Garland Xpress XG-24
Double-Sided Griddle Performance Test

Application of ASTM Standard
Test Method F 1605-95(2007)

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Specific appreciation is extended to Garland for supplying the FSTC with a 3-foot double sided gas and electric griddle, for controlled testing in the appliance laboratory.

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Executive Summary

Griddles are widely used throughout the hospitality industry to prepare a variety of menu items, from pancakes to hamburgers. As concern over food safety continues, griddle performance parameters such as temperature uniformity and productivity are becoming more important to the food service operator. Garland's double-sided griddle features a two-sided cooking technology including programmable thermostats, independently controlled heating zones, and removable non-stick sheaths for the upper platens. Heat is delivered to the lower griddle surface by individual 33,000 Btu/h gas fired burner per 12-inch section of griddle surface. The upper platens use two 4.33 kW elements to deliver heat to the food product. Each 12-inch cooking zone is controlled by a programmable computer which allows for multiple programs for various food products (see Figure ES-1).

Figure ES-1.
Garland XG-24 griddle.

Food Service Technology Center (FSTC) engineers tested the 2-foot griddle under the tightly controlled conditions of the American Society for Testing and Materials' (ASTM) Standard Test Method for the Performance of Griddles.[1] Griddle performance is characterized by temperature uniformity preheat time and energy consumption, idle energy consumption rate, cooking-energy efficiency, and production capacity.

Cooking-energy efficiency and production capacity were determined by cooking frozen hamburgers under two different loading scenarios (heavy—16 hamburgers and light—4 hamburgers). The cook time for the heavy-load cooking scenarios was 3.24 minutes. Production capacity includes the cooking time and the time required for the cooking surface to return to within 10°F of the thermostat set point. Production rate varies with the amount of food being cooked.

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 cook-

[1] American Society for Testing and Materials. 2003. *Standard Test Method for the Performance of Griddles.* ASTM Designation F 1605-95(2007), in *Annual Book of ASTM Standards,* West Conshohocken, PA.

ing process. Cooking-energy efficiency is therefore defined by the following relationship:

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

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

Table ES-1. Summary of Griddle Performance.

Input Test	
Rated Gas Energy Input Rate (Btu/h)	66,000
Measured Gas Energy Input Rate (Btu/h)	66,308
Rated Electric Input Rate (kW)	8.66
Measured Electric Input Rate (kW)	8.50
Uniformity Test	
Temperature Uniformity (°F) [a]	± 38.2
Preheat and Idle Tests	
Preheat Time to 350°F (min)	9.00
Gas Preheat Energy to 350°F (Btu)	9,940
Electric Preheat Energy to 350°F (kWh)	1.24
Gas Idle Energy Rate @ 350°F (Btu/h)	8,845
Electric Idle Energy Rate @ 350°F (kW)	1.27
Cooking Tests	
Heavy-Load Cooking-Energy Efficiency (%)	51.1 ± 1.9
Light-Load Cooking-Energy Efficiency (%)	33.0 ± 2.3
Production Capacity (lb/h) [b]	58.1 ± 0.9
Cooking Surface Reload Time (min) [b]	< 1.0

a Temperature uniformity reflects the absolute temperature variance across the cooking surface to within 1 inch from each edge.
b Due to the logistics of loading the griddle cooking surface, reload time includes 30 seconds to remove the cooked patties and 30 seconds to scrap the griddle surface before reloading the next heavy-load test.

Executive Summary

The Xpress double-sided griddle incorporates an electric upper platen with a gas-fired lower griddle cooking surface. The 2-sided design provides faster cook times compared to traditional open griddle platforms. Food service operators can expect a 9.00 minute preheat to 350°F with the platens in the lowered positions. The griddle demonstrated a competitive gas idle energy rate of 8,845 Btu/h, with the upper platens consuming 1.27 kW. The temperature uniformity across the griddle-cooking shows a maximum temperature range of 76.4°F.

The double-sided griddle demonstrated solid cooking performance while being tested at the Food Service Technology Center, with a heavy-load cooking-energy efficiency of 51.1% and a production capacity of 58.1 lb/h. Most food service operations cook under less than full-load scenarios with light-loads being more representative of real world operations. The Xpress griddle posted an impressive light-load cooking-energy efficiency of 33.0%.

The test results can be used to estimate the annual energy consumption for the griddle in a real-world operation. A simple cost model was developed to calculate the relationship between the various cost components (e.g., preheat, idle and cooking costs) and the annual operating cost, using the ASTM test data. For the calculations shown in Table ES-2, the griddle was used to cook 100 pounds of hamburger patties over a 12-hour day, with one preheat per day, 365 days per year.

Table ES-2. Estimated Griddle Energy Consumption and Cost.

	Upper Plattens (kW)	Griddle Plate (Btu/h)
Preheat Energy (daily)	1.24	9.94
Idle Energy (daily)	11.5	79.8
Cooking Energy (daily)	8.18	80.4
Annual Energy (yearly)	7,636	62,077
Total Annual Cost ($/year) [a]	1,385	

[a] Griddle energy costs are based on $0.10/kWh for electric and $1.00/therm for the gas.

Executive Summary

Garlands Xpress XG-24 double-sided griddles offers a small foot print, high performance and production capacity making this a strong cooking platform for high volume restaurants.

1 Introduction

Background

Griddles are used throughout the hospitality industry from their first order of bacon at breakfast to the last seared steak at dinner. The griddle is a work-horse that usually occupies a central position on the short order line. Double-sided griddles offer a greater diversity of use and cook food more quickly than their single-sided counterparts. Its versatility ranges from crisping and browning, for foods like hash brown potatoes, bacon and pancakes, to searing, for foods like hamburgers, chicken, steak and fish, and to warming or toasting, for bread and buns. For a high production restaurant, the temperature uniformity of the griddle surface is important to assure that the food is evenly cooked.

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

The test methods, approved and ratified by the American Society for Testing and Materials (ASTM), allow benchmarking of equipment such that users can make meaningful comparisons among available equipment choices. By collaborating with the Electric Power Research Institute (EPRI) and the Gas Technology Institute (GTI) through matching funding agreements, the test methods have remained unbiased to fuel choice. End-use customers and commercial appliance manufacturers consider the FSTC to be the national leader in commercial food service equipment testing and standards, sparking alliances with several major chain customers to date.

Introduction

Since the development of the ASTM test method for griddles in 1989, the FSTC has tested a wide range of gas and electric griddles.[2-18]

In 1995, ASTM approved and ratified a similar test method for double-sided griddles (Designation F 1605-95). This test method retained many similarities to the griddle test method, with the individual procedures adapted specifically for use with two-sided cookers.

The Garland double-sided griddle delivers heat to the food product via a gas-fired lower cooking surface and electrical upper platens. The upper platens can be mechanically raised and lowered by buttons on the control panel. The 24-inch griddle features two separately controllable 12-inch sections of cooking surface. Each cook zone features a removable grease trough. The Garland griddle was tested according to the ASTM procedure, and this report documents the results.

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

Objectives

The objective of this report is to examine the operation and performance of the electric griddle, 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. Document the temperature uniformity of the lower cooking surface and the accuracy of the thermostats.
3. Determine the time and energy required to preheat the cooking surface from room temperature to 350°F.
4. Characterize the idle energy use with the thermostat set at a calibrated 350°F.
5. Document the cooking energy consumption and efficiency under two hamburger loading scenarios: heavy (16 patties), and light (4 patties).

6. Determine the production capacity and cooking surface temperature recovery time during the heavy-load test.
7. Estimate the annual operating cost for the griddle using a standard cost model.

Appliance Description

Garland's Double-sided electric griddle features two independently controllable 12-inch cooking zones. The Garland double-sided griddle delivers heat to the food product via a gas-fired lower cooking surface and electrical upper platens. The upper platens can be mechanically raised and lowered by buttons on the control panel. Each cook zone features a removable grease trough. (Figure 1-1).

Figure 1-1.
Garland XG-24 griddle.

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

Table 1-1. Appliance Specifications.

Manufacturer	Garland
Model	Xpress XG-24
Generic Appliance Type	Thermostatically Controlled Double-Sided Griddle
Rated Input	
Lower Cooking Surface	66,000 Btu/h
Upper Cooking Surface	8.66 kW
Dimensions	39-3/4" x 28-3/16" x 40-1/4"
Construction	The stainless steel front, top and sides griddle features a 3/4" carbon steel griddle plate and stainless dual sided grease trough.
Control	The griddle is operated by separate programmable controllers for each 12" section.

2 Methods

Setup and Instrumentation

FSTC researchers installed the double-sided griddle over a tiled floor under a 4-foot-deep canopy hood that was installed at a height of 6 feet, 6 inches above the floor. The exhaust rate was set to a nominal rate of 300 cfm per linear foot of hood. The griddle was installed with at least 6 inches of clearance between the vertical plane of the griddle and the edge of the hood. All test apparatus were installed in accordance with Section 9 of the ASTM test method.[1]

Researchers instrumented the griddle with 24-gauge Type K thermocouples to measure cooking surface temperatures. For the temperature uniformity test, 36 thermocouples were welded to the cooking surface in a grid pattern (see Figure 2-1). Three thermocouples, one at the center of each linear foot of griddle plate (Figure 2-2) were used for the remainder of the tests.

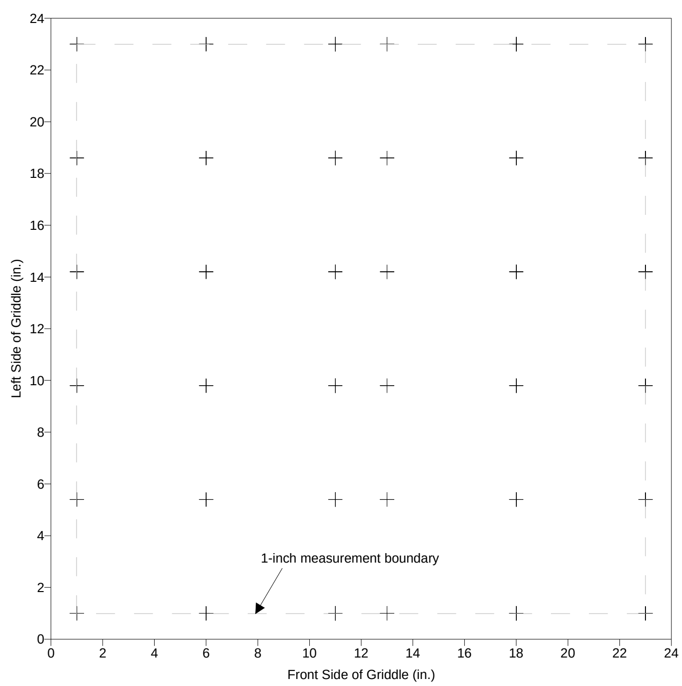

Figure 2-1. Thermocouple grid for temperature uniformity test.

Natural gas consumption was measured using a positive displacement-type gas meter that generated a pulse every 0.1 ft^3. The gas meter and the thermocouples were connected to an automated data acquisition unit that recorded data every 5 seconds. A Cutler-Hammer calorimeter was used to determine the gas heating value on each day of testing. All gas measurements were corrected to standard conditions.

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. A voltage regulator, connected to the griddle, maintained a constant voltage for all tests. Control energy was monitored with a watt-hour transducer that generated a pulse for every 0.00001 watt-hours. The energy meters and thermocouples were connected to a data logger which recorded data every five seconds.

Measured Energy Input Rate

Rated energy input rate is the maximum or peak rate at which the griddle consumes energy—as specified on the griddle's nameplate. Measured energy input rate is the maximum or peak rate of energy consumption, which is recorded during a period when the elements are fully energized (such as preheat). Researchers compared the measured energy input rate with the nameplate energy input rate to ensure that the griddle was operating properly.

Cooking Tests

Researchers specified frozen, 20% fat, quarter-pound hamburger patties for all cooking tests. Each load of hamburgers was cooked to a 35% weight loss. The cooking tests involved "barreling" six loads of frozen hamburger patties; cooking surface temperature was used as a basis for recovery (see Figure 2-2). Each test was followed by a 1-hour wait period and was then repeated two more times. Researchers tested the griddle using 16 patty (heavy) loads and 4 patty (light) loads.

Due to the logistics involved in removing one load of cooked hamburgers and placing another load onto the double-sided griddle, a minimum prepara-

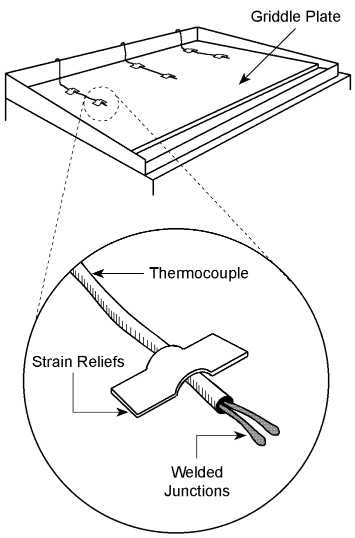

Figure 2-2.
Thermocouple placement for testing.

tion time of 30 seconds (based on 15 seconds per linear foot) was incorporated into the cooking procedure. This ensures that the cooking tests are uniformly applied from laboratory to laboratory. Double-sided griddle recovery was then based on the cooking surface reaching a threshold temperature of 340°F (measured at the center of each linear foot of the bottom cooking surface). Reloading within 10°F of the 350°F thermostat set point does not significantly lower the average cooking surface over the cooking cycle, nor does it extend the cook time. The double-sided griddle was reloaded either after both thermocouples reached the threshold temperature, or 30 seconds after removing the previous load from the double-sided griddle, whichever was longer.

Prior to the six-load test, one to two loads of hamburgers were cooked to stabilize the double-sided griddle thermostat response. Energy consumption, elapsed time, and the average weight loss of the hamburger patties were recorded during the final six loads of the cooking test. After removing the last load and allowing the double-sided griddle to recover, researchers terminated the test.

Each cooking test scenario (heavy- and light-) was repeated a minimum of three times to ensure that the reported cooking-energy efficiency and production capacity results had an uncertainty of less than ±10%. The results from each test run were averaged, and the absolute uncertainty was calculated based on the standard deviation of the results.

The ASTM results reporting sheets appear in Appendix C.

Energy Cost Model

Griddle operating cost was calculated based on a combination of test data and assumptions about typical griddle usage. This provides a standard method for estimating griddle energy consumption based on ASTM performance test results. The examples contained in the operating cost model are for informational purposes only, and should not be considered an absolute.

The model assumed a typical twelve-hour day, with the operation being broken down into three operating scenarios; preheat, idle and cooking. One preheat is assumed per day with the remainder being split between idle and cooking periods. During the day, 100 lbs. of food would be cooked; 70% under heavy-load (16 patties) conditions with the remaining 30% under light-load (4 patties) conditions. The idle time was calculated as the total time of operation minus preheat and cooking times. The total daily energy usage was calculated based on the griddle's energy consumption in each of these operating scenarios. The cost model assumptions are listed in Table 2-2. Details of this calculation can be found in Appendix E of this report.

Table 2-1: Griddle Operation Assumptions.

Operating Time (h)	12
Number of Preheats	1
Total Amount of Food Cooked (lb)	100

3 Results

Energy Input Rate

Prior to testing, the energy input rate was measured and compared with the manufacturer's nameplate value. The double-sided griddle features electric upper platens and a gas-fired griddle plate. Table 3.1 summarizes the results of the input test. This procedure ensured that the griddle was operating within its specified parameters. The measured gas energy input rate was 66,308 Btu/h (a difference of 0.47 % from the nameplate rating).

Table 3-1. Input Test Results.

Rated Gas Energy Input Rate (Btu/h)	66,000
Measured Gas Energy Input Rate (Btu/h)	66,308
Percentage Difference (%)	0.47
Rated Electric Input Rate (kW)	8.66
Measured Electric Energy Input Rate (kW)	8.50
Percentage Difference (%)	1.81

Temperature Uniformity

Thermocouples were welded to the bottom cooking surface at the center of each linear foot to facilitate temperature calibration. The thermostat control was turned to a ~ 350°F setting. The thermocouples were then monitored after the griddle had stabilized at the set temperature for one hour. Researchers manually adjusted the control to maintain an average of 350 ± 5°F on the bottom cooking surface at the center of each linear foot. To characterize the temperature profile of the bottom cooking surface at 350°F, researchers welded additional thermocouples to the cooking surface in a 36-point grid with no more than 5 inches between adjacent points. Griddle temperatures were monitored for one hour after the cooking surface had stabilized at a calibrated 350°F.

Results

Figure 3-1 illustrates the temperatures across the bottom griddle-cooking surface. The temperature uniformity profiles are represented in Figure 3-2. The results from these temperature uniformity tests are summarized in Table 3-2.

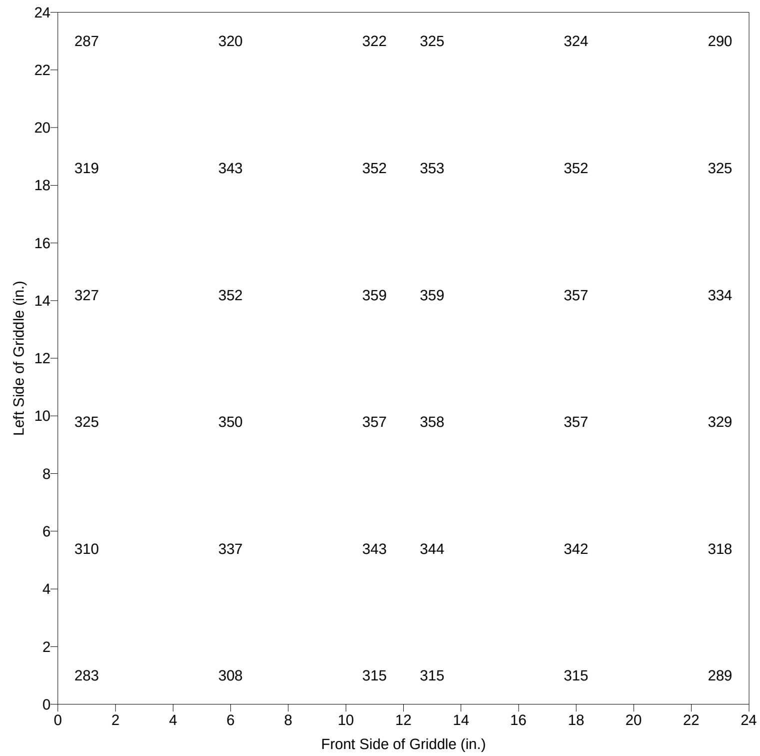

Figure 3-1.
Temperature sensing points on the griddle surface.

Table 3-2. Temperature Uniformity and Thermostat Accuracy [a].

Thermostat Setting (°F)	340
Average Surface Temperature (°F)	347
Maximum Temperature Difference Across Plate (°F) [b]	76.4
Standard Deviation of Surface Temperatures (°F)	22.2

[a] Thermostat accuracy is the thermostat setting required to maintain 350 ± 5°F on the cooking surface.
[b] Maximum temperature difference to within 1-inch of the edge of the griddle plate.

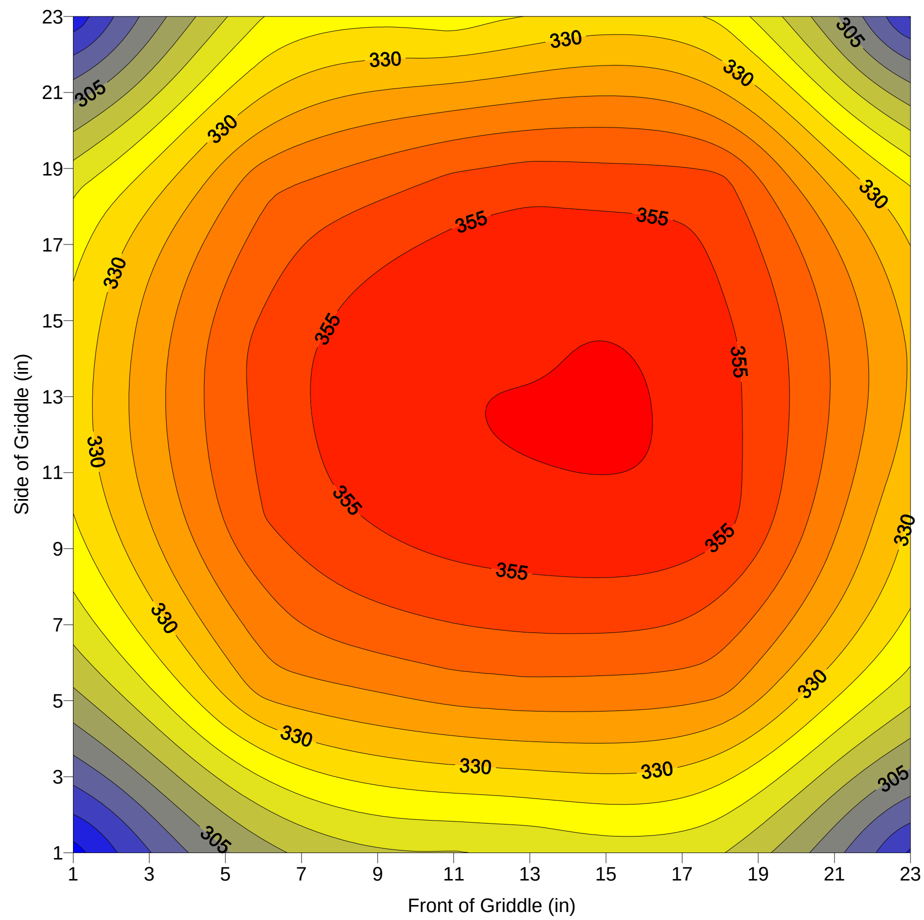

Figure 3-2.
Temperature map of the cooking surface.

Preheat and Idle Tests

Preheat Energy and Time

Researchers removed the additional thermocouples, leaving only the points at the center of each linear foot. The cooking surface temperature was an average of 73°F at the outset of the preheat test. Researchers measured the energy consumption and time required to preheat the cooking surface to a calibrated 350°F. The time necessary to bring the griddle surface to a temperature of 350°F with the platens down was 9.0 minutes, during which the griddle consumed 9,940 Btu of gas and 1.24 kWh of electricity. Figure 3-3 shows the energy consumption rate in conjunction with the cooking surface temperature with the platens down during the preheat test. After the griddle had cooled down and stabilized at room temperature for 8 hours, the preheat was repeated with the platens in the raised position. With the platens raised, the griddle consumed 14,627 Btu of gas and 1.36 kWh of electricity.

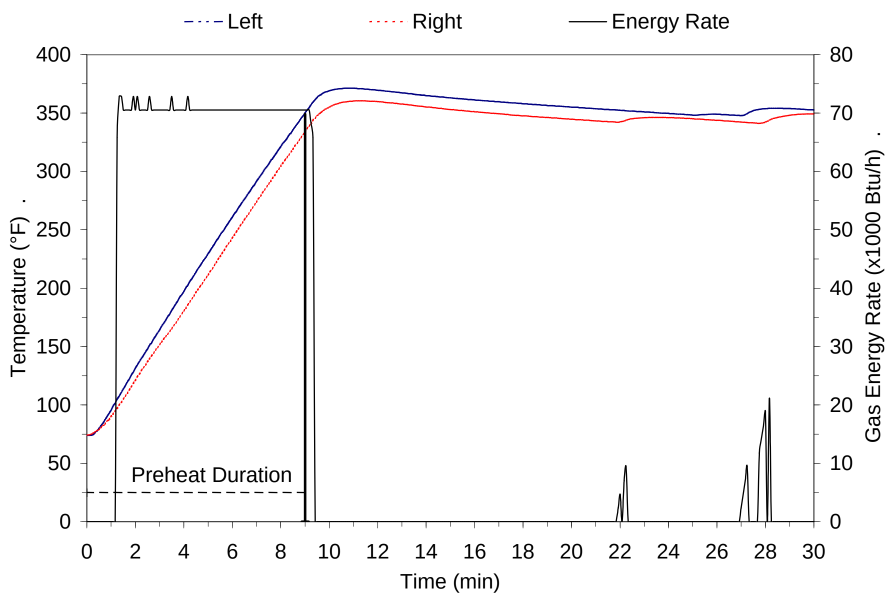

Figure 3-3.
Preheat characteristics – platens down.

Idle Energy Rate

The griddle was allowed to stabilize at 350°F for one hour with the platens down. Researchers then monitored the energy consumption over a 2-hour period. The idle energy rate during this period was 8,845 Btu/h for the gas fired bottom cooking surface and 1.27 kW for the upper platens. The 3-hour idle test was then repeated with the platens raised. The idle energy rate with the platens up increased to 8982 Btu/h and 1.28 kW for the bottom and top cooking surfaces, respectively.

Test Results

Input, preheat, and idle test results are summarized in Table 3-2.

Table 3-3. Preheat and Idle Test Results.

	Plattens Down	Plattens Up
Preheat		
Starting Temperature (°F)	73.1	75.0
Gas Energy Consumption (Btu)	9,940	9,985
Electric Energy Consumption (kWh)	1.24	1.36
Duration (min)	9.00	9.42
Preheat Rate (°F/min)	30.8	29.2
Idle		
Gas Energy Rate (Btu/h)	8,845	8,982
Electric Energy Rate (kW)	1.27	1.28

Cooking Tests

The griddle was tested under two loading scenarios: heavy- (16 hamburger patties) and light- (4 hamburger patties) loads. The hamburgers used for the cooking tests consisted of 20% fat and approximately 60% moisture, as specified by the ASTM procedure. Researchers monitored hamburger patty cook time and weight loss, cooking surface recovery time, and griddle energy consumption during these tests.

Heavy-Load Tests

The heavy-load cooking tests were designed to reflect a griddle's maximum performance. The griddle is used to cook six loads of 16 frozen hamburger patties—one load after the other, similar to a batch-cooking procedure. Figure 3-4 shows the average cooking surface temperature during a heavy-load test. One load was used to stabilize the griddle, and six loads were used to calculate cooking-energy efficiency and production capacity.

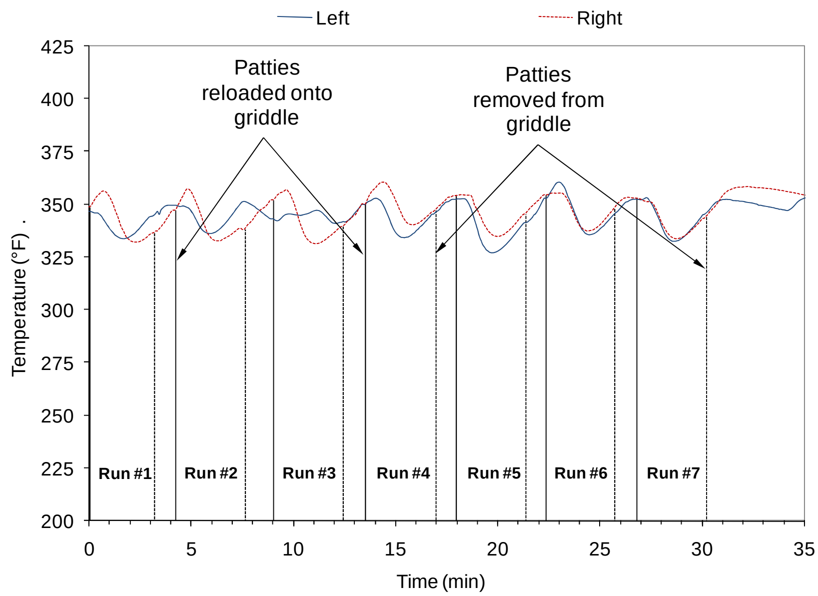

Figure 3-4.
Average heavy-load cooking surface temperatures.

Figure 3-5 illustrates the griddle's temperature response while a heavy-load of frozen hamburger patties was cooked. Production capacity includes the time required to remove the cooked hamburgers and scrape the cooking surface (reload time) or for the cooking surface to recover to 340°F (recovery time).

Light-Load Tests

Light-load tests represent a more typical usage pattern for a griddle in cook-to-order applications. Since a griddle may not be fully loaded during slower periods, the light-load efficiency can be used to estimate griddle performance in a light duty operation. Since the entire griddle was heated to 350°F, the energy consumed during the light-load test includes radiant heat losses from the unused portion of the griddle.

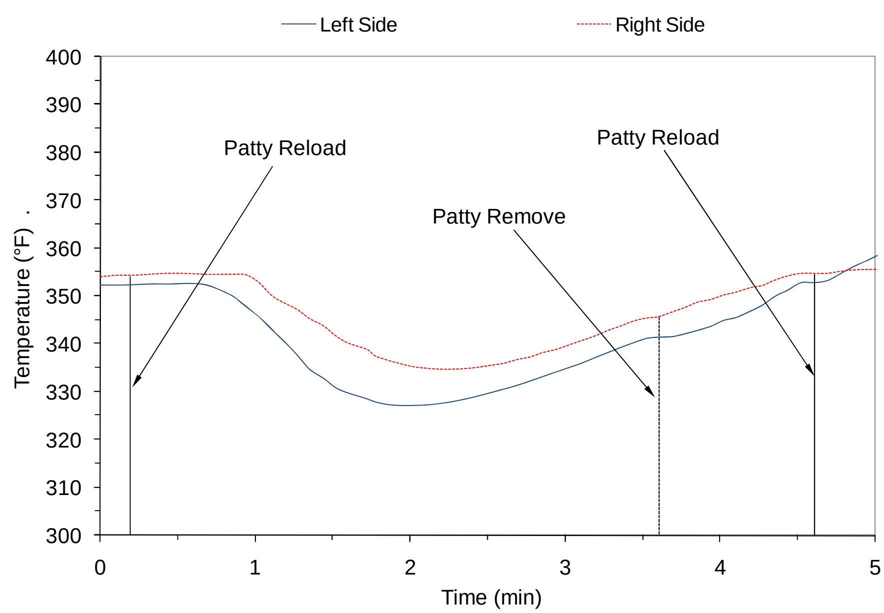

Figure 3-5.
Griddle temperature signature while cooking a heavy-load of hamburgers.

Test Results

Energy imparted to the hamburger patties was calculated by separating the various components of the patties (water, fat, and solids) and determining the amount of heat gained by each component (Appendix D). The griddle's cooking-energy efficiency for a given loading scenario is the amount of energy imparted to the hamburger patties, expressed as a percentage of the amount of energy consumed by the griddle during the cooking process.

Cooking-energy efficiency results for the heavy-load tests were 50.7%, 52.0%, and 50.6% yielding a maximum uncertainty of 1.9% in the test results. A single heavy-load test required 3.24 minutes to cook 16 frozen hamburger patties. Table 3-3 summarizes the results of the ASTM cooking-energy efficiency and production capacity tests.

Table 3-4. Cooking-Energy Efficiency and Production Capacity Test Results.

	Heavy-Load	Light-Load
Load Size (patties)	16	4
Hamburger Cook Time (min)	3.24	2.83
Average Reload Time (min) [a]	< 1.0	< 1.0
Production Rate (lb/h)	58.1 ± 0.9	18.4 ± 0.7
Energy per Pound of Food Cooked (Btu/lb)	930	1,452
Gas Energy Rate (Btu/h)	38,991	20,591
Electric Energy Rate (kW)	4.40	1.78
Cooking-Energy Efficiency (%)	51.1 ± 1.9	33.0 ± 2.3

[a] Due to the logistics of loading the griddle cooking surface, reload time includes 30 seconds to remove the cooked patties and 30 seconds to scrap the griddle surface before reloading the next heavy-load test.

Figure 3-6 illustrates the relationship between cooking-energy efficiency and production rate for this griddle. Griddle production rate is a function of both the hamburger patty cook time and the recovery time. Appendix D contains a synopsis of test data for each replicate of the cooking tests.

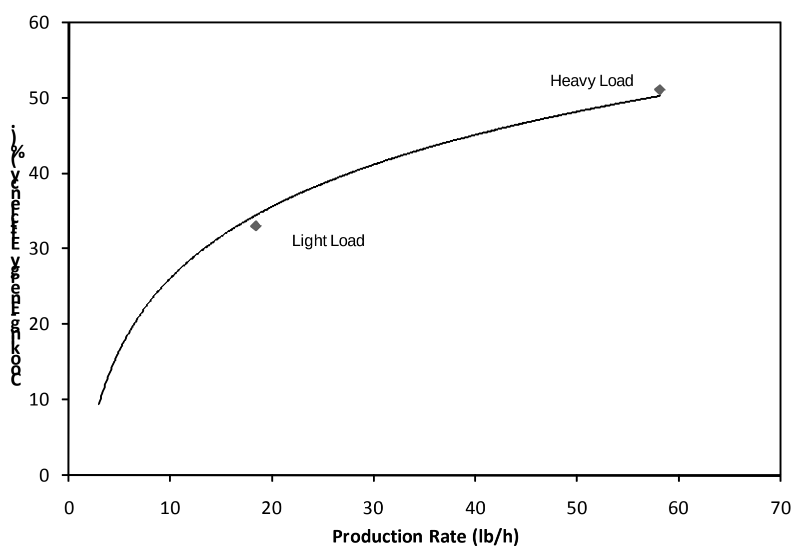

Figure 3-6.
Griddle part-load cooking-energy efficiency.

Note: Light-load = 4 hamburgers/load; heavy-load = 16 hamburgers/load.

Energy Cost Model

The test results can be used to estimate the annual energy consumption for the griddle in a real-world operation. A simple cost model was developed to calculate the relationship between the various cost components (e.g., preheat, idle and cooking costs) and the annual operating cost (Appendix E), using the ASTM test data. For this model, the griddle was used to cook 100 pounds of hamburger patties over a 12-hour day, with one preheat per day, 365 days per year. The idle (standby) time for the griddle was determined by taking the difference between the total daily on time (12 hours) and the time spent cooking and preheating. This approach produces a more accurate estimate of the operating costs for the griddle. Table 3-4 summarizes the annual energy consumption and associated energy cost for the griddle under this scenario.

Table 3-5. Estimated Griddle Energy Consumption and Cost.

	Upper Plattens (kW)	Griddle Plate (Btu/h)
Preheat Energy (daily)	1.24	9.94
Idle Energy (daily)	11.5	79.8
Cooking Energy (daily)	8.18	80.4
Annual Energy (yearly)	7,636	62,077
Total Annual Cost ($/year) [a]	1,385	

[a] Griddle energy costs are based on $0.10/kWh for electric and $1.00/therm for the gas.

4 Conclusions

Garland's Double-sided electric griddle exhibited impressive cooking performance during heavy-load testing. The double-sided design allows the griddle to cook significantly faster when compared to standard flat open griddles. This was demonstrated by a heavy-load cook time of 3.24 minutes compared to 7-8 minutes for open griddles with a production capacity of 58.1 lb/h, this 2-foot clam-shell griddle produced nearly twice the amount of food as most 3-foot flat griddles.

The griddle surface with the platens in the lowered position preheated in a rapid 9.00 minutes. Preheating with the platens in the raised position increased the duration by 25 seconds. The Xpress gas idle energy rate was a very low 8,845 Btu/h with the electric platens consuming a rate of 1.27 kW. The griddle's low idle energy rate contributes to the impressive partial-load efficiency. Light-loads represent more of a real world application and the Garland double-sided griddle demonstrated an economical part-load cooking-energy efficiency of 33.0%.

Temperature uniformity for the griddle showed a maximum temperature difference across the plate of 76.4°F, between the hottest and coldest zones.

The ASTM results can be used to estimate the griddle's operating cost in a typical operation. The cost model estimates showed that the Garland Xpress griddle, when used to cook 100 pounds of hamburgers a day, 365 days a year, would consume 7,621 kWh of energy for the upper platens and 76,861 Btu/h for the gas-fired griddle surface. Assuming an energy cost of $0.10 cents per kWh and $1.00 per therm, the cost of operating this griddle annually is $1,385 dollars. The griddle's small foot print coupled with its high performance and production capacity make this a strong cooking platform for high volume restaurants.

5 References

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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- and light-load tests.

Duty Cycle (%)
Load Factor

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

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

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

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

Heating Value (Btu/ft^3)
Heating Content

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

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

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

Idle Temperature (°F, Setting)

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

Idle Duty Cycle (%)
Idle Energy Factor

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

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

Glossary

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

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

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

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

Preheat Energy (kWh or Btu)
Preheat Energy Consumption

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

Preheat Rate (°F/min)

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

Preheat Time (minute)
Preheat Period

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

Production Capacity (lb/h)

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

Production Rate (lb/h)
Productivity

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

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

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

Recovery Time (minute, second)

The average time from the removal of the cooked hamburger patties from the griddle cooking surface until the cooking surface is within 10°F of the thermostat set point and then griddle 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.

Typical Day

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

B Appliance Specifications

Appendix B includes the product literature for the Garland griddle.

Appliance Specifications

Manufacturer	Garland
Model	Xpress XG-24
Generic Appliance Type	Thermostatically Controlled Double-Sided Electric Griddle
Rated Input	
Lower Cooking Surface	66,000 Btu/h
Upper Cooking Surface	8.66 kW
Dimensions	39-3/4" x 28-3/16" x 40-1/4"
Construction	The stainless steel front, top and sides griddle features a 3/4" carbon steel griddle plate and stainless dual sided grease trough.
Control	The griddle is operated by separate programmable controllers for each 12" section.

Garland®

Master Series
Gas Xpress Grill

Item: ______________________________

Quantity: ___________________________

Project: ____________________________

Approval: ___________________________

Date: ______________________________

Master Series Gas Xpress Grill

Models:

☐ XG24	☐ XG24-1L	☐ XG24-1R	☐ XG24-F
☐ XG24CE	☐ XG24CE-1L	☐ XG24CE-1R	☐ XG24CE-F

Model XG24

Standard Features:

- Stainless steel front, top & sides
- Swivel casters (4) w/ front brakes
- 33,000 BTU/hr. heat input for each 12" section of griddle
- 3/4" NPT bottom gas connection
- Built in pressure regulator (one per 12" section of griddle) and gas shut-off valve
- 3/4" (19mm) thick, Carbon steel griddle plate, machine ground, highly polished
- "CE" approved models have suffix "CE" within the model structure
- Die cast aluminum electric top heating elements rated 208V/220V/240V three phase for XG24 models and 380V/400V/415V three phase for XG24CE models
- Automatic lifting and lowering of top heaters
- Towel bar with bun pan lip
- Stainless steel dual side grease collectors
- Separate programmable controller for each 12" section
- Multi-colored LED indicator lights to identify operational mode
- One year limited parts and labor (USA & Canada)

Optional Features:

☐ Stainless steel main back

☐ 6" (152mm) adjustable stainless steel legs

☐ Quick disconnect gas hose 3' (914mm) length

☐ Cutting board

Specification:

Two sided cooking device with gas-fired griddle and two independently controlled 11.5" (292mm) wide electric top heaters. Each 12" inches of lower griddle plate to have 33,000 BTU/hr of heat input natural or propane gas. Burner to be rectangular shaped 16 GA stainless steel with laser cut port pattern. Griddle plate to be 3/4" (19mm) thick Carbon steel, machine ground and highly polished. Automatic lighting, temperature, time & gap control monitored via custom programmable controllers, one per foot of griddle. Gas pressure regulator and manual shut-off valve to be provided as standard. Electric top heaters to be provided with replaceable quick release Teflon sheets. Top heaters to have gapping adjustment in 0.010" increments. Available with two (XG24), one (XG24-1L/R) or zero (XG36-F) top platen. Grill available in 208V/220V/240V three phase and 380V/400V/415V three phase for export

NOTE: Grills supplied with casters must be installed with an approved restraining device.

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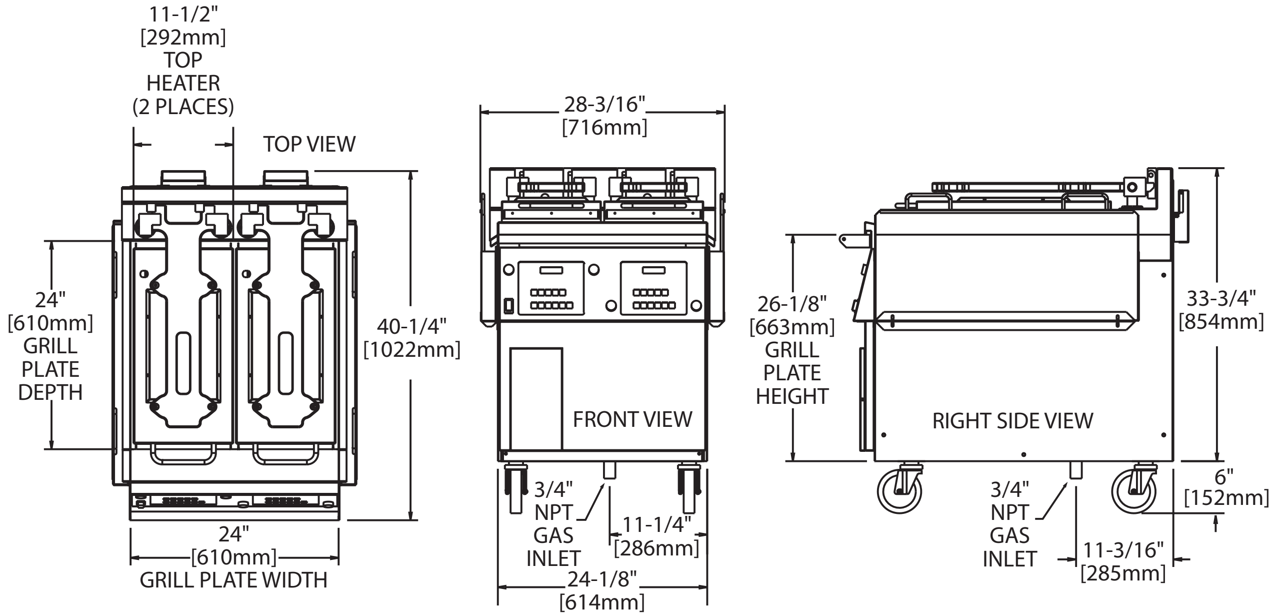
Enodis

Garland

Master Series Gas Xpress Grill



Model	Total kW Load	Loading kW Per Phase			Nominal Amps Per Line								
		208/220/240V 3ph			208V 3-Phase Delta			220V 3-Phase Delta			240V 3-Phase Delta		
		X-Y	X-Z	Y-Z	X	Y	Z	X	Y	Z	X	Y	Z
XG24	8.66	2.66	3.33	2.66	2.49	22.14	24.90	23.50	20.94	23.50	21.61	19.19	21.61
XG24-1 L/R	4.33	1.33	1.65	1.33	12.14	11.07	12.14	11.75	10.47	11.75	10.80	9.59	10.80
XG24-F	0.660	–	0.660	–	2.74	–	2.74	2.59	–	2.59	2.38	–	2.38

Model	Total kW Load	Loading kW Per Phase				Nominal Amps Per Line											
		380/400/415V				380V				400V				415V			
		L1/N	L1/L2	L1/L3	L2/L3	L1/N	L1	L2	L3	L1/N	L1	L2	L3	L1/N	L1	L2	L3
XG24CE	8.74	0.74	2.66	2.66	2.66	3.36	15.90	12.46	12.46	3.22	13.40	11.55	11.55	3.08	12.10	11.11	11.11
XG24CE-1 L/R	4.56	0.56	1.33	1.33	1.33	2.54	7.33	6.02	6.02	4.30	19.80	17.32	17.32	4.12	18.75	16.70	16.70
XG24CE-F	0.38	0.38	0.00	0.00	0.00	1.72	1.00	0.00	0.00	1.58	0.95	0.00	0.00	0.91	12.10	11.11	11.11

Clearances				Gas Pressure				Total Input	
Entry		Installation		Supply (min.)		Operating			
Crated	Uncrated	Sides	Rear	NAT	PRO	NAT	PRO	BTU/Hr	kW
47-1/2" (1207mm)	32" (813mm)	6" (152mm)	3" (76mm)	7.0" WC	11.0" WC	3.2" WC	10.0" WC	66,000	19.4

Form# XG24 (07/07)

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Enodis

C Results Reporting Sheets

Manufacturer: Garland Products, Inc.

Model: Xpress XG-24

Date: December 2007

Test Griddle.

Description of operational characteristics: Garland's XG24 gas griddle is a double-sided (clam shell) griddle featuring electric upper platens and a gas fired lower griddle surface. The lower griddle surface features two 12-inch sections with an input rating of 66,000 Btu/h. Two individually controlled upper platens for each 12-inch section have an overall input rate of 8.66 kW. The griddle features a 3/4-inch carbon steel griddle surface with individual cooking computers controlling the product cooking information and automatic upper platens.

Apparatus.

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

Deviations:

Energy Input Rate.

Rated Gas Energy Input (Btu/h)	66,000
Measured Gas Energy Input (Btu/h)	66,308
Percent Difference between Measured and Rated (%)	0.47
Rated Electrical Energy Input (kW)	8.66
Measured Electrical Input Rate (kW)	8.55
Percent Difference between Measured and Rated (%)	1.81

Results Reporting Sheets

Temperature Uniformity and Thermostat Accuracy [a]

Thermostat Setting (°F)	340
Average Surface Temperature (F°)	347
Maximum Temperature Difference Across Plate (°F) [b]	76.4
Standard Deviation of Surface Temperature (°F)	22.2

[a] Thermostat settings required to maintain 350°F cooking surface temperature

[b] Maximum temperature difference to within 1-inch of the edge of the griddle plate.

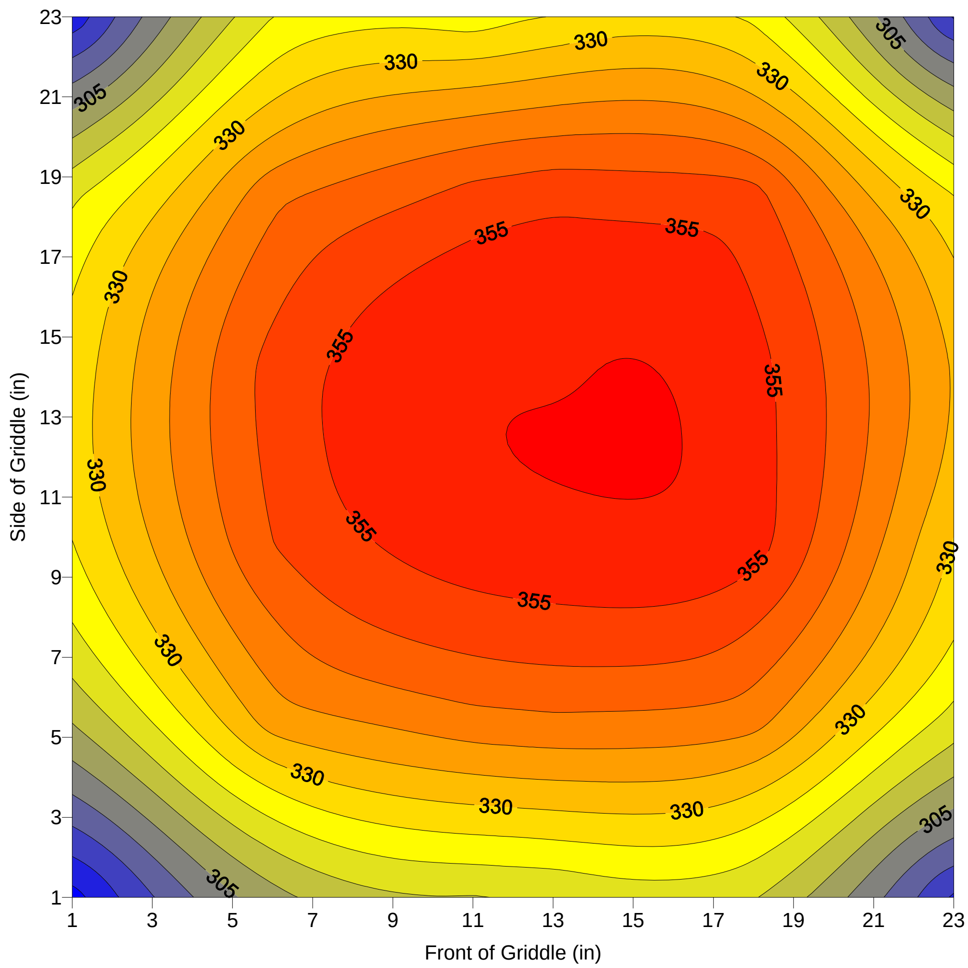

Figure C-1. Average cooking surface temperatures.

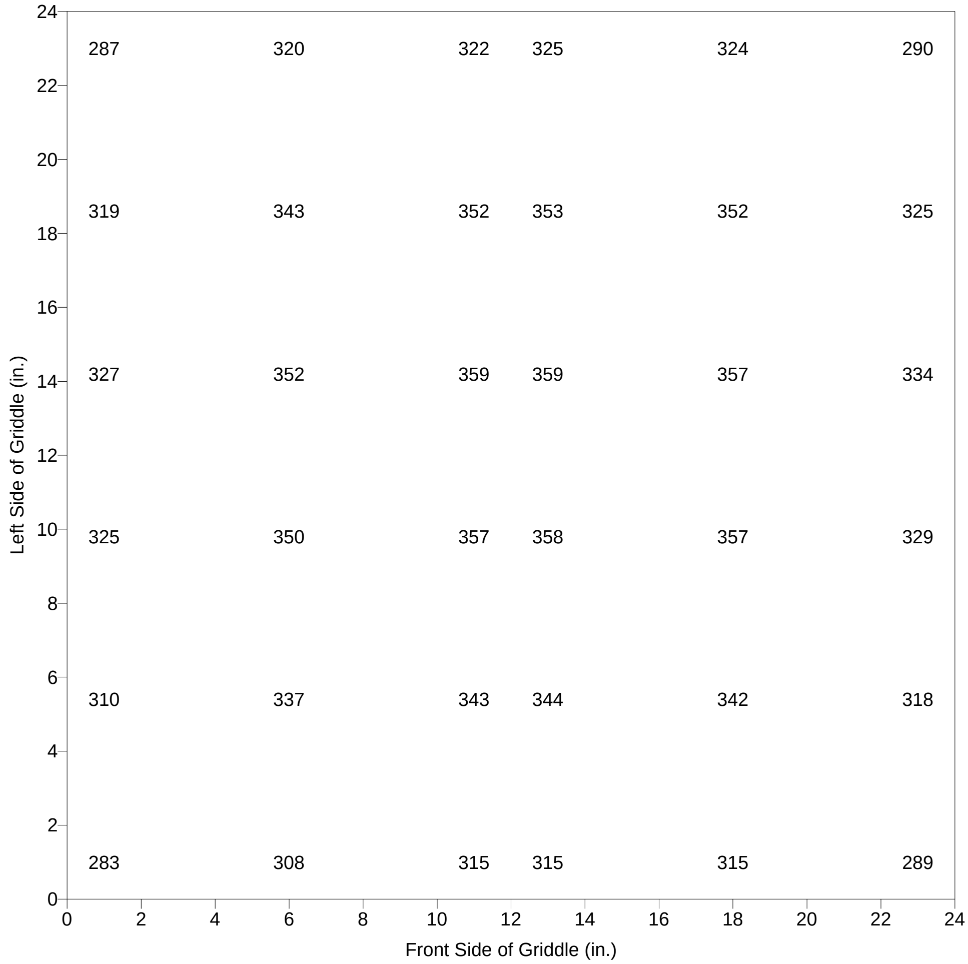

Figure C-2. Average cooking surface temperatures.

Preheat Energy and Time.

	Platens Down	Platens Up
Starting Temperature (°F)	73.1	75.0
Gas Energy Consumption (Btu/h)	9,940	9,985
Electric Energy Consumption (kWh)	1.24	1.36
Duration (min)	9.00	9.42
Preheat Rate (°F/min)	30.8	29.2

Results Reporting Sheets

Idle Energy Rate.

	Platens Down	Platens Up
Gas Energy Rate (Btu/h)	8,845	8,982
Electric Energy Rate (kW)	1.27	1.28

Heavy-Load Cooking-Energy Efficiency Test Results.

Cooking Time (min)	3.24
Average Reload Time (min) [a]	< 1.0
Production Capacity (lb/h)	58.1 ± 0.9
Energy to Food (Btu/lb)	475
Gas Energy Rate (Btu/h)	38,991
Electric Energy Rate (kW)	4.40
Energy per Pound of Food Cooked (Btu/lb)	930
Cooking-Energy Efficiency (%)	51.1 ± 1.9

[a] Due to the logistics of loading the griddle cooking surface, reload time includes 30 seconds to remove the cooked patties and 30 seconds to scrap the griddle surface before reloading the next heavy-load test.

Light-Load Cooking-Energy Efficiency Test Results.

Cooking Time (min)	2.83
Average Reload Time (min) [a]	< 1.0
Production Capacity (lb/h)	18.4 ± 0.7
Energy to Food (Btu/lb)	479
Gas Energy Rate (Btu/h)	20,591
Electric Energy Rate (kW)	1.78
Energy per Pound of Food Cooked (Btu/lb)	1,452
Cooking-Energy Efficiency (%)	33.0 ± 2.3

[a] Due to the logistics of loading the griddle cooking surface, reload time includes 30 seconds to remove the cooked patties and 30 seconds to scrap the griddle surface before reloading the next heavy-load test.

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
Latent Heat (Btu/lb)	
Fusion, Water	144
Fusion, Fat	44
Vaporization, Water	970

Cooking-Energy Efficiency Data

Table D-2. Heavy-Load Test Data

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Electrical Energy Consumption (Wh)	1,800	1,800	1,880
Gas Energy Consumption (Btu)	16,483	15,536	16,518
Cook Time (min)	3.22	3.25	3.25
Total Test Time (min)	25.1	24.8	24.7
Weight Loss (%)	35.9	34.9	36.9
Initial Weight (lb)	24.139	24.119	24.019
Final Weight (lb)	15.465	15.705	15.160
Initial Fat Content (%)	17.9	17.9	17.9
Initial Moisture Content (%)	62.1	62.1	62.1
Final Moisture Content (%)	53.9	54.1	53.8
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	165	163	168
Calculated Values			
Initial Weight of Water (lb)	14.990	14.978	14.916
Final Weight of Water (lb)	8.340	8.494	8.151
Weight of Fat (lb)	4.321	4.317	4.299
Weight of Solids (lb)	4.828	4.824	4.804
Sensible to Ice (Btu)	240	240	239
Sensible to Water (Btu)	1,997	1,955	2,024
Sensible to Fat (Btu)	286	281	288
Sensible to Solids (Btu)	160	157	161
Latent - Water Fusion (Btu)	2,159	2,157	2,148
Latent - Fat Fusion (Btu)	190	190	188
Latent - Water Vaporization (Btu)	6,451	6,290	6,562
Total Energy to Food (Btu)	11,481	11,268	11,610
Energy to Food (Btu/lb)	476	467	483
Total Energy to Griddle (Btu)	22,627	21,680	22,934
Energy Per Pound of Food Cooked (Btu/lb)	937	899	955
Cooking-Energy Efficiency (%)	50.7	52.0	50.6
Electric Cooking Energy Rate (kW)	4.30	4.35	4.56
Gas Cooking Energy Rate (Btu/h)	39,371	37,512	40,091
Production Rate (lb/h)	57.7	58.2	58.3
Average Reload Time (min)	< 1.0	< 1.0	< 1.0

Cooking-Energy Efficiency Data

Table D-4. Light-Load Test Data

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Electrical Energy Consumption (Wh)	600	520	600
Gas Energy Consumption (Btu/h)	6,813	6,432	6,689
Cook Time (min)	2.87	2.75	2.87
Total Test Time (min)	19.8	19.0	19.32
Weight Loss (%)	34.8	33.6	36.4
Initial Weight (lb)	5.940	5.870	5.955
Final Weight (lb)	3.875	3.895	3.790
Initial Fat Content (%)	17.9	17.9	17.9
Initial Moisture Content (%)	62.1	62.1	62.1
Final Moisture Content (%)	52.4	53.3	51.2
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	162	159	166
Calculated Values			
Initial Weight of Water (lb)	3.689	3.645	3.698
Final Weight of Water (lb)	2.031	2.076	1.941
Weight of Fat (lb)	1.063	1.051	1.066
Weight of Solids (lb)	1.188	1.174	1.191
Sensible to Ice (Btu)	59	58	59
Sensible to Water (Btu)	480	464	497
Sensible to Fat (Btu)	69	67	71
Sensible to Solids (Btu)	39	37	40
Latent - Water Fusion (Btu)	531	525	533
Latent - Fat Fusion (Btu)	47	47	47
Latent - Water Vaporization (Btu)	1,608	1,522	1,704
Total Energy to Food (Btu)	2,833	2,720	2,950
Energy to Food (Btu/lb)	477	463	495
Total Energy to Griddle (Btu)	8,860	8,207	8,737
Energy Per Pound of Food Cooked (Btu/lb)	1,492	1,398	1,467
Cooking-Energy Efficiency (%)	32.0	33.1	33.8
Electric Energy Rate (kW)	1.82	1.64	1.86
Gas Energy Rate (Btu/h)	20,665	20,334	20,774
Production Rate (lb/h)	18.0	18.6	18.5
Average Reload Time (min)	< 1.0	< 1.0	< 1.0

Cooking-Energy Efficiency Data

Table D-6. Cooking-Energy Efficiency and Production Capacity Statistics

	Cooking-Energy Efficiency		Production Capacity
	Heavy-Load	Light-Load	
Replicate #1	50.7	32.0	57.7
Replicate #2	52.0	33.1	58.2
Replicate #3	50.6	33.8	58.3
Average	51.1	33.0	58.1
Standard Deviation	0.75	0.91	0.35
Absolute Uncertainty	1.86	2.25	0.88
Percent Uncertainty	3.63	6.83	1.51

E Energy Cost Model

Procedure for Calculating the Energy Consumption of a Griddle Based on Reported Test Results

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

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

The calculation will proceed as follows: First, determine the appliance operating time and total number of preheats. Then estimate the quantity of food cooked and establish the breakdown among heavy- (whole cooking surface loaded with product) and light- (single-serving) loads. For example, a griddle operating for 12 hours a day with one preheat cooked 100 pounds of food: 70% of the food was cooked under heavy-load conditions and 30% was cooked under light-load conditions. Calculate the energy due to cooking at heavy- and light-load cooking rates, and then calculate the idle energy consumption. The total daily energy is the sum of these components plus the preheat energy. For simplicity, it is assumed that subsequent preheats require the same time and energy as the first preheat of the day.

The application of the test method to the griddle yielded the following results:

Energy Cost Model

Table E-1: Griddle Test Results.

Test	Result
Preheat Time (min)	9.00
Gas Preheat Energy (Btu/h)	9,940
Electric Preheat Energy (kWh)	1.24
Gas Idle Energy Rate (Btu/h)	8,845
Electric Idle Energy Rate (kW)	1.27
Gas Heavy-Load Cooking Energy Rate (Btu/h)	38,991
Electric Heavy-Load Cooking Energy Rate (kW)	4.40
Gas Light-Load Cooking Energy Rate (Btu/h)	20,591
Electric Light-Load Cooking Energy Rate (kW)	1.78
Production Capacity (lb/h)	58.1
Light-Load Production Rate (lb/h)	18.4

***Step 1*—The following appliance operation is assumed:**

Table E-2: Griddle Operation Assumptions.

Operating Time (h)	12
Number of Preheats	1
Total Amount of Food Cooked (lb)	100
Percentage of Food Cooked Under Heavy-Load Conditions (%)	70% (× 100 lb = 70 lb)
Percentage of Food Cooked Under Light-Load Conditions (%)	30% (× 100 lb = 30 lb)

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

The total time cooking heavy-loads is as follows:

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

$$t_h = \frac{70\% \times 100\ lb}{58.1\ lb/h},$$

$$t_h = 1.20\ h$$

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

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

$E_{gas,h} = 38{,}991\ Btu/h \times 1.20\ h$

$E_{gas,h} = 46{,}789\ Btu$

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

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

$E_{elec,h} = 4.40\ kW \times 1.20\ h$

$E_{elec,h} = 5.28\ kWh$

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

The total time cooking light-loads is as follows:

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

$$t_l = \frac{30\% \times 100\ lb}{18.4\ \ lb/h},$$

$t_l = 1.63\ h$

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

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

$E_{gas,l} = 20{,}591\ Btu/h \times 1.63\ h$

$E_{gas,l} = 33{,}563\ Btu$

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

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

$E_{elec,l} = 1.78\ kW \times 1.63\ h$

$E_{elec,l} = 2.90\ kWh$

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

The total idle time is determined as follows:

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

$$t_i = 12.0\ h - 1.20\ h - 1.63\ h - \frac{1\ preheat \times 9.00\ min}{60\ min/h}$$

$$t_i = 9.02\ h$$

The idle energy consumption is then calculated as follows:

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

$$E_{gas,i} = 8{,}845\ Btu/h \times 9.02\ h$$

$$E_{gas,i} = 79{,}781\ Btu$$

The idle energy consumption is then calculated as follows:

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

$$E_{elec,i} = 1.27\ kW \times 9.02\ h$$

$$E_{elec,i} = 11.5\ kWh$$

***Step 5*—The total daily energy consumption is calculated as follows:**

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

$$E_{gas,daily} = 46{,}789\ Btu + 33{,}563\ Btu + 79{,}781\ Btu + 1 \times 9{,}940\ Btu$$

$$E_{gas,daily} = 170{,}073\ Btu/day = 1.70\ therms/day$$

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

$$E_{elec,daily} = 5.28\ kWh + 2.90\ kWh + 11.5\ kWh + (1 \times 1.24\ kWh)$$

$$E_{elec,daily} = 20.92\ kWh$$

***Step 6*—Calculate the average demand as follows:**

$$q_{avg} = \frac{E_{elec,\, daily}}{t_{on}},$$

$$q_{avg} = \frac{20.92 \;\; kWh}{12.0 \;\; h},$$

$$q_{avg} = 1.74 \; kW$$

***Step 7*—The annual energy cost is calculated as follows:**

$$Gas\ Cost_{annual} = E_{gas,daily} \times R_{gas} \times Days$$

$$Gas\ Cost_{snnual} = 1.70\ therms/day \times 1.00\ dollars/therm \times 365\ days/year$$

$$Gas\ Cost_{annual} = 621\ dollars/year$$

$$Electric\ Cost_{annual} = E_{elec,daily} \times R_{elec} \times Days$$

$$Electric\ Cost_{snnual} = 20.92\ kWh/day \times 0.10\ \$/kWh \times 365\ days/year$$

$$Electic\ Cost_{annual} = 764\ \$/year$$

$$Total\ Cost_{annual} = 1{,}385\ \$/year$$