26,821	29,663	28,021	28,209
Energy to Convection Oven (Btu/lb)	613	653	622	653
Cooking-Energy Efficiency (%)	41.3	40.8	41.8	39.9
Cooking Energy Rate (Btu/h)	34,310	34,260	34,850	34,575
Fan Energy Rate (W)	540	540	540	540
Production Rate (lb/h)	56.8	53.9	57.4	55.7

Cooking-Energy Efficiency Data

Table D-4. Light-Load Test Data.

	Rep #1	Rep #2	Rep #3	Rep #4
Measured Values				
Appliance Energy (Btu)	15,590	14,980	15,128	14,960
Fan/Control Energy (Wh)	410	380	384	370
Total Energy (Btu)	16,989	16,277	16,438	16,223
Cook Time (min)	45.5	45.0	45.3	43.8
Initial Weight (lb)	14.751	14.714	14.683	14.705
Final Weight (lb)	12.507	12.508	12.402	12.586
Initial Temperature (°F)	75.3	75.7	72.5	75.5
Final Temperature (°F)	205	205	205	205
Calculated Values				
Sensible (Btu)	1,608	1,598	1,634	1,599
Latent - Water Vaporization (Btu)	2,176	2,140	2,212	2,055
Total Energy to Food (Btu)	3,784	3,738	3,846	3,655
Energy to Food (Btu/lb)	257	254	262	249
Total Energy to Convection Oven	16,989	16,277	16,438	16,223
Energy to Convection Oven (Btu/lb)	1,151	1,102	1,114	1,101
Cooking-Energy Efficiency (%)	24.3	25.0	25.4	24.4
Cooking Energy Rate (Btu/h)	20,560	19,970	20,060	20,480
Fan Energy Rate (W)	520	520	529	530
Production Rate (lb/h)	19.5	19.6	19.5	20.1

Cooking-Energy Efficiency Data

Table D-5. Cooking-Energy Efficiency and Production Capacity Statistics.

	ASTM Cooking-Energy Efficiency			ASTM Production Capacity
	Heavy Load	Medium Load	Light Load	
Replicate #1	45.3	41.3	24.3	80.3
Replicate #2	46.2	40.8	25.0	78.0
Replicate #3	47.7	41.8	25.4	78.4
Replicate #4	45.8	39.9	24.4	85.0
Average	46.3	40.9	24.8	80.4
Standard Deviation	1.0	0.82	0.52	3.21
Absolute Uncertainty	1.59	0.30	0.83	5.10
Percent Uncertainty	3.45	3.17	3.36	6.34
