Jade JGTSD Gas Griddle Performance Test

Application of ASTM Standard Test Method F 1275-99

FSTC Report 5011.03.18

Food Service Technology Center
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Specific appreciation is extended to Jade Range, for supplying the Food Service Technology Center with a 3-foot gas griddles for controlled testing in the appliance laboratory.

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Jade JGTSD 2436 gas griddle.

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.

Jade's JGTSD 2436 griddle features an all stainless steel construction, snap action thermostats, and a 1-inch thick-brushed cooking surface (see Figure ES-1). Food Service Technology Center (FSTC) engineers tested the 3-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 was determined by cooking frozen hamburgers under three different loading scenarios (heavy—24 hamburgers, medium—12 hamburgers, and light—4 hamburgers). The cook time for the heavy-loading scenario was 7.85 minutes. Production capacity includes the cooking time and the time required for the cooking surface to return to within 25°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 cooking process. Cooking-energy efficiency is therefore defined by the following relationship:

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

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[1] American Society for Testing and Materials. 1999. *Standard Test Method for the Performance of Griddles.* ASTM Designation F 1275-99, in *Annual Book of ASTM Standards,* West Conshohocken, PA.

Executive Summary

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

Table ES-1. Summary of Griddle Performance.

Rated Energy Input Rate (Btu/h)	78,000
Measured Energy Input Rate (Btu/h)	76,031
Temperature Uniformity (°F) [a]	± 39.7
Useable cooking surface area (in^2) [b]	592
Preheat Time to 375°F (min)	17.5
Preheat Energy to 375°F (Btu)	20,799
Idle Energy Rate @ 375°F (Btu/h)	14,399
Heavy-Load Cooking-Energy Efficiency (%)	35.3 ± 0.8
Medium-Load Cooking-Energy Efficiency (%)	24.4 ± 0.6
Light-Load Cooking-Energy Efficiency (%)	11.2 ± 0.8
Production Capacity (lb/h) [c]	32.2 ± 2.2
Cooking Surface Recovery Time (min) [c]	3.31

[a] Temperature uniformity reflects the absolute temperature variance across the cooking surface to within 1 inch from each edge.

[b] Area that is between 360°F and 390°F.

[c] Based on the heavy-load cooking test with a minimum 30-second preparation time between loads.

The Jade JGTSD 2436 gas griddle exhibited a quick preheat time of 17.5 minutes and a low idle rate of 14,399 Btu/h. An impressive useable cooking surface area of 592 in^2 gives an operator ample room to cook.

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 (see Appendix E). 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.

Executive Summary

During heavy-load testing the Jade griddle posted a respectable cooking-energy efficiency of 35.3% with a production capacity 32.2 lb/h and was comparable to other 3-foot griddles tested in its class. Medium and light loads were also on par with other gas griddles with medium and light loads cooking energy efficiencies of 24.4% and 11.2% respectively. The Jade JGTSD 2436 gas griddle combines a simple sturdy design with competitive cooking performance characteristics.

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

Preheat Energy (kBtu/day)	20.8
Idle Energy (kBtu/day)	52.8
Cooking Energy (kBtu/dayr)	226.4
Annual Energy (kBtu/year) [a]	109,791
Annual Cost ($/year) [b]	659

[a] 1kBtu = 1,000 Btu

[b] Griddle energy costs are based on $0.60/therm for gas appliances (1 therm = 100,000 Btu)

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 workhorse that usually occupies a central position on the short order line. 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.

Since the development of the ASTM test method for griddles in 1989, the FSTC has tested a wide range of gas and electric griddles. [2-14]

Introduction

Jade's JGTSD 2436 griddle features an all stainless steel construction and snap-action thermostats, a pilot igniter, and a 1-inch thick griddle-cooking surface. The Jade gas 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 Jade gas griddle, model JGTSD 2436, 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 cooking surface and the accuracy of the thermostats.
3. Determine the time and energy required to preheat the cooking surface from room temperature to 375°F.
4. Characterize the idle energy use with the thermostats set at a calibrated 375°F.
5. Document the cooking energy consumption and efficiency under three hamburger loading scenarios: heavy (24 patties), medium (12 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

Jade's JGTSD 2436 gas griddle features snap-action thermostats controlling three 26,000 Btu U-shaped burners – one burner for every twelve inches of griddle surface (Figure 1-1). Cooking temperatures from 200°F to 450°F are adjusted using three thermostats located on the front panel. The cooking surface is 1-inch thick steel surrounded by stainless steel splashguards and back splash.

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

Figure 1-1.
Jade JGTSD 2436 gas griddle.

Table 1-1. Appliance Specifications.

Manufacturer	Jade Range
Model	JGTSD 2436
Generic Appliance Type	Counter Top Thermostatically Controlled Griddle
Rated Input	78,000 Btu/h
Dimensions	36.0" x 31.5" x 14.8"
Construction	1 inch-thick steel
Controls	Individual snap-action thermostats for each 1-foot cooking zone adjustable from 175 to 550°F. Pilot light ignition switch.

2 Methods

Setup and Instrumentation

FSTC researchers installed the griddle 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 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 thermocouples to measure cooking surface temperatures. For the temperature uniformity test, 48 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.

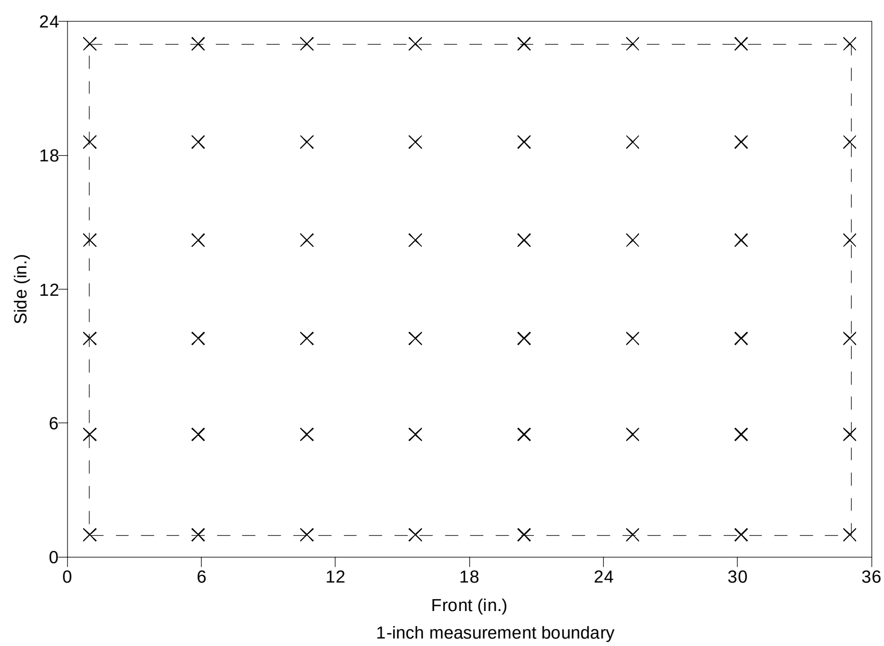

Figure 2-1.
Thermocouple grid for temperature uniformity test.

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 chemical laboratory used a gas chromatograph to determine the gas heating value on each day of testing. All gas measurements were corrected to standard conditions.

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 burners are operating on full (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 24 patty (heavy) loads, 12 patty (medium) loads, and 4 patty (light) loads.

Due to the logistics involved in removing one load of cooked hamburgers and placing another load onto the griddle, a minimum preparation time of 30 seconds (based on 10 seconds per linear foot) was incorporated into the cooking procedure. This ensures that the cooking tests are uniformly applied from laboratory to laboratory. Griddle recovery was then based on the cooking surface reaching a threshold temperature of 350°F (measured at the center of each linear foot of griddle plate). Reloading within 25°F of the 375°F thermostat set point does not significantly lower the average cooking surface over the cooking cycle, nor does it extend the cook time. The griddle was reloaded either

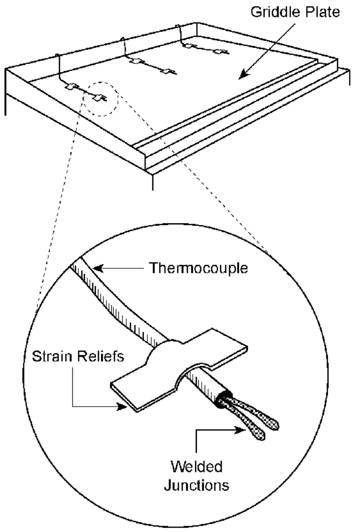

Figure 2-2. Thermocouple placement for testing.

after all three thermocouples reached the threshold temperature, or 30 seconds after removing the previous load from the griddle, whichever was longer.

Prior to the six-load test, one to two loads of hamburgers were cooked to stabilize the griddle 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 griddle to recover, researchers terminated the test.

Cooking tests were run in the following sequence: three replicates of the extra heavy-load, three replicates of the heavy-load test, three replicates of the medium-load test, and three replicates of the light-load test. This procedure ensured 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.

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 griddle was operating within its specified parameters. The measured energy input rate was 76,031 (a difference of 2.52 % from the nameplate rating).

Temperature Uniformity

Thermocouples were welded to the cooking surface at the center of each linear foot to facilitate temperature calibration. The thermostat control was turned to a ~ 375°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 375 ± 5°F on the cooking surface at the center of each linear foot. To characterize the temperature profile of the cooking surface at 375°F, researchers welded additional thermocouples to the cooking surface in a 48-point grid with approximately 5 inches between adjacent points. Griddle temperatures were monitored for one hour after the cooking surface had stabilized at a calibrated 375°F. Figure 3-1 illustrates the temperatures across the griddle cooking surface. The temperature uniformity profiles are represented Figure 3-2. The results from these temperature uniformity tests are summarized in Table 3-1.

Results

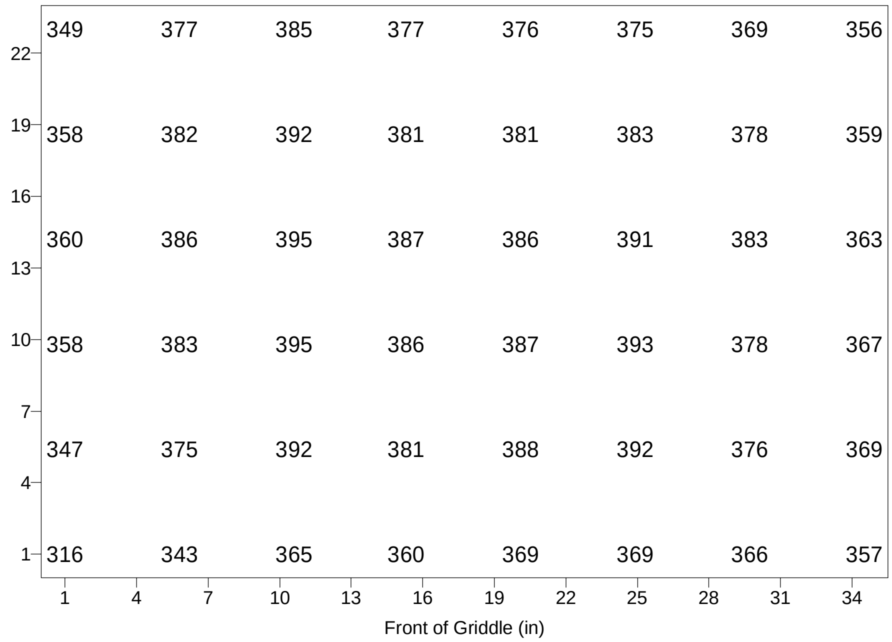

Figure 3-1.
Temperature sensing points on the griddle surface.

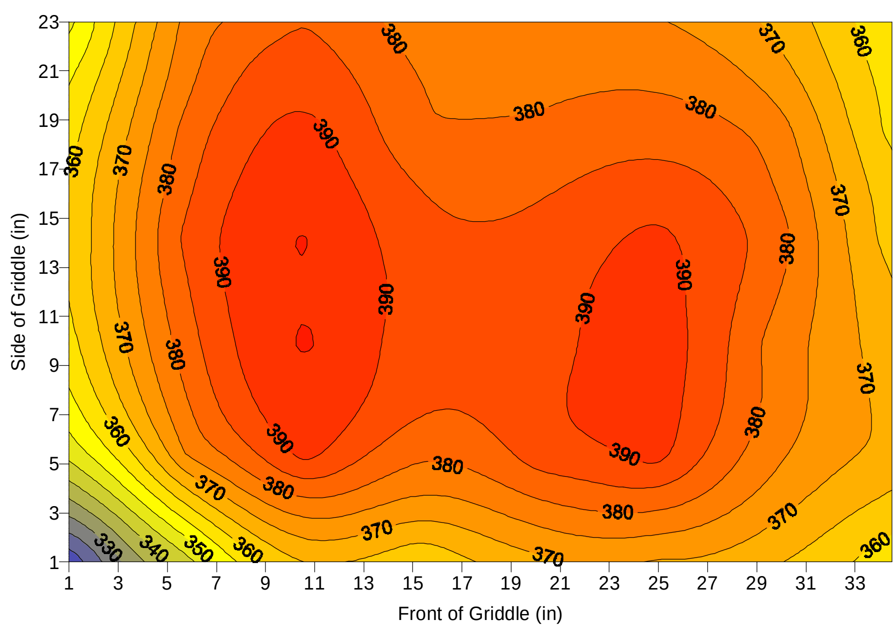

Figure 3-2.
Temperature map of the cooking surface.

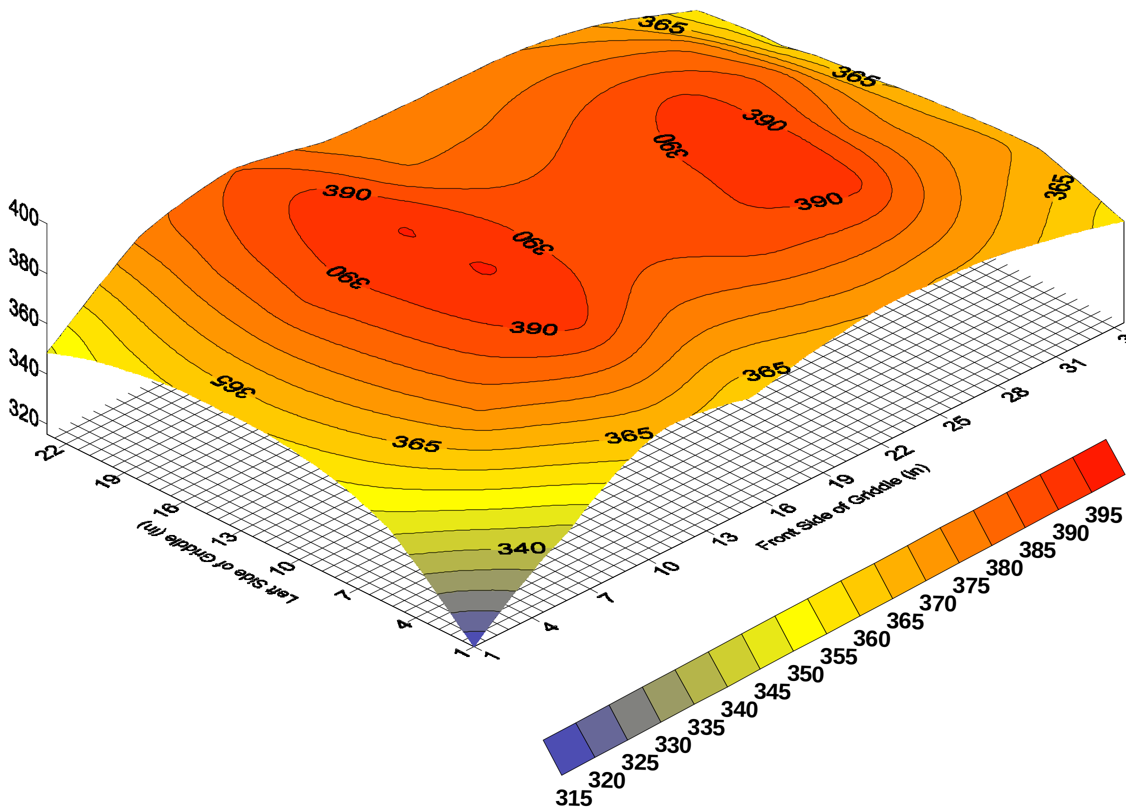

Table 3-1. Temperature Uniformity and Thermostat Accuracy [a].

Thermostat Setting (°F)	375
Average Surface Temperature (°F)	374
Left Thermostat (°F)	375
Center Thermostat (°F)	375
Right Thermostat (°F)	375
Maximum Temperature Difference Across Plate (°F) [b]	79.3
Useable Cooking Surface (in^2) [c]	592
Standard Deviation of Surface Temperatures (°F)	16.0

[a] Thermostat accuracy is the thermostat setting required to maintain 375 ± 5°F on the cooking surface.

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

[c] Area that is between 360°F and 390°F.

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 74°F at the outset of the preheat test. Researchers measured the energy consumption and time required to preheat the cooking surface to a calibrated 375°F. The griddle's preheat required 20,799 Btu and 17.5 minutes.
Figure 3-3 shows the energy consumption rate in conjunction with the cooking surface temperature during the preheat test.

Idle Energy Rate

The griddle was allowed to stabilize at 375°F for one hour. Researchers then monitored the energy consumption over a 2-hour period. The idle energy rate during this period was 14,399 Btu/h.

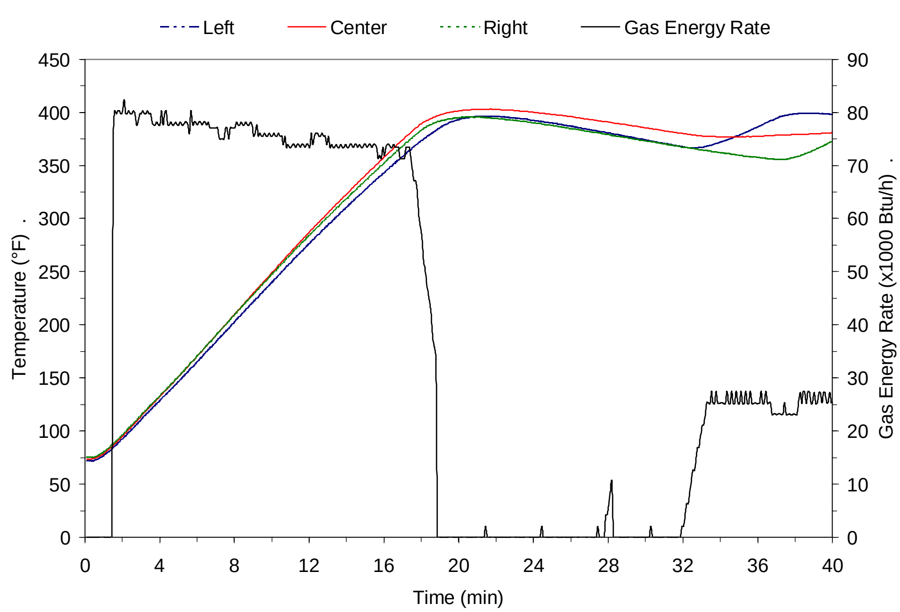

Figure 3-3.
Preheat characteristics.

Results

Test Results

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

Table 3-2. Input, Preheat, and Idle Test Results.

Rated Energy Input Rate (Btu/h)	78,000
Measured Energy Input Rate (Btu/h)	76,031
Percentage Difference (%)	2.52
Preheat	
Time to 375°F (min)	17.5
Energy (Btu)	20,799
Rate to 375°F (°F/min)	17.2
Idle Energy Rate @ 375°F (Btu/h)	14,399

Cooking Tests

The griddle was tested under three loading scenarios: heavy (24 hamburger patties), medium (12 hamburger patties), and light (4 hamburger patties). 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 24 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.

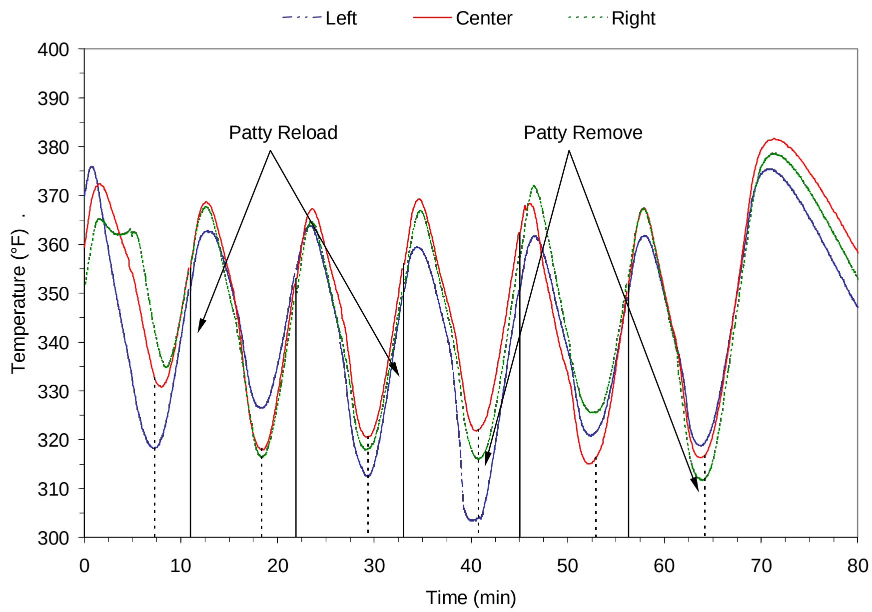

Figure 3-4.
Average heavy-load cooking surface temperatures.

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 for the cooking surface to recover to 350°F (recovery time.

Medium- and Light-Load Tests

Medium- and light-load tests represent a more typical usage pattern for a griddle in cook-to-order applications. Since a griddle is seldom fully loaded in many food service establishments, these part-load efficiencies can be used to estimate griddle performance in an actual operation. Both the medium- and light-load tests were conducted on the left half of the cooking surface. Since the entire griddle was heated to 375°F, the energy consumed during these part-load tests includes radiant heat losses from the unused half of the griddle.

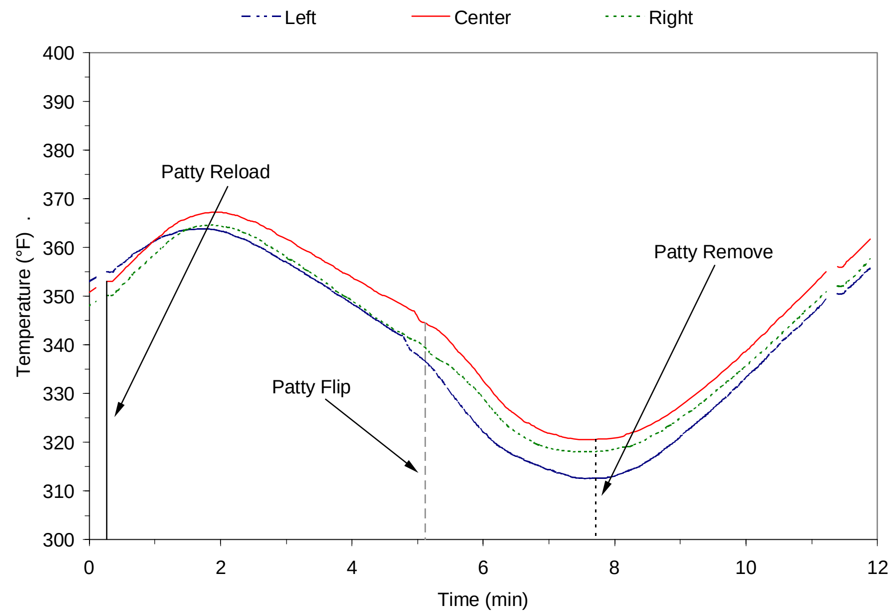

Figure 3-5.
Griddle temperature signature while cooking a heavy-load of hamburgers.

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 35.6%, 35.1%, and 35.0%, yielding a maximum uncertainty of 0.85% in the test results. Table 3-3 summarizes the results of the ASTM cooking-energy efficiency and production capacity tests.

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

	Heavy-Load	Medium-Load	Light-Load
Hamburger Patty Cook Time (min)	7.85	8.30	7.75
Average Recovery Time (min)	3.31	3.26	2.79
Production Rate (lb/h)	32.2 ± 2.2	15.7 ± 0.7	5.6 ± 0.5
Energy Consumption (Btu/lb)	1,362	1,959	4,134
Cooking Energy Rate (Btu/h)	43,886	30,701	22,963
Cooking-Energy Efficiency (%)	35.3 ± 0.8	24.4 ± 0.6	11.2 ± 0.8

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.

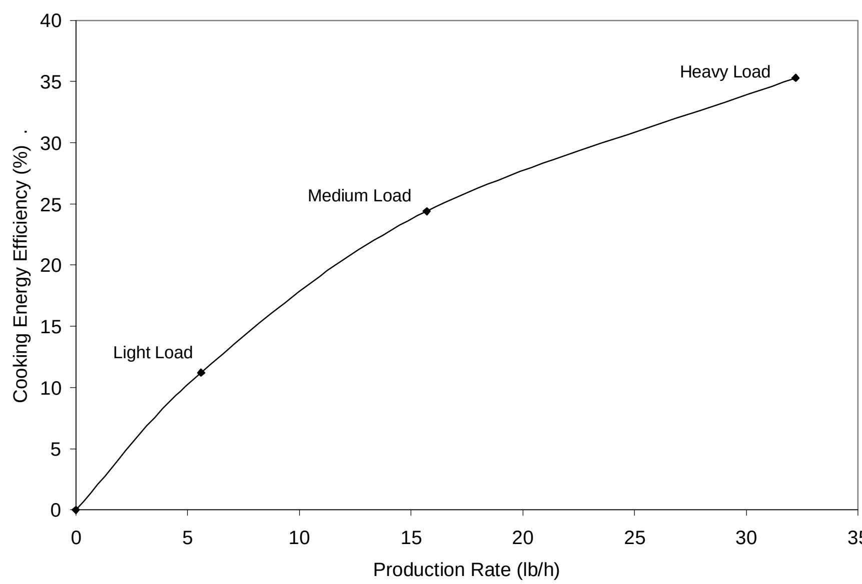

Figure 3-6.
Griddle part-load cooking-energy efficiency.

Note: Light-load = 4 hamburgers/load; medium-load = 12 hamburgers/load; heavy-load = 24 hamburgers/load

Figure 3-7 illustrates the relationship between the griddle's average energy consumption rate and the production rate. This graph can be used as a tool to estimate the average energy rate for different types of operations. Average energy consumption rates at 10, 20, and 30 pounds per hour are 26,090 Btu/h, 35,190 Btu/h, and 42,420 Btu/h, respectively.

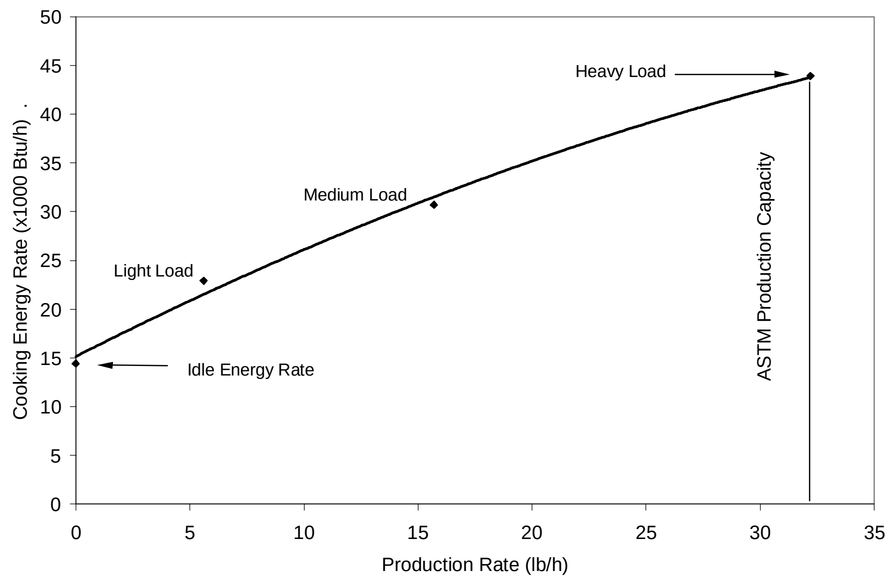

Figure 3-7. Griddle cooking energy consumption profile.

Note: Light-load = 4 hamburgers/load; medium-load = 12 hamburgers/load; heavy-load = 24 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 paties 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 3-4. Estimated Griddle Energy Consumption and Cost.

Preheat Energy (kBtu/day)	20.8
Idle Energy (kBtu/day)	52.8
Cooking Energy (kBtu/day)	226.4
Annual Energy (kBtu/year) [a]	109,791
Annual Cost ($/year) [b]	659

[a] 1kBtu = 1,000 Btu

[b] Griddle energy costs are based on $0.60/therm for gas appliances (1 therm = 100,000 Btu)

4 Conclusions

The Jade JGTSD 2436 gas griddle was successfully tested in accordance with ASTM standard test method, exhibiting performance that compares favorably with other griddles in its class. The griddle preheated to 375°F in a workman-like 17.5 minutes and had the lowest idle rate of any gas griddle tested to date a the Food Service Technology Center.[2-14] The griddle showed good uniformity and an impressive 592 in^2 usable cooking surface area.

During heavy-load testing, the JGTSD 2436 griddle posted a respectable cooking-energy efficiency of 35% while running at a 56% duty cycle. The extra power reserved during cooking suggests that a more responsive control would dramatically improve it's 32 lb/h production capacity.

Food service operations typically cook under less than full-load scenarios. The Jade griddle demonstrated economical part-load cooking energy efficiencies (24.4% and 11.2%) during the medium and light-load tests. The Jade JGTSD 2436 gas griddle combines a simple sturdy design with solid performance characteristics.

The cost model estimates showed that the Jade JGTSD 2436 griddle, when used to cook 100 pounds of hamburgers a day, 365 days a year, would consume 109,791 kBtu of energy. Assuming an energy cost of 60 cents per therm, 109,791 kBtu (1,098 therms) translates to an annual operating cost of 659 dollars.

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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-, 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/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.

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

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 25°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 Jade griddle.

Appliance Specifications

Manufacturer	Jade Range
Model	JGTSD 2436
Generic Appliance Type	Counter Top Thermostatically Controlled Griddle
Rated Input	78,000 Btu/h
Dimensions	36.0” x 31.5” x 14.8”
Construction	1 inch-thick steel
Controls	Individual snap-action thermostats for each 1-foot cooking zone adjustable from 175 to 550°F. Pilot light ignition switch.

C Results Reporting Sheets

Manufacturer: Jade Range

Model: JGTSD 2436

Date: June 2003

Test Griddle

Description of operational characteristics: 1-inch thick steel plate with stainless steel construction on the sides, landing ledge and front. Three 26,000 Btu/h steel U-shaped burners are individually controlled by mechanical snap-action thermostats. The griddle features four adjustable legs and a built in removable grease trough.

Apparatus

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

Deviations: The griddle temperature uniformity plot was increased in size to characterize temperatures to within 1-inch of the outside edge of the griddle plate. Also, surface temperature recovery was lowered from 365°F to 350°F per an upcoming revision of the griddle test method.

Energy Input Rate

Heating Value (Btu/scf)	1023
Rated (Btu/h)	78,000
Measured (Btu/h)	76,031
Percent Difference between Measured and Rated (%)	2.52

Results Reporting Sheets

Preheat Energy and Time

Heating Value (Btu/scf)	1018
Starting Temperature (°F)	73.4
Energy Consumption (Btu)	20,799
Duration (min)	17.5
Preheat Rate (°F/min)	17.2

Temperature Uniformity and Thermostat Accuracy [a]

Left Thermostat (°F)	375
Center Thermostat (°F)	375
Right Thermostat (°F)	375
Maximum Temperature Difference (°F) [b]	79.3
Useable Cooking Surface (in^2) [c]	592

[a] Thermostat settings required to maintain 375°F cooking surface temperature

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

[c] Area that is between 360°F and 390 °F.

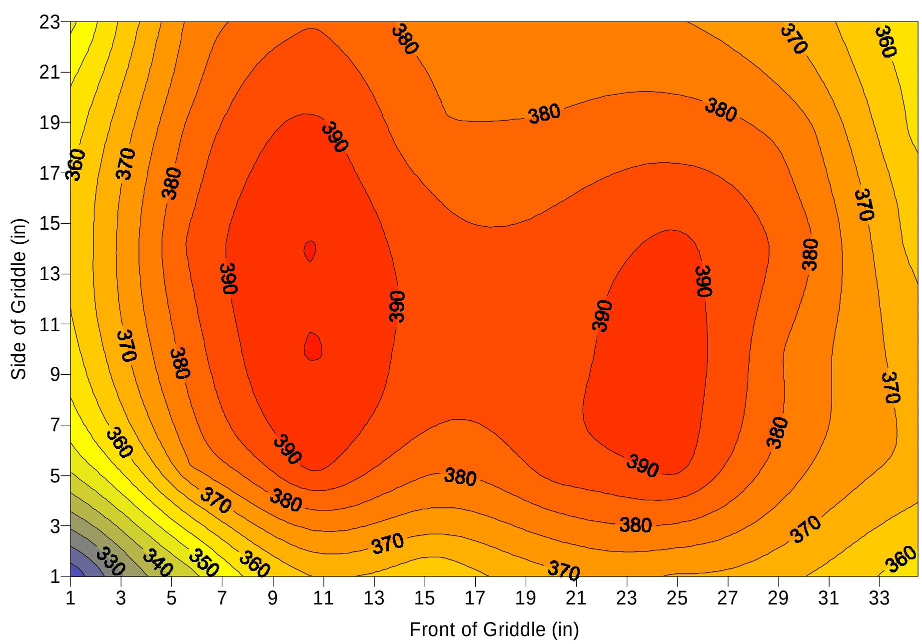
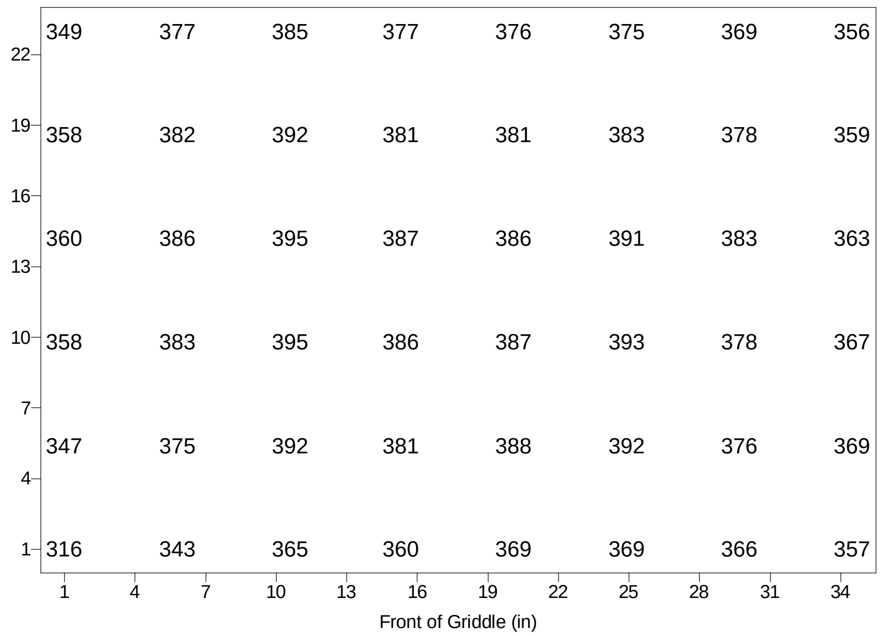


Figure C-1. Average cooking surface temperatures.

Results Reporting Sheets



Idle Energy Rate

Heating Value (Btu/scf)	1019
Idle Energy Rate @ 375°F (Btu/h)	14,399

Heavy-Load Cooking-Energy Efficiency Test Results

Heating Value (Btu/scf)	1020
Cooking Time (min)	7.85
Average Cooking Surface Recovery Time (min)	3.31
Production Capacity (lb/h)	32.2 ± 2.2
Energy to Food (Btu/lb)	480
Cooking Energy Rate (Btu/h)	43,886
Energy per Pound of Food Cooked (Btu/lb)	1,362
Cooking-Energy Efficiency (%)	35.3 ± 0.8

Results Reporting Sheets

Medium-Load Cooking-Energy Efficiency Test Results

Heating Value (Btu/scf)	1023
Cooking Time (min)	8.30
Average Cooking Surface Recovery Time (min)	3.26
Production Rate (lb/h)	15.7 ± 0.7
Energy to Food (Btu/lb)	478
Cooking Energy Rate (Btu/h)	30,701
Energy per Pound of Food Cooked (Btu/lb)	1,959
Cooking-Energy Efficiency (%)	24.4 ± 0.6

Light-Load Cooking-Energy Efficiency Test Results

Heating Value (Btu/scf)	1023
Cooking Time (min)	7.75
Average Cooking Surface Recovery Time (min)	2.79
Production Rate (lb/h)	5.6 ± 0.5
Energy to Food (Btu/lb)	462
Cooking Energy Rate (Btu/h)	22,963
Energy per Pound of Food Cooked (Btu/lb)	4,134
Cooking-Energy Efficiency (%)	11.2 ± 0.8

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			
Total Energy (Btu)	47,763	50,224	48,854
Cook Time (min)	7.46	8.16	7.92
Total Test Time (min)	66.8	69.0	65.0
Weight Loss (%)	33.0	34.4	33.8
Initial Weight (lb)	36.160	35.958	35.728
Final Weight (lb)	24.231	23.594	23.651
Initial Fat Content (%)	17.7	17.7	17.7
Initial Moisture Content (%)	62.3	62.3	62.3
Final Moisture Content (%)	51.8	50.3	51.4
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	158	161	160
Calculated Values			
Initial Weight of Water (lb)	22.529	22.403	22.260
Final Weight of Water (lb)	12.551	11.869	12.153
Weight of Fat (lb)	6.399	6.363	6.323
Weight of Solids (lb)	7.232	7.192	7.146
Sensible to Ice (Btu)	360	358	356
Sensible to Water (Btu)	2,829	2,895	2,843
Sensible to Fat (Btu)	403	410	404
Sensible to Solids (Btu)	228	232	228
Latent - Water Fusion (Btu)	3,244	3,226	3,205
Latent - Fat Fusion (Btu)	282	278	277
Latent - Water Vaporization (Btu)	9,679	10,218	9,803
Total Energy to Food (Btu)	17,026	17,618	17,117
Energy to Food (Btu/lb)	471	490	479
Total Energy to Griddle (Btu)	47,763	50,224	48,854
Energy to Griddle (Btu/lb)	1,321	1,397	1,367
Cooking-Energy Efficiency (%)	35.6	35.1	35.0
Cooking Energy Rate (Btu/h)	42,901	43,667	45,089
Production Capacity (lb/h)	32.5	31.3	33.0
Average Recovery Time (min)	3.67	3.34	2.91

Table D-3. Medium-Load Test Data

	Repetition #1	Repetition #2	Repetition #3	Repetition #4
Measured Values				
Total Energy (Btu)	34,763	35,574	35,466	36,032
Cook Time (min)	8.06	8.13	8.50	8.50
Total Test Time (min)	68.0	71.1	72.0	66.4
Weight Loss (%)	33.1	33.4	33.6	34.4
Initial Weight (lb)	17.964	18.163	18.384	17.896
Final Weight (lb)	12.023	12.102	12.211	11.741
Initial Fat Content (%)	17.7	17.7	17.7	17.7
Initial Moisture Content (%)	62.3	62.3	62.3	62.3
Final Moisture Content (%)	52.3	50.3	51.4	51.4
Initial Temperature (°F)	0	0	0	0
Final Temperature (°F)	158	159	159	161
Calculated Values				
Initial Weight of Water (lb)	11.192	11.316	11.454	11.149
Final Weight of Water (lb)	6.293	6.088	6.275	6.033
Weight of Fat (lb)	3.179	3.214	3.253	3.167
Weight of Solids (lb)	3.593	3.633	3.677	3.579
Sensible to Ice (Btu)	179	181	183	178
Sensible to Water (Btu)	1,408	1,432	1,456	1,441
Sensible to Fat (Btu)	201	204	207	204
Sensible to Solids (Btu)	113	115	117	115
Latent - Water Fusion (Btu)	1,612	1,630	1,649	1,606
Latent - Fat Fusion (Btu)	140	141	143	139
Latent - Water Vaporization (Btu)	4,752	5,072	5,024	4,963
Total Energy to Food (Btu)	8,405	8,775	8,779	8,646
Energy to Food (Btu/lb)	468	483	478	483
Total Energy to Griddle (Btu)	34,763	35,574	35,466	36,032
Energy to Griddle (Btu/lb)	1,935	1,959	1,929	2,013
Cooking-Energy Efficiency (%)	24.2	24.7	24.8	24.0
Cooking Energy Rate (Btu/h)	30,656	30,008	29,555	32,584
Production Rate (lb/h)	15.8	15.3	15.3	16.2
Average Recovery Time (min)	3.28	3.72	3.50	2.56

Cooking-Energy Efficiency Data

Table D-4. Light-Load Test Data

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Total Energy (Btu)	23,071	24,831	24,717
Cook Time (min)	7.75	7.75	7.75
Total Test Time (min)	60.8	63.3	65.7
Weight Loss (%)	34.9	36.2	36.0
Initial Weight (lb)	5.847	5.859	5.860
Final Weight (lb)	3.805	3.738	3.751
Initial Fat Content (%)	19.9	19.9	19.9
Initial Moisture Content (%)	60.1	60.1	60.1
Final Moisture Content (%)	52.5	53.1	51.4
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	163	166	165
Calculated Values			
Initial Weight of Water (lb)	3.513	3.520	3.521
Final Weight of Water (lb)	1.997	1.983	1.926
Weight of Fat (lb)	1.165	1.167	1.167
Weight of Solids (lb)	1.169	1.172	1.172
Sensible to Ice (Btu)	56	56	56
Sensible to Water (Btu)	459	472	470
Sensible to Fat (Btu)	76	77	77
Sensible to Solids (Btu)	38	39	39
Latent - Water Fusion (Btu)	506	507	507
Latent - Fat Fusion (Btu)	56	56	56
Latent - Water Vaporization (Btu)	1,471	1,491	1,547
Total Energy to Food (Btu)	2,662	2,698	2,751
Energy to Food (Btu/lb)	455	461	470
Total Energy to Griddle (Btu)	23,071	24,831	24,717
Energy to Griddle (Btu/lb)	3,946	4,238	4,218
Cooking-Energy Efficiency (%)	11.5	10.9	11.1
Cooking Energy Rate (Btu/h)	22,768	23,544	22,576
Production Rate (lb/h)	5.8	5.6	5.4
Average Recovery Time (min)	2.38	2.80	3.20

Cooking-Energy Efficiency Data

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

	Cooking-Energy Efficiency			Production Capacity
	Heavy-Load	Medium-Load	Light-Load	
Replicate #1	35.6	24.2	11.5	32.5
Replicate #2	35.1	24.7	10.9	31.3
Replicate #3	35.0	24.8	11.1	33.0
Replicate #4	--	24.0	--	--
Average	35.3	24.4	11.2	32.2
Standard Deviation	0.34	0.37	0.34	0.88
Absolute Uncertainty	0.85	0.59	0.84	2.18
Percent Uncertainty	2.40	2.41	7.49	6.77

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-, medium-, 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), medium- (half the 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: 20% of the food was cooked under heavy-load conditions, 60% was cooked under medium-load conditions, and 20% was cooked under light-load conditions. Calculate the energy due to cooking at heavy-, medium-, 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 a gas griddle yielded the following results:

Energy Cost Model

Table E-1. Gas Griddle Test Results.

Test	Result
Preheat Time	17.5 min
Preheat Energy	20,799 Btu
Idle Energy Rate	14,399 Btu/h
Heavy-Load Cooking Energy Rate	43,886 Btu/h
Medium-Load Cooking Energy Rate	30,701 Btu/h
Light-Load Cooking Energy Rate	22,963 Btu/h
Production Capacity	32.2 lb/h
Medium-Load Production Rate	15.7 lb/h
Light-Load Production Rate	5.56 lb/h

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

Table E-2. Griddle Operation Assumptions.

Operating Time	12 h
Number of Preheats	1 preheat
Total Amount of Food Cooked	100 lb
Percentage of Food Cooked Under Heavy-Load Conditions	20% (× 100 lb = 20 lb)
Percentage of Food Cooked Under Medium-Load Conditions	60% (× 100 lb = 60 lb)
Percentage of Food Cooked Under Light-Load Conditions	20% (× 100 lb = 20 lb)

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

The total time cooking heavy-loads is as follows:

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

$$t_h = \frac{20\% \times 100\ lb}{32.2\ lb/h},$$

$$t_h = 0.62\ h$$

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

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

$$E_{gas,h} = 43{,}886\ Btu/h \times 0.62\ h$$

$$E_{gas,h} = 27{,}209\ Btu$$

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

The total time cooking medium-loads is as follows:

$$t_m = \frac{\%_m \times W}{PR_m},$$

$$t_m = \frac{60\% \times 100\ lb}{15.7\ lb/h},$$

$$t_m = 3.82\ h$$

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

$$E_{gas,m} = q_{gas,m} \times t_m$$

$$E_{gas,m} = 30{,}701\ Btu/h \times 3.82\ h$$

$$E_{gas,m} = 117{,}277\ Btu$$

***Step 4*—Calculate the total light-load energy.**

The total time cooking light-loads is as follows:

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

$$t_l = \frac{20\% \times 100\ lb}{5.56\ lb/h},$$

$$t_l = 3.60\ h$$

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

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

$$E_{gas,l} = 22{,}963\ Btu/h \times 3.60\ h$$

$$E_{gas,l} = 82{,}667\ Btu$$

Step 5—Calculate the total idle time and energy consumption.

The total idle time is determined as follows:

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

$$t_i = 12.0\ h - 0.62\ h - 3.82\ h - 3.60\ h - \frac{1\ preheat \times 17.5\ min}{60\ min/h}$$

$$t_i = 3.67\ h$$

The idle energy consumption is then calculated as follows:

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

$$E_{gas,i} = 14{,}399\ Btu/h \times 3.67\ h$$

$$E_{gas,i} = 52{,}844\ Btu$$

***Step 6*—The total daily energy consumption is calculated as follows:**

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

$$E_{gas,daily} = 27{,}209\ Btu + 117{,}277\ Btu + 82{,}667\ Btu + 52{,}844\ Btu + 1 \times 20{,}799\ Btu$$

$$E_{gas,daily} = 300{,}797\ Btu/day = 3.01\ therms/day$$

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

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

$$Cost_{snnual} = 3.01\ therms/day \times 0.60\ \$/therm \times 365\ days/year$$

$$Cost_{annual} = 659\ \$/year$$