Star 836TSCHS Gas Griddle Performance Test

Application of ASTM Standard
Test Method F 1275-03

FSTC Report 5011.04.13

Food Service Technology Center
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Specific appreciation is extended to Star Manufacturing for supplying the FSTC with a 3-foot gas griddle, Model 836TSCHS for controlled testing in the appliance laboratory.

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Star 836TSCHS 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.

Star's 836TSCHS griddle features stainless steel construction, snap-action thermostats, and a 1-inch thick brushed-steel 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 were determined by cooking frozen hamburgers under two different loading scenarios (heavy—24 hamburgers and light—4 hamburgers). The cook time for the heavy-load cooking scenarios was 7.93 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. 2003. *Standard Test Method for the Performance of Griddles.* ASTM Designation F 1275-03, 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)	90,000
Measured Energy Input Rate (Btu/h)	92,171
Temperature Uniformity (°F) [a]	± 39
Useable cooking surface area (in^2) [b]	542
Preheat Time to 375°F (min)	12.0
Preheat Energy to 375°F (Btu)	18,300
Idle Energy Rate @ 375°F (Btu/h)	11,099
Heavy-Load Cooking-Energy Efficiency (%)	37.2 ± 1.2
Light-Load Cooking-Energy Efficiency (%)	13.9 ± 1.3
Production Capacity (lb/h) [c]	39.8 ± 2.3
Cooking Surface Recovery Time (min) [c]	1.16

[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 Star 836TSCHS gas griddle incorporates a simple, solid and easy to clean design into a daily workhorse. Food service operators can expect the griddle to be ready to cook at 375°F in a very fast 12.0 minutes while consuming 18,300 Btu. The griddle further impresses with a very low idle rate of 11,099 Btu/h and a duty cycle of 12.0%. Temperature uniformity across the griddle-cooking surface was comparable with a range of 70°F and a respectable useable cooking surface area of 542 in^2.

The gas griddle demonstrated competitive cooking-energy efficiencies while being tested at the Food Service Technology Center with a heavy-load cooking-energy efficiency of 37.2% and a production capacity of 39.8lb/h. Most food service operations cook under less than full-load scenarios with light-loads being more representative of real world operations. The Star posted a respectable light-load cooking-energy efficiency of 13.9%.

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.

Preheat Energy (kBtu/day) [a]	18.3
Idle Energy (kBtu/day) [a]	61.7
Cooking Energy (kBtu/day) [a]	189.9
Annual Energy (kBtu/year) [a]	98,513
Annual Cost ($/year) [b]	591

[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 the 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. [2-16]

Introduction

The Star 836TSCHS gas griddle features stainless steel construction, 110V snap-action thermostats, a hard chrome griddle-cooking surface, front mounted grease trough, and removable grease pan. The Star 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 Star gas griddle, model 836TSCHS, 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 two hamburger loading scenarios: heavy (24 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

Star's 836TSCHS gas griddle features three U-shaped atmospheric burners – one for every twelve inches of griddle surface. One 110V snap-action thermostat controls each burner (Figure 1-1). The cooking surface is hard chrome surrounded by stainless steel front and sides. The griddle sits on four heavy-duty adjustable legs.

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

Figure 1-1.
Star 836TSCHS gas griddle.

Table 1-1. Appliance Specifications.

Manufacturer	Star Manufacturing
Model	836TSCHS
Generic Appliance Type	Counter Top Thermostatically Controlled Griddle
Rated Input	90,000 Btu/h
Dimensions	36" x 32 1/2" x 18 1/4"
Construction	hard chrome griddle plate with stainless steel construction on the front and sides. The griddle features a standing pilot ignition with snap-action thermostats controlling 30,000 Btu/h burners, one for each linear foot of griddle surface. The griddle features four heavy-duty adjustable legs, a spatula wide 3-½" built in grease trough, and 6 quart removable grease container.
Controls	Individual 110V snap-action thermostats for each 1-foot cooking zone.

2 Methods

Setup and Instrumentation

FSTC researchers installed the griddle on a table 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 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.

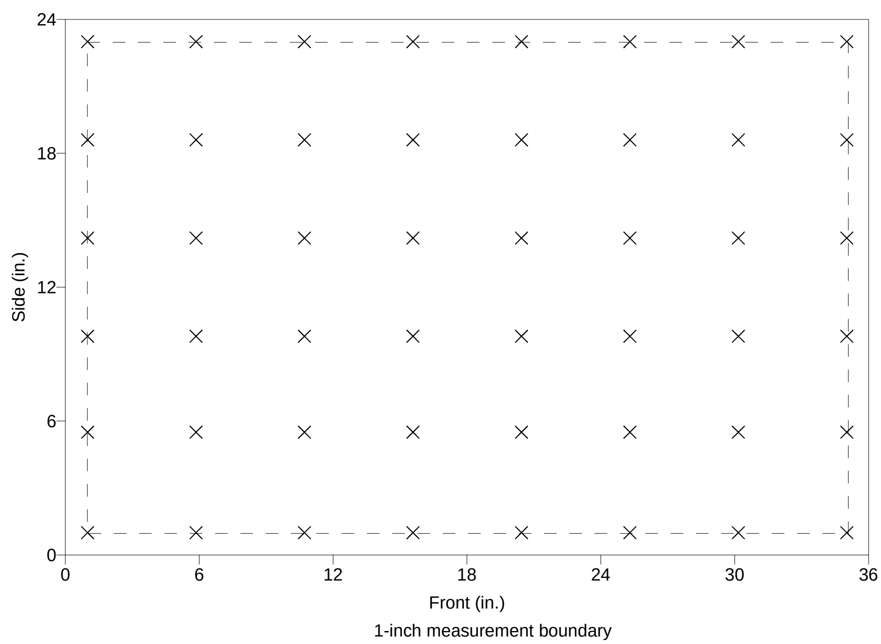

Figure 2-1. Thermocouple grid for temperature uniformity test.

Methods

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.

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 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 after all three thermocouples reached the threshold temperature,

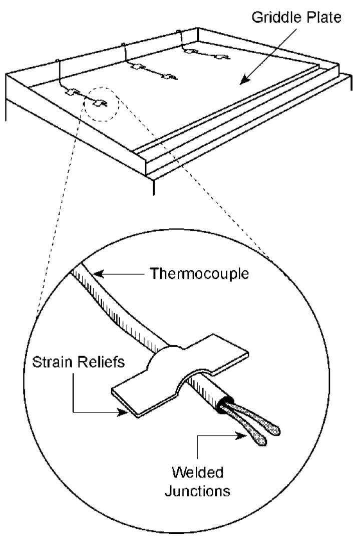

Figure 2-2. Thermocouple placement for testing.

either 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.

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.

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 92,171 Btu/h (a difference of 0.87 % 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

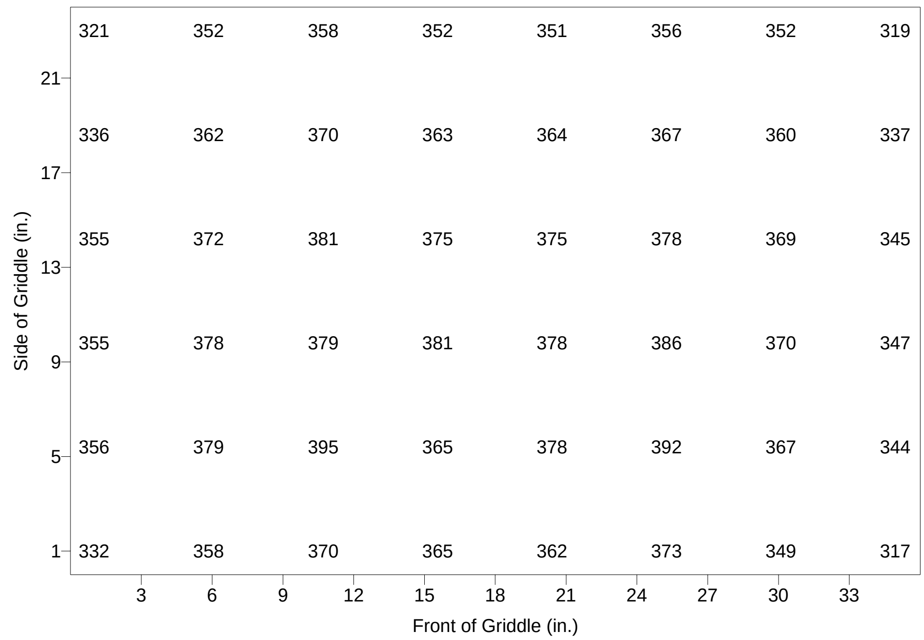

Figure 3-1.
Temperature sensing points on the griddle surface.

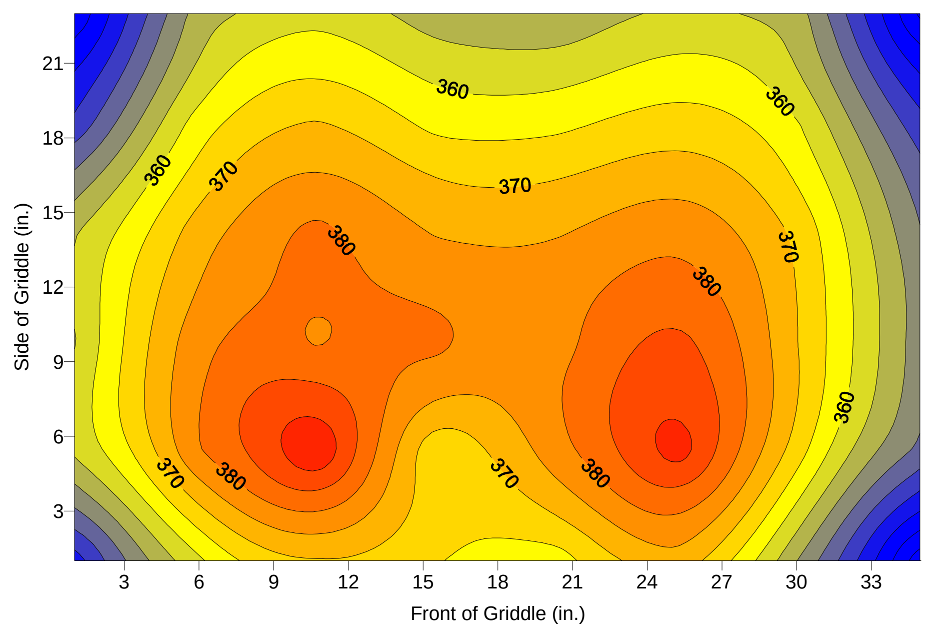

Figure 3-2.
Temperature map of the cooking surface.

Results

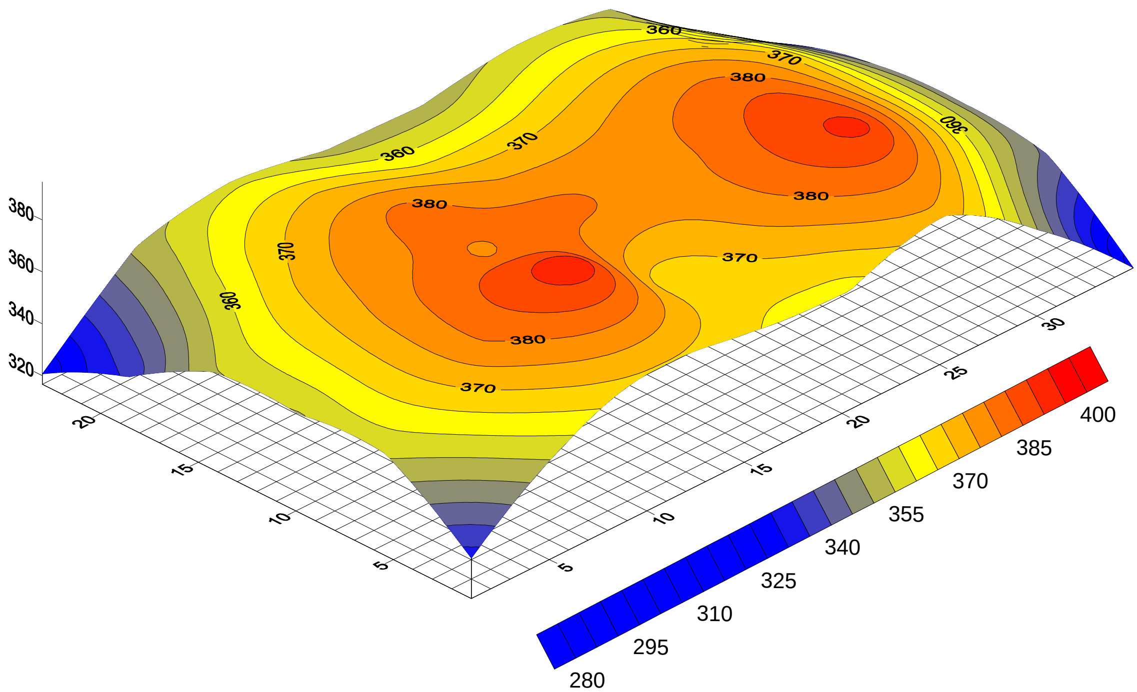

Table 3-1. Temperature Uniformity and Thermostat Accuracy [a].

Thermostat Setting (°F)	375
Average Surface Temperature (°F)	358
Left Thermostat (°F)	377
Center Thermostat (°F)	375
Right Thermostat (°F)	380
Maximum Temperature Difference Across Plate (°F) [b]	78
Useable Cooking Surface (in^2) [c]	542
Standard Deviation of Surface Temperatures (°F)	14.1

[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 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 375°F. The time necessary to bring the griddle surface to a temperature of 375°F was 12.0 minutes, during which time the griddle consumed 18,300 Btu. 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 11,099 Btu/h.

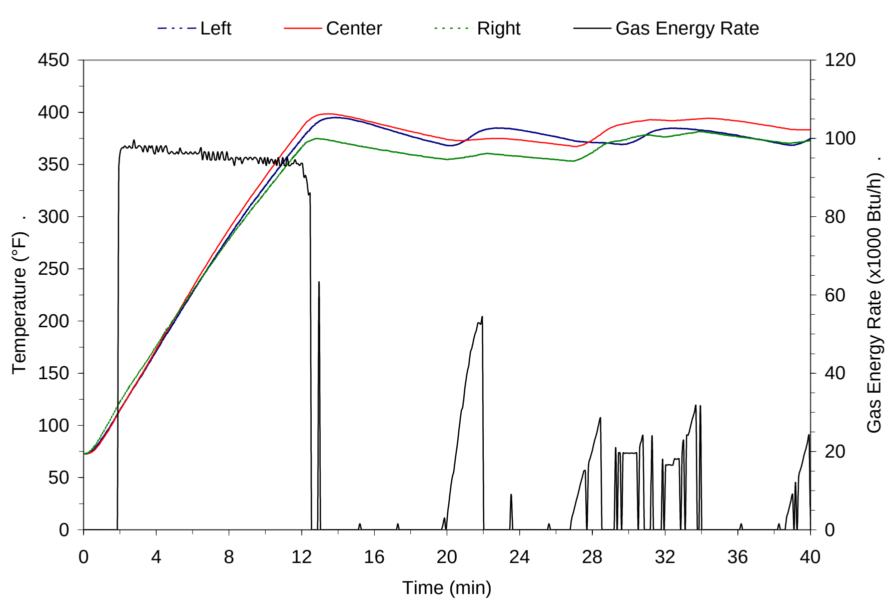

Figure 3-3.
Preheat characteristics.

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)	90,000
Measured Energy Input Rate (Btu/h)	92,171
Percentage Difference (%)	0.87
Preheat	
Time to 375°F (min)	12.0
Energy (Btu)	18,300
Rate to 375°F (°F/min)	25.1
Idle Energy Rate @ 375°F (Btu/h)	11,099

Cooking Tests

The griddle was tested under two loading scenarios: heavy- (24 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.

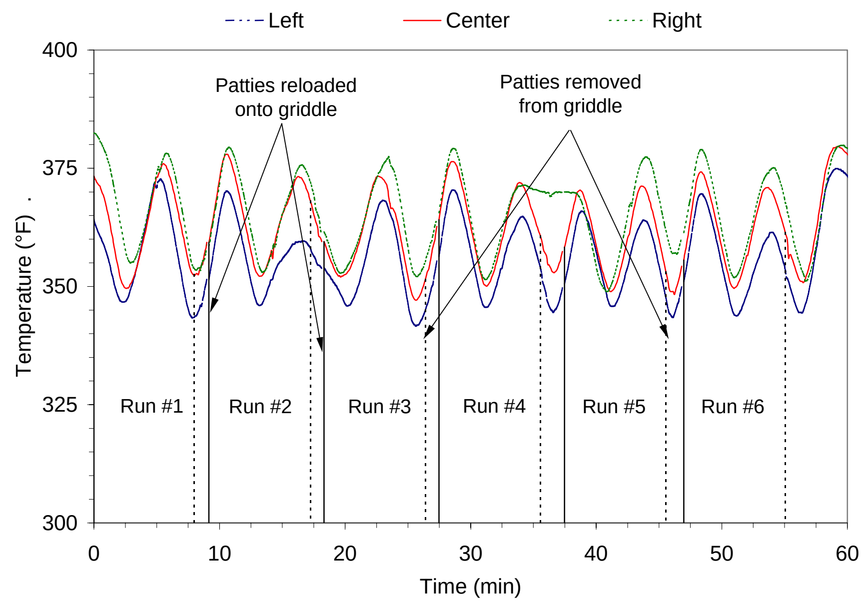

Figure 3-4.
Average heavy-load cooking surface temperatures.

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).

Light-Load Tests

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, the light-load efficiency can be used to estimate griddle performance in an actual operation. Since the entire griddle was heated to 375°F, the energy consumed during the light-load test includes radiant heat losses from the unused portion of the griddle.

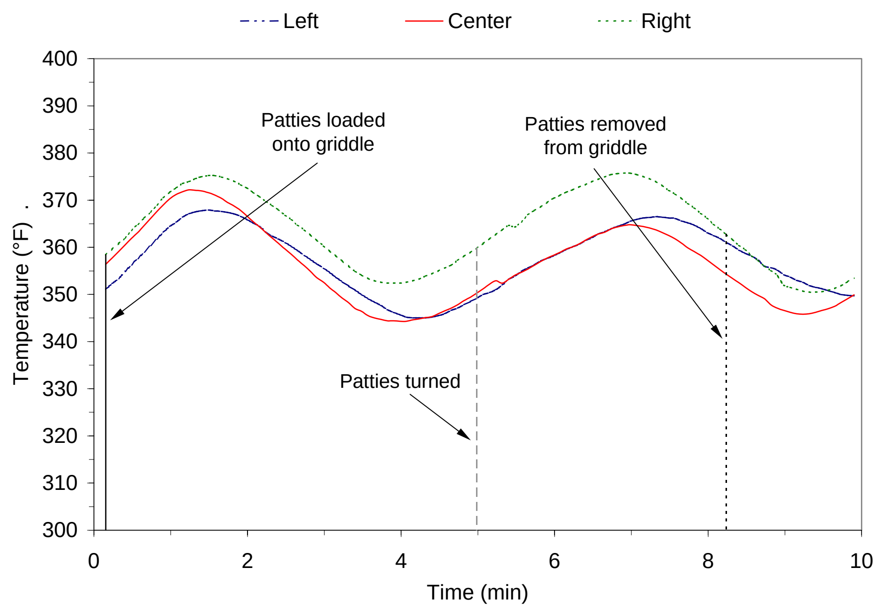

Figure 3-5.
Griddle temperature signature while cooking a heavy-load of hamburgers.

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 36.6%, 36.5%, 38.1%, and 37.2% yielding a maximum uncertainty of 1.2% 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	Light-Load
Hamburger Cook Time (min)	7.93	8.02
Average Recovery Time (min)	1.16	< 1.0
Production Rate (lb/h)	39.8 ± 2.3	6.7 ± 1.1
Energy per Pound of Food Cooked (Btu/lb)	1,234	3,453
Cooking Energy Rate (Btu/h)	49,083	23,103
Cooking-Energy Efficiency (%)	37.2 ± 1.2	13.9 ± 1.3

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.

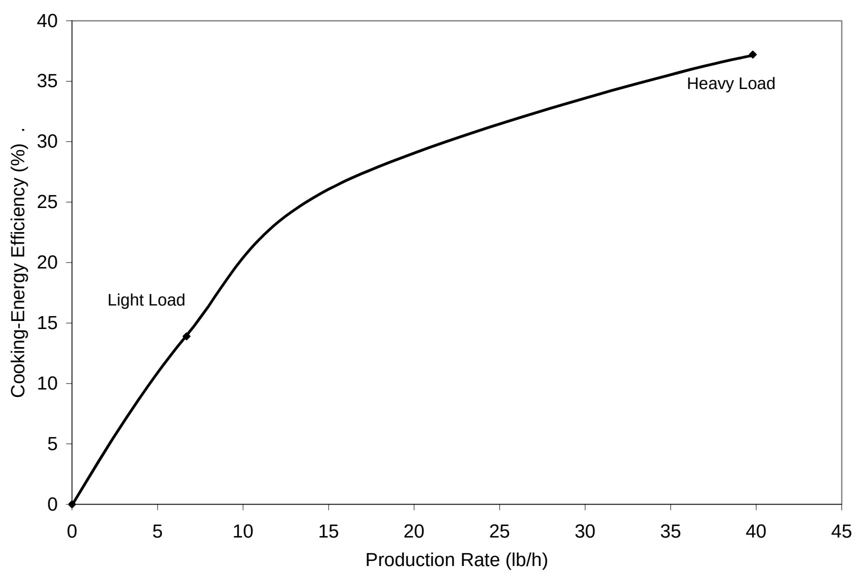

Figure 3-6.
Griddle part-load cooking-energy efficiency.

Note: Light-load = 4 hamburgers/load; heavy-load = 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 28,710 Btu/h, 40,190 Btu/h, and 47,140 Btu/h, respectively.

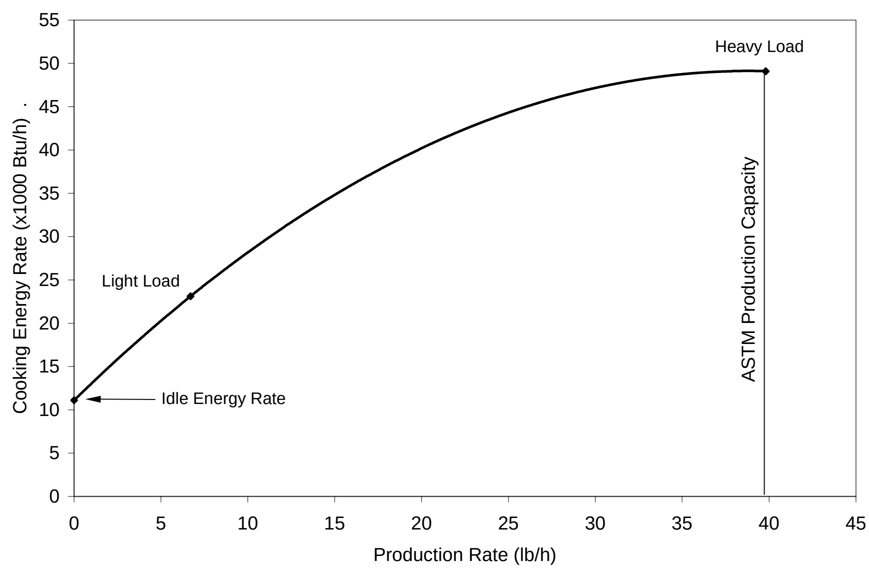

Figure 3-7.
Griddle cooking energy consumption profile.

Note: Light-load = 4 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 food 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 pre-

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) [a]	18.3
Idle Energy (kBtu/day) [a]	61.7
Cooking Energy (kBtu/day) [a]	189.9
Annual Energy (kBtu/year) [a]	98,513
Annual Cost ($/year) [b]	591

[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 Star 836TSCHS gas griddle was successfully tested in accordance with ASTM standard test method, exhibiting respectable performance when compared to other griddles in its class. The Star griddle surface preheated to 375°F in a very fast 12.0 minutes. The griddle exhibited a very low idle energy rate of 11,099 Btu/h when compared to other griddles of the same class, despite a high input rate of 90,000 Btu/h. The griddle's low idle energy rate is in part due to the chrome surface. During temperature uniformity testing, the griddle exhibited a respectable 542 in^2 of useable cooking surface (area between 360°F and 390°F) with a maximum temperature difference across the plate of ± 39°F.

During heavy-load cooking tests, the griddle demonstrated a cooking-energy efficiency of 37.2%, while producing 39.8 lb/h of cooked hamburgers. Light-load tests represent more of a real world application and the Star 836TSCHS griddle demonstrated an economical part-load cooking-energy efficiency of 13.9%.

The cost model estimates showed that the Star griddle, when used to cook 100 pounds of food a day, 365 days a year, would consume 98,513 kBtu of energy. Assuming an energy cost of 60 cents per therm, 98,513 kBtu (1,095 therms) translates to an annual operating cost of 591 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-, 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 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.

Useable Cooking Surface (in^2)

The area of griddle surface with a temperature that falls between 360°F and 390°F.

B Appliance Specifications

Appendix B includes the product literature for the Star griddle.

Appliance Specifications

Manufacturer	Star Manufacturing
Model	836TSCHS
Generic Appliance Type	Counter Top Thermostatically Controlled Griddle
Rated Input	90,000 Btu/h
Dimensions	36" x 32 1/2" x 18 1/4"
Construction	1-inch thick hard chrome griddle plate with stainless steel construction on the front and sides. The griddle features a standing pilot ignition with snap-action thermostats controlling 30,000 Btu/h burners, one for each linear foot of griddle surface. The griddle features four heavy-duty adjustable legs, a spatula wide 3-½" built in grease trough, and 6 quart removable grease container.
Controls	Individual 110V snap-action thermostats for each 1-foot cooking zone.

Star Manufacturing International, Inc.

Ultra-Max™ Gas Griddles

ULTRA-MAX™ CHROME GAS GRIDDLES

Models 824TSCHS, 836TSCHS, 848TSCHS, 860TSCHS & 872TSCHS

Features/Benefits:

- ★ Ultra-Max™ Chrome Griddles feature a hard chrome surface to provide superior cooking performance and more even heat distribution. Highly polished smooth surface reflects heat inward reducing radiant heat, lowers energy cost 30% and keeps the kitchen cooler. The non-pourous chrome surface eliminates food taste transfer and can be cleaned quickly, reducing labor cost.
- ★ Snap-Action thermostat control from 150° to 450°F provides accurate temperature control of +/- 10° of set point. Internal plate sensor accurately measures the temperature of the griddle plate 3/16" from the cooking surface for instant response to surface temperature change and fast recovery.
- ★ Available in 24, 36, 48, 60 and 72 inch widths to meet your space and volume requirements.
- ★ Custom designed 30,000 BTU steel burner every 12" of cooking surface provides superior cooking performance.
- ★ Heavy-duty all-weld body construction with stainless steel front, side panels, bull nose and splash guard.
- ★ "Euro-style" design with stylishly curved, ergonomically advanced front panel providing easy access and viewing of controls.
- ★ Spatula wide 3-1/2" front grease trough and grease chute for easier cleaning.
- ★ Large 6 quart stainless steel grease drawer.
- ★ Extra-heavy 4" adjustable legs to fit your countertop needs.
- ★ Floor model stands available for free standing unit. Optional casters available.

Model 848TSCHS

Model 836TSCHS
Shown with Optional Floor Stand

c UL us LISTED · CLASSIFIED UL EPH

Applications:

Ultra-Max™ griddles provide high volume operations with superior performance, labor savings, energy savings and maximum results for a variety of menu items.

Construction:

Ultra-Max™ griddles feature 1" thick highly polished steel plate with chromium surface, 5" tapered stainless steel splash guard and 3-1/2" wide front access grease trough with 6 quart grease drawer capacity. Models 860TSCHS and 872TSCHS house two 6 quart grease drawers. Includes a 30,000 BTU aluminized steel burner every 12" of width controlled by snap-action control valve (110V) 3/4" N.P.T. male gas connection with convertible pressure regulator and 4" adjustable legs. Units are approved for installation within 6" of combustible surfaces and supplied with 6' cord and NEMA 5-15 plug

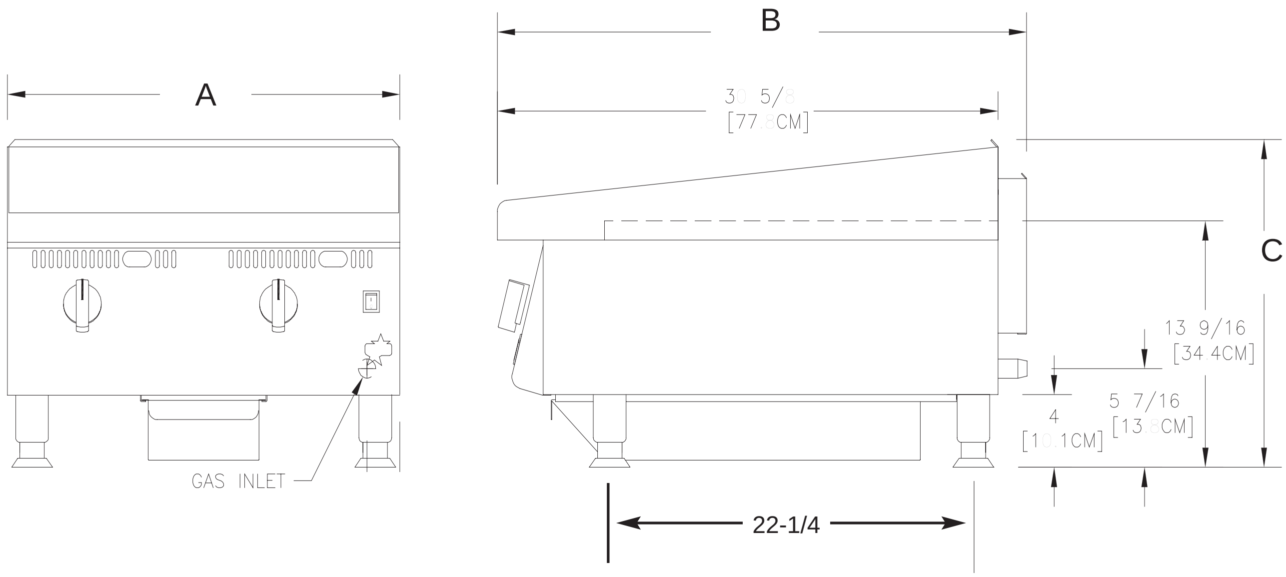
Warranty:

Ultra-Max™ gas griddles are covered by Star's one year parts and labor warranty. In addition, the Ultra-Max Chrome surface is warranted for 5 years!

Star Manufacturing International Inc. - 10 Sunnen Drive - P.O. Box 430129 - St. Louis, MO 63143-3800
Phone: (800) 264-7827 - FAX: (800) 264-6666 - www.star-mfg.com

ULTRA-MAX™ CHROME GAS GRIDDLES

Models 824TSCHS, 836TSCHS, 848TSCHS, 860TSCHS & 72TSCHS



Specifications

Model No.	Dimensions (A) Width Inches	(B) Depth Inches	(C) Height Inches	No. Controls	BTU	Grid Area	Plate Thickness	Approximate Weight Installed	Shipping
824TSCHS	24" (61 cm)	32-3/8" (82.2 cm)	18" (45.7 cm)	2	60,000	573 sq. in. (3,697sq cm)	1" (2.54 cm)	222 lbs. (100.6 kg)	305 lbs. (137.3 kg)
836TSCHS	36" (91.4 cm)	32-3/8" (82.2 cm)	18" (45.7 cm)	3	90,000	860 sq. in. (5,545 sq cm)	1" (2.54 cm)	333 lbs. (150.9 kg)	409 lbs. (184.1 kg)
848TSCHS	48" (121.9cm)	32-3/8" (82.2 cm)	18" (45.7 cm)	4	120,000	1146 sq. in. (7,394 sq cm)	1" (2.54 cm)	444 lbs. (201.2 kg)	524 lbs. (235.8 kg)
860TSCHS	60" (152.4 cm)	32-3/8" (82.2 cm)	18" (45.7 cm)	5	150,000	1433 sq. in. (9,242 sq cm)	1" (2.54 cm)	555 lbs. (251.5 kg)	688 lbs. (309.6 kg)
872TSCHS	72" (182.9 cm)	32-3/8" (82.2 cm)	18" (45.7 cm)	6	180,000	1719 sq. in. (11,091 sq cm)	1" (2.54 cm)	666 lbs. (301.8 kg)	794 lbs. (357.3 kg)

Typical Specifications

Gas griddles are constructed of stainless steel, valve knobs are protected by a stainless steel bull nose front. Griddle plate is a 1" (2.54 cm) thick highly polished steel plate with 5" (7.6 cm) high tapered wrap-around stainless steel splash guard. Unit has 3-1/2" (8.3 cm) wide front grease trough with grease chute and a 6 qt. (5.68 L) capacity stainless steel grease drawer. Models 860TSCHS and 872TSCHS house two each 6 quart grease drawers. Units are equipped with a 30,000 BTU aluminized steel burner for every 12" (30.5 cm) of width and are controlled by a snap action control valve (110) with an automatic safety pilot and 3/4" N.P.T. male gas connection with a convertible pressure regulator. Griddles are supplied with 4" (10.2 cm) high stainless steel legs that have a 1-5/8" (4.5 cm) adjustment. Supplied with 6' cord and NEMA 5-15 plug. Units are approved for installation within 6" (15.2 cm) of combustible surfaces and are cULus Classified and UL classified to NSF Standard 4 Sanitation. Printed in the U.S.A.

Star Manufacturing International Inc. - 10 Sunnen Drive - P.O. Box 430129 - St. Louis, MO 63143-3800
Phone: (800) 264-7827 - FAX: (800) 264-6666 - www.star-mfg.com

C Results Reporting Sheets

Manufacturer:	Star Manufacturing
Model:	836TSCHS
Serial Number:	83600498
Date:	June 2004

Test Griddle.

Description of operational characteristics: 1-inch thick hard chrome griddle plate with stainless steel construction on the front and sides. The griddle features a standing pilot ignition with snap-action thermostats controlling 30,000 Btu/h burners, one for each linear foot of griddle surface. The griddle features four heavy-duty adjustable legs, a spatula wide 3-½" built in grease trough, and 6 quart removable grease container.

Apparatus.

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

Energy Input Rate.

Heating Value (Btu/scf)	1018
Rated (Btu/h)	90,000
Measured (Btu/h)	92,171
Percent Difference between Measured and Rated (%)	0.87

Temperature Uniformity and Thermostat Accuracy [a]

Left Thermostat (°F)	377
Center Thermostat (°F)	375
Right Thermostat (°F)	380
Maximum Temperature Difference Across Plate (°F) [b]	78
Useable Cooking Surface (in^2) [c]	542

[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.

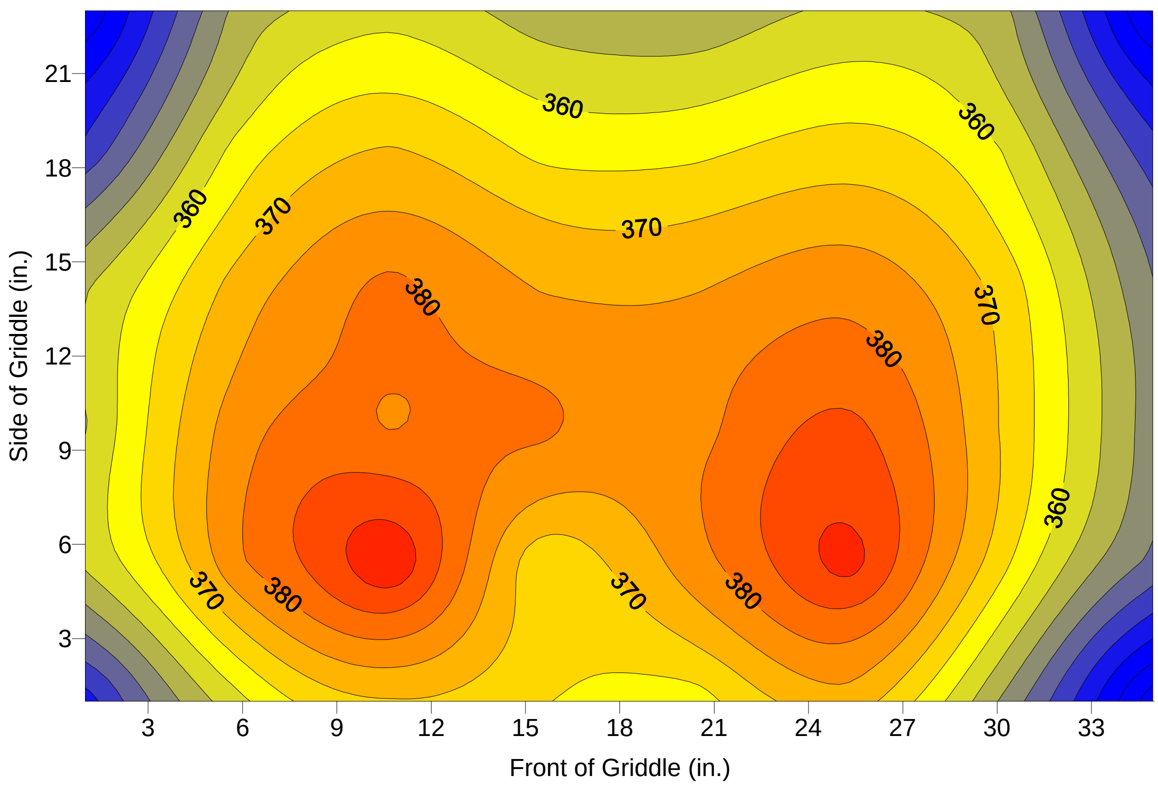


Figure C-1. Average cooking surface temperatures.

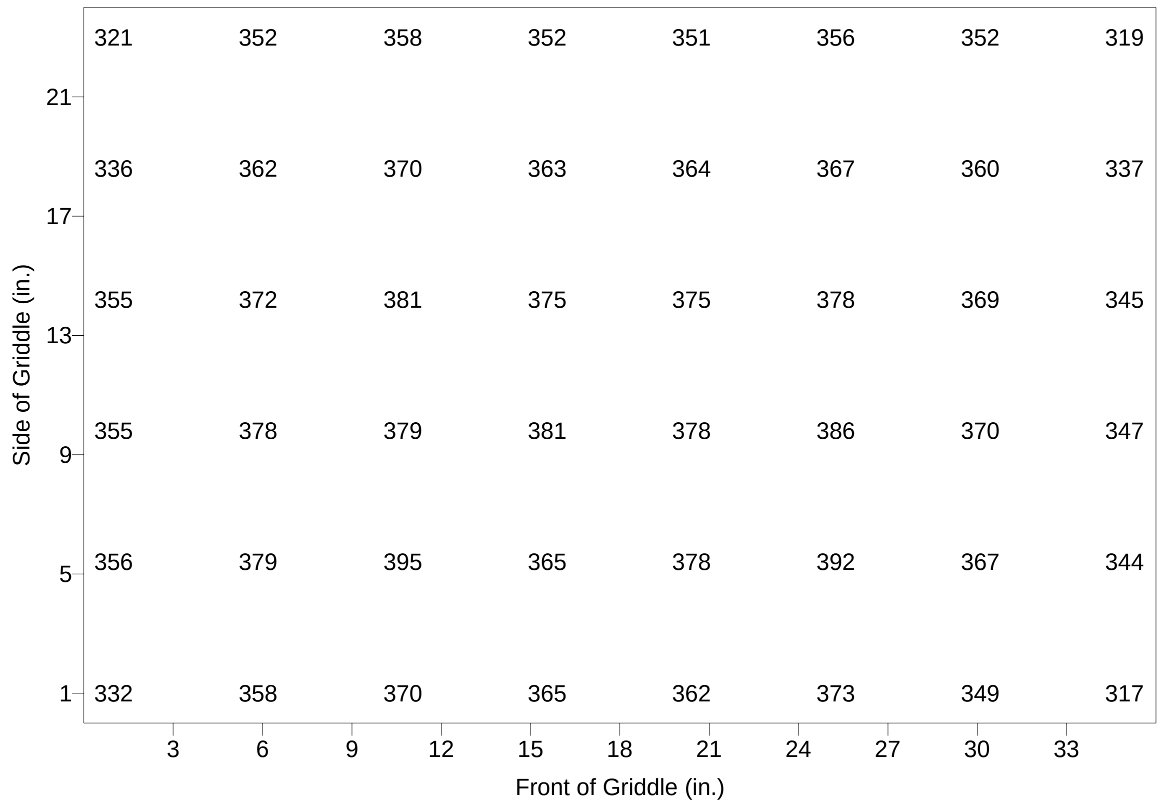


Figure C-2. Average cooking surface temperatures.

Preheat Energy and Time.

Heating Value (Btu/scf)	1018
Starting Temperature (°F)	72.1
Energy Consumption (Btu)	18,300
Duration (min)	12.0
Preheat Rate (°F/min)	25.1

Idle Energy Rate.

Heating Value (Btu/scf)	1017
Idle Energy Rate @ 375°F (Btu/h)	11,099

Results Reporting Sheets

Heavy-Load Cooking-Energy Efficiency Test Results.

Heating Value (Btu/scf)	1019
Cooking Time (min)	7.93
Average Cooking Surface Recovery Time (min)	1.16
Production Capacity (lb/h)	39.8 ± 2.3
Energy to Food (Btu/lb)	458
Cooking Energy Rate (Btu/h)	49,083
Energy per Pound of Food Cooked (Btu/lb)	1,234
Cooking-Energy Efficiency (%)	37.2 ± 1.2

Light-Load Cooking-Energy Efficiency Test Results.

Heating Value (Btu/scf)	1019
Cooking Time (min)	8.02
Average Cooking Surface Recovery Time (min)	< 1.0
Production Capacity (lb/h)	6.7 ± 1.1
Energy to Food (Btu/lb)	479
Cooking Energy Rate (Btu/h)	23,103
Energy per Pound of Food Cooked (Btu/lb)	3,453
Cooking-Energy Efficiency (%)	13.9 ± 1.3

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	Repetition #4
Measured Values				
Total Energy (Btu)	44,596	45,088	43,599	44,721
Cook Time (min)	8.00	8.00	7.81	7.92
Total Test Time (min)	56.5	55.9	52.4	53.4
Weight Loss (%)	34.9	35.1	35.6	35.6
Initial Weight (lb)	36.089	36.142	36.160	36.138
Final Weight (lb)	23.510	23.463	23.300	23.279
Initial Fat Content (%)	19.9	19.9	19.9	19.9
Initial Moisture Content (%)	60.1	60.1	60.1	60.1
Final Moisture Content (%)	52.4	52.7	52.6	52.4
Initial Temperature (°F)	0	0	0	0
Final Temperature (°F)	162	163	164	164
Calculated Values				
Initial Weight of Water (lb)	21.698	21.730	21.741	21.728
Final Weight of Water (lb)	12.315	12.363	12.247	12.190
Weight of Fat (lb)	7.173	7.184	7.187	7.183
Weight of Solids (lb)	7.218	7.228	7.232	7.228
Sensible to Ice (Btu)	347	348	348	348
Sensible to Water (Btu)	2,830	2,847	2,876	2,875
Sensible to Fat (Btu)	466	468	472	472
Sensible to Solids (Btu)	234	236	238	238
Latent - Water Fusion (Btu)	3,124	3,129	3,131	3,129
Latent - Fat Fusion (Btu)	343	343	343	343
Latent - Water Vaporization (Btu)	9,101	9,086	9,209	9,251
Total Energy to Food (Btu)	16,446	16,457	16,616	16,655
Energy to Food (Btu/lb)	456	455	460	461
Total Energy to Griddle (Btu)	44,956	45,088	43,599	44,721
Energy Per Pound of Food Cooked (Btu/lb)	1,246	1,248	1,206	1,238
Cooking-Energy Efficiency (%)	36.6	36.5	38.1	37.2
Cooking Energy Rate (Btu/h)	47,766	48,412	49,904	50,248
Production Rate (lb/h)	38.3	38.8	41.4	40.6
Average Recovery Time (min)	1.41	1.31	0.93	0.98

Cooking-Energy Efficiency Data

Table D-3. Light-Load Test Data

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Total Energy (Btu)	20,390	20,410	21,293
Cook Time (min)	8.18	7.89	8.00
Total Test Time (min)	53.5	53.3	54.5
Weight Loss (%)	37.1	37.8	36.9
Initial Weight (lb)	5.994	6.005	5.982
Final Weight (lb)	3.771	3.736	3.774
Initial Fat Content (%)	19.9	19.9	19.9
Initial Moisture Content (%)	60.1	60.1	60.1
Final Moisture Content (%)	51.3	50.8	52.1
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	168	170	168
Calculated Values			
Initial Weight of Water (lb)	3.604	3.610	3.596
Final Weight of Water (lb)	1.935	1.899	1.966
Weight of Fat (lb)	1.191	1.194	1.189
Weight of Solids (lb)	1.199	1.201	1.196
Sensible to Ice (Btu)	58	58	58
Sensible to Water (Btu)	491	498	488
Sensible to Fat (Btu)	80	81	80
Sensible to Solids (Btu)	40	41	40
Latent - Water Fusion (Btu)	519	520	518
Latent - Fat Fusion (Btu)	57	57	57
Latent - Water Vaporization (Btu)	1,618	1,660	1,581
Total Energy to Food (Btu)	2,863	2,915	2,821
Energy to Food (Btu/lb)	478	485	472
Total Energy to Griddle (Btu)	20,390	20,410	21,293
Energy Per Pound of Food Cooked (Btu/lb)	3,402	3,399	3,560
Cooking-Energy Efficiency (%)	14.0	14.3	13.2
Cooking Energy Rate (Btu/h)	22,859	22,997	23,455
Production Rate (lb/h)	6.7	6.8	6.6
Average Recovery Time (min)	< 1.0	< 1.0	< 1.0

Cooking-Energy Efficiency Data

Table D-4. Cooking-Energy Efficiency and Production Capacity Statistics

	Cooking-Energy Efficiency		Production Capacity
	Heavy-Load	Light-Load	
Replicate #1	36.6	14.0	38.3
Replicate #2	36.5	14.3	38.8
Replicate #3	38.1	13.2	41.4
Replicate #4	37.2		40.6
Average	37.1	13.9	39.6
Standard Deviation	0.75	0.54	1.45
Absolute Uncertainty	1.19	1.34	2.30
Percent Uncertainty	3.20	9.67	5.78

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 125 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 a gas griddle yielded the following results:

Energy Cost Model

Table E-1: Gas Griddle Test Results.

Test	Result
Preheat Time	12.0 min
Preheat Energy	18,300 Btu
Idle Energy Rate	11,099 Btu/h
Heavy-Load Cooking Energy Rate	49,083 Btu/h
Light-Load Cooking Energy Rate	23,103 Btu/h
Production Capacity	39.8 lb/h
Light-Load Production Rate	6.7 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	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:

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

$$t_h = \frac{70\% \times 100\ lb}{39.8\ lb/h},$$

$$t_h = 1.76\ h$$

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

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

$$E_{gas,h} = 49{,}083\ Btu/h \times 1.76\ h$$

$$E_{gas,h} = 86{,}386\ Btu$$

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

The total time cooking light-loads is as follows:

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

$$t_l = \frac{30\% \times 100\ lb}{6.7\ lb/h},$$

$$t_l = 4.48\ h$$

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

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

$$E_{gas,l} = 23{,}103\ Btu/h \times 4.48\ h$$

$$E_{gas,l} = 103{,}501\ Btu$$

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

The total idle time is determined as follows:

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

$$t_i = 12.0\ h - 1.76\ h - 4.48\ h - \frac{1\ preheat \times 12.0\ min}{60\ min/h}$$

$$t_i = 5.56\ h$$

The idle energy consumption is then calculated as follows:

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

$$E_{gas,i} = 11{,}099\ Btu/h \times 5.56\ h$$

$$E_{gas,i} = 61{,}710\ Btu$$

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

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

$$E_{gas,daily} = 86{,}386\ Btu + 103{,}501\ Btu + 61{,}710\ Btu + (1 \times 18{,}300\ Btu)$$

$$E_{gas,daily} = 269{,}897\ Btu/day = 2.70\ therms/day$$

***Step 6*—The annual energy cost is calculated as follows:**

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

$$Cost_{snnual} = 2.70\ therms/day \times 0.60\ dollars/therm \times 365\ days/year$$

$$Cost_{annual} = 591\ dollars/year$$