Toastmaster Accu-Miser, Model AM36SS
Electric Griddle Performance Test

Application of ASTM Standard
Test Method F 1275-95

FSTC Report 5011.96.34

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Specific appreciation is extended to Toastmaster, for supplying the Food Service Technology Center with an Accu-Miser electric griddle for controlled testing in the appliance laboratory and subsequent installation and monitoring in the production-test kitchen.

Contents

	Page
Executive Summary	iii
1 Introduction	1-1
Background	1-1
Objectives	1-2
Appliance Description	1-2
2 Methods	2-1
Setup and Instrumentation	2-1
Measured Energy Input Rate	2-3
Cooking Tests	2-3
3 Results	3-1
Energy Input Rate	3-1
Temperature Uniformity	3-1
Preheat and Idle Tests	3-3
Cooking Tests	3-4
4 Conclusions	4-1
5 References	5-1
Appendix A: Glossary	
Appendix B: Appliance Specifications	
Appendix C: Results Reporting Sheets	
Appendix D: Cooking Energy Efficiency Data	

List of Figures and Tables

Figures

		Page
2-1	Thermocouple grid for temperature uniformity test	2-1
2-2	Thermocouple placement for testing	2-2
3-1	Temperature sensing points on the griddle surface	3-2
3-2	Temperature map of the cooking surface	3-2
3-3	Preheat characteristics	3-3
3-4	Cooking surface temperatures during a heavy-load test	3-5
3-5	Average cooking surface temperature during a heavy-load test	3-5
3-6	Average griddle temperature while cooking a heavy load	3-6
3-7	Griddle part-load cooking energy efficiency	3-8
3-8	Griddle cooking energy consumption profile	3-9

Tables

		Page
1-1	Appliance Specifications	1-3
3-1	Temperature Uniformity and Thermostat Accuracy	3-1
3-2	Input, Preheat, and Idle Test Results	3-4
3-3	Cooking Energy Efficiency and Production Capacity Test Results	3-8

Executive Summary

Toastmaster's Accu-Miser electric griddle is equipped with infrared heat panels. These panels spread heat over a larger surface than standard elements, allowing the griddle to perform the same amount of work with a lower input rating.

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.[1] Griddle performance is characterized by temperature uniformity, preheat time and energy consumption, idle energy consumption rate, cooking energy efficiency, and production capacity.

Griddle cooking performance was determined by cooking frozen hamburgers under three different loading scenarios (heavy—24 hamburgers, medium—12 hamburgers, and light—4 hamburgers). The cook times for the three loading scenarios were 10¾ minutes for the light-load test, 10¼ minutes for the medium-load test, and 9½ minutes for the heavy-load test. Cooking energy efficiency is defined by the following relationship:

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

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

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

Table ES-1. Summary of Griddle Performance.

Rated Energy Input Rate (kW)	9.30
Measured Energy Input Rate (kW)	9.27
Temperature Uniformity (°F)	± 23.5
Preheat Time to 375°F (min)	11.6
Preheat Energy to 375°F (kWh)	1.72
Idle Energy Rate @ 375°F (kW)	2.31
Heavy-Load Cooking Energy Efficiency (%)	71.9
Medium-Load Cooking Energy Efficiency (%)	58.1
Light-Load Cooking Energy Efficiency (%)	42.2
Production Capacity[a] (lb/h)	34.8
Cooking Surface Recovery Time[a] (min)	0.85

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

Figure ES-1 summarizes griddle cooking energy efficiency for different production rates. Griddle production rate is a function of both the hamburger patty cook time and the cooking surface recovery time.

Figure ES-2 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 daily energy consumption for the griddle. Average energy consumption rates at 10, 20, and 30 pounds per hour are 2.65 kW, 4.40 kW, and 6.15 kW, respectively.

The Toastmaster griddle's 71.9% heavy-load efficiency is the highest for any griddle tested to date at the Food Service Technology Center. Its high cooking energy efficiency is supported by a low cooking energy rate under all loading scenarios (heavy, medium, and light). In fact, this griddle's energy consumption rate under load is 11 to 17% lower than the average electric griddle.[2]

[2] Pacific Gas and Electric Company. 1989. *Development and Application of a Uniform Testing Procedure for Griddles.* Report 008.1-89.2 prepared for Research and Development. San Ramon, California: Pacific Gas and Electric Company.

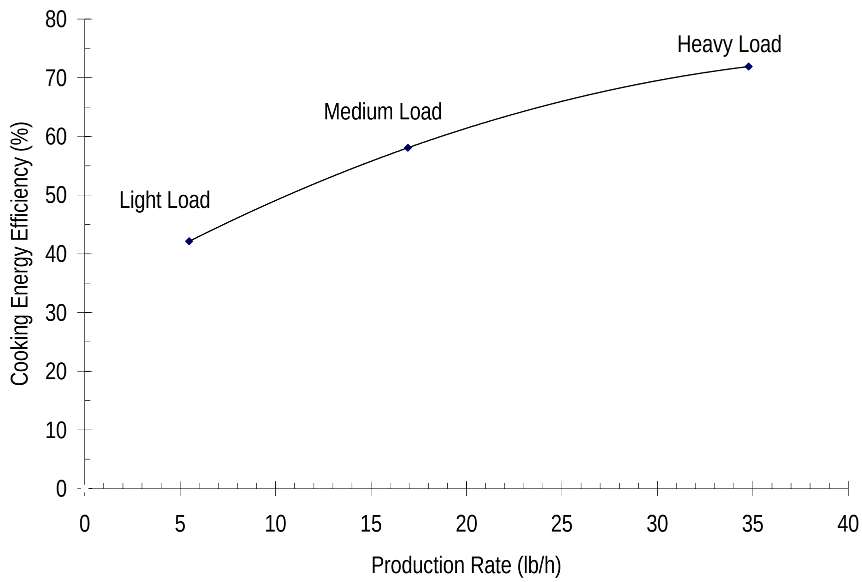

Figure ES-1.

Griddle part-load cooking energy efficiency.

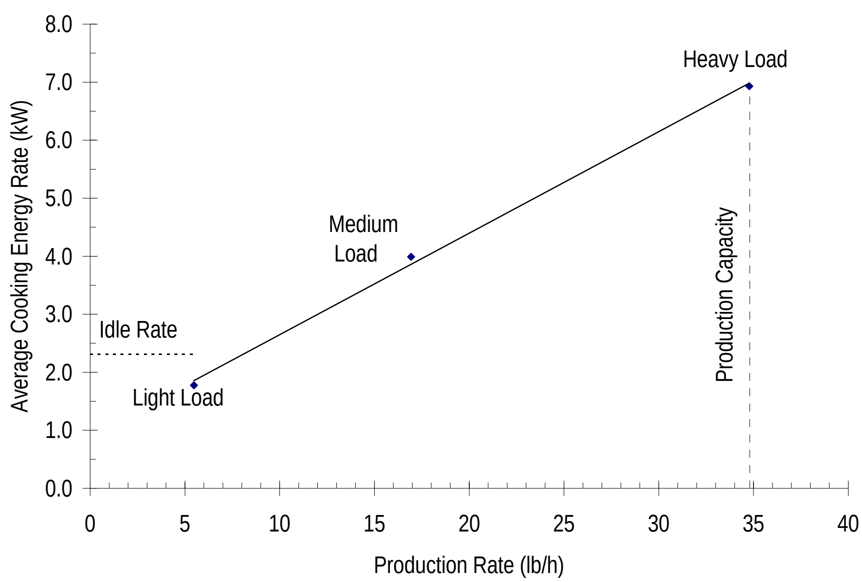

Figure ES-2.

Griddle cooking energy consumption profile.

Note: The heavy-load and idle tests were conducted with all three sections heated to 375°F, the medium-load test was conducted with two sections heated. Because the light-load test was conducted with only one section heated, the light-load cooking energy rate may be lower than the griddle's idle rate.

Executive Summary

The Toastmaster griddle's strongest feature, however, is its remarkable temperature uniformity. While a temperature spread of 70°F or more across the cooking surface is not uncommon among griddles, the Accu-Miser spreads heat more evenly and thereby reduces the impact of hot spots and temperature falloff around the edges. The maximum temperature difference on this griddle's surface is 47°F from the corner of the plate to the center; therefore, this griddle will cook more uniformly when fully-loaded than other griddles tested.[2]

This griddle's high cooking energy efficiency, quick preheat, and uniform cooking surface make it an excellent option for short-order applications with varying load sizes.

FSTC Manager ____________________
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1 Introduction

Background

Griddles are used throughout the hospitality industry to prepare a variety of menu items such as pancakes and hamburgers. An operator shopping for a new griddle looks for energy usage, uniformity of cooking surface temperature, and amount of food that can be cooked in a given period of time.

The infrared heat panels spread heat over a larger surface than standard elements.

With support from the Electric Power Research Institute (EPRI), the Gas Research Institute (GRI), and the National Restaurant Association, PG&E's Food Service Technology Center (FSTC) developed a uniform testing procedure to evaluate the performance of gas and electric griddles. This test procedure was submitted to the American Society for Testing and Materials (ASTM), and it was accepted as a standard test method (Designation F 1275-90) in January 1990.[1] PG&E's *Development and Application of a Uniform Testing Procedure for Griddles* documents the developmental procedures and test results of several gas and electric griddles.[2]

In keeping with ASTM's policy that a document be periodically reviewed, the FSTC re-evaluated the griddle test method and suggested various simplifications. The test method was subsequently updated in 1995 (*new* Designation F 1275-95). Other PG&E reports document results of applying the revised version of the ASTM test method and discuss the scope of these revisions.[3,4]

Toastmaster developed the Accu-Miser griddle with infrared heat panels. These panels spread heat over a larger surface than standard elements, allowing the griddle to perform the same amount of work with a lower input rating. The Toastmaster Accu-Miser 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.

Introduction

Objectives

The objective of this report is to examine the operation and performance of the Toastmaster electric griddle, model AM36SS, 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.

Appliance Description

The Toastmaster griddle is powered by three 12-inch infrared heat panels. These heat panels route electricity through a filament wound back and forth through a ceramic composite block. A 1/8-inch aluminum plate is sandwiched between the heat panels and a 3/8-inch-thick steel cooking surface to further distribute heat.

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

Table 1-1. Appliance Specifications.

Manufacturer	Toastmaster
Model	AM36SS
Generic Appliance Type	Thermostatically Controlled Griddle
Rated Input	9.30 kW
Dimensions	36” x 28½” x 15”
Construction	3/8”-thick steel cooking surface bonded to a 1/8”-thick aluminum plate
Controls	Three operating zones, each controlled by a snap-acting thermostat adjustable from 150 to 450°F
Accessories	Stand with stainless steel bottom shelf

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, 35 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) were used for the remainder of the tests (see Figure 2-2).

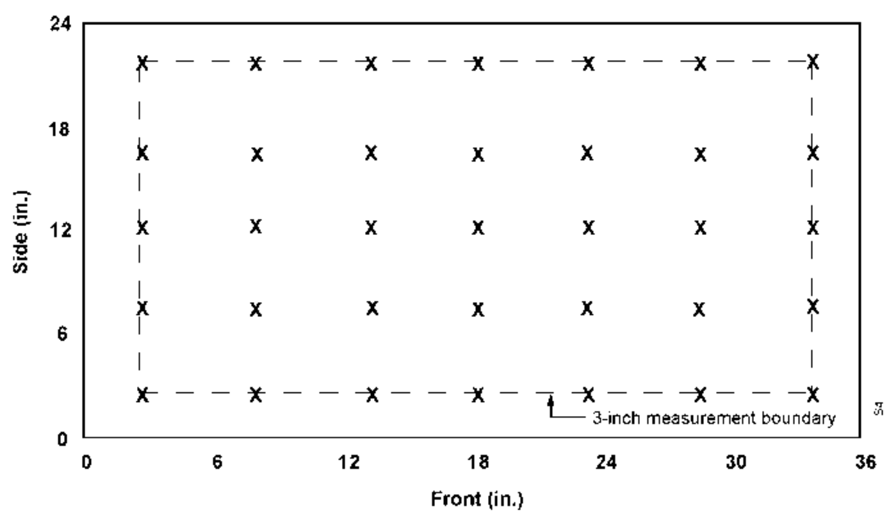

Figure 2-1. Thermocouple grid for temperature uniformity test.

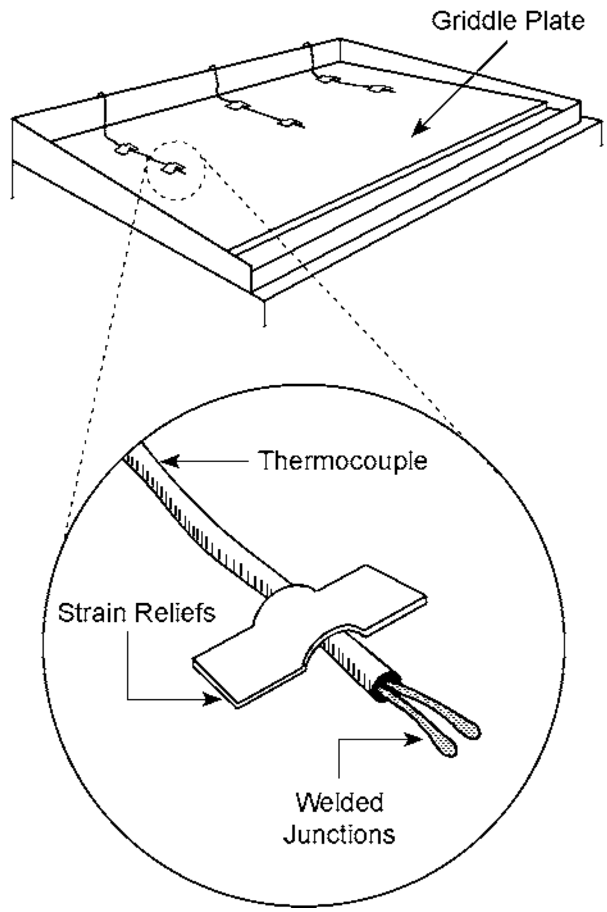

Figure 2-2.
Thermocouple placement for testing.

Power and energy were measured with a Watt/Watt-hour transducer that generated an analog signal for instantaneous power and a pulse for every 10 Wh. The transducer and thermocouples were connected to an automated data acquisition unit that recorded data every 5 seconds. A voltage regulator was connected to the griddle to maintain a constant voltage for all tests.

Measured Energy Input Rate

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

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 patties (heavy load), 12 patties (medium load), and 4 patties (light load).

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’s reaching a threshold temperature of 365°F (measured at the center of each linear foot of griddle plate). Reloading within 10°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, 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 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 energy input rate was 9.27 kW (a difference of 0.3% from the nameplate rating).

Temperature Uniformity

Thermocouples were welded to the cooking surface directly above the thermostat sensing probes to facilitate temperature calibration. The thermostat controls were 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 controls to maintain an average of 375 ± 5°F on the cooking surface directly above the thermostat probes.

To characterize the temperature profile of the cooking surface at 375°F, researchers welded additional thermocouples to the cooking surface in a 35-point grid with approximately 5 inches between points. Griddle temperatures were monitored for one hour after the cooking surface had stabilized at a calibrated 375°F. Table 3-1 lists the thermostat settings required to maintain the cooking surface at 375°F and the maximum temperature difference across the griddle plate. The temperature sensing points and resulting profile are illustrated in Figures 3-1 and 3-2, respectively.

Table 3-1. Temperature Uniformity and Thermostat Accuracy.

Left Thermostat Setting (°F)	370
Center Thermostat Setting (°F)	365
Right Thermostat Setting (°F)	380
Maximum Temperature Difference Across Plate (°F)	46

Note: Thermostat accuracy is the thermostat setting required to maintain 375 ± 5°F on the cooking surface.

Results

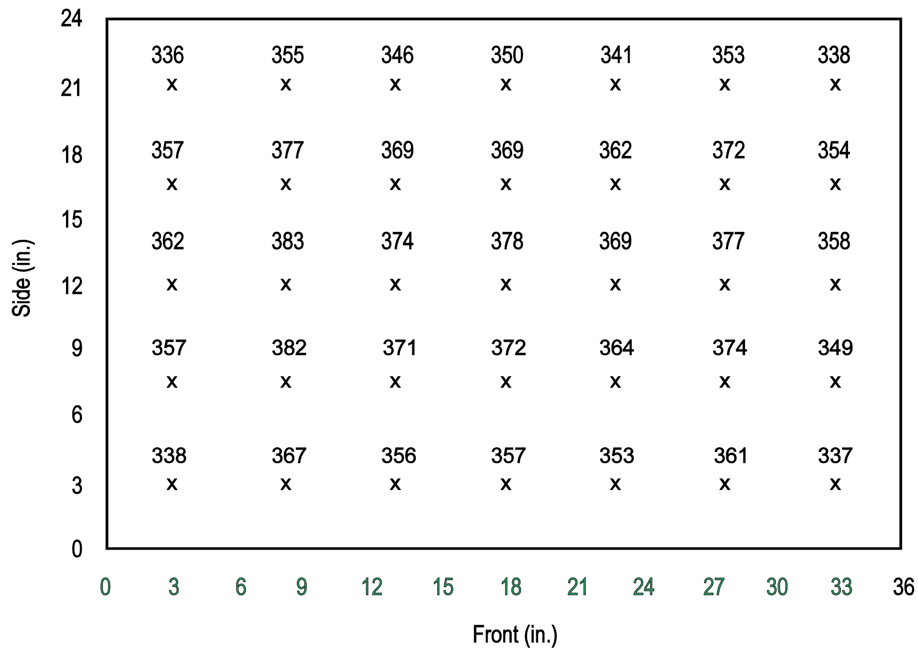

Figure 3-1.
Temperature sensing points on the griddle surface.

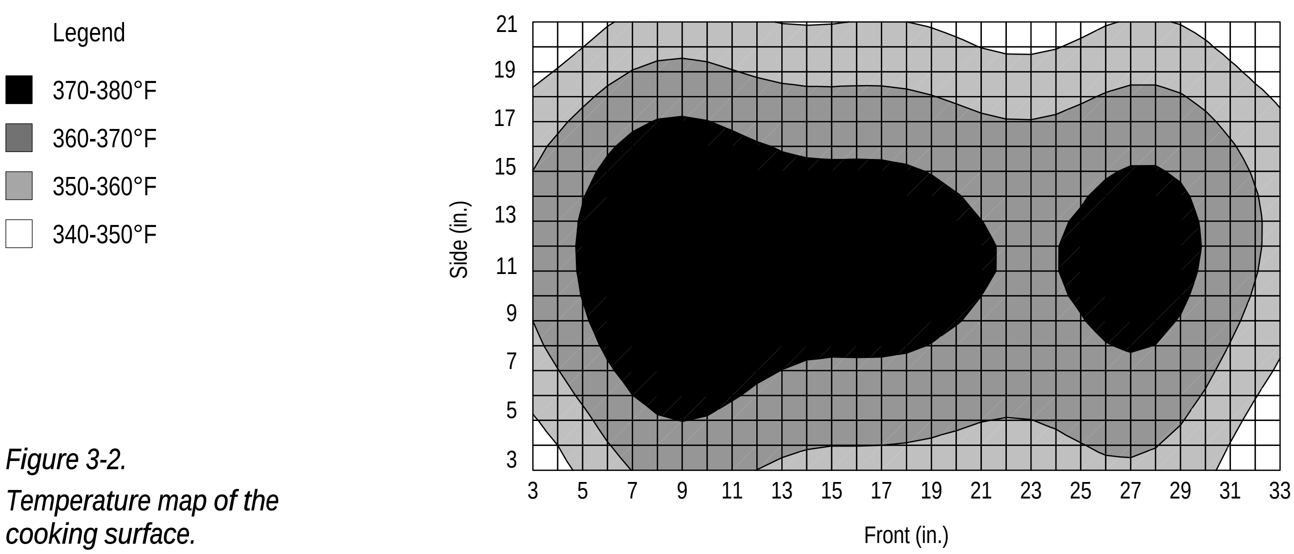

Figure 3-2.
Temperature map of the cooking surface.

Preheat and Idle Tests

Preheat Energy and Time

Researchers removed the additional thermocouples, leaving only the points above the thermostat probes. The cooking surface temperature was an average of 72°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 1.72 kWh and 11.6 minutes. Figure 3-3 shows the energy consumption rate in conjunction with the cooking surface temperature during the preheat test.

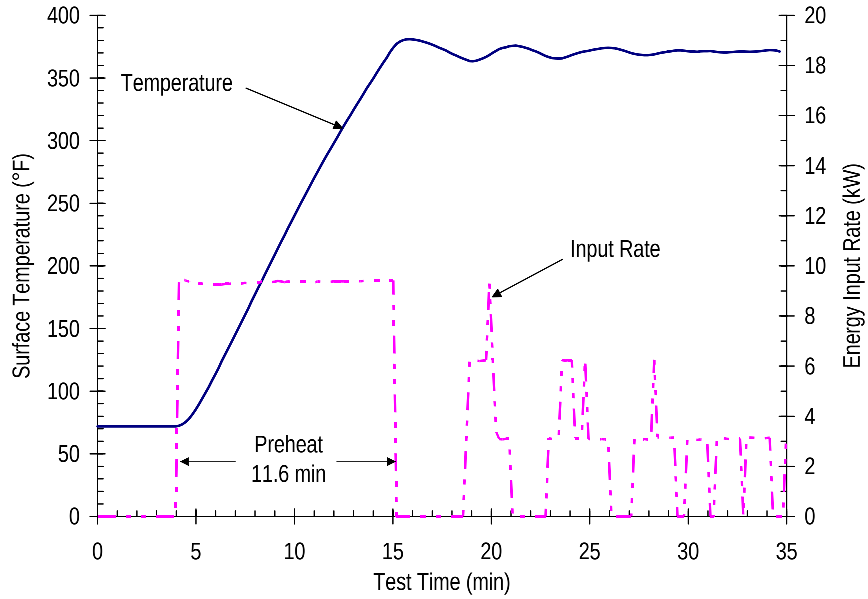

Figure 3-3.
Preheat characteristics.

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 2.31 kW.

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 (kW)	9.30
Measured Energy Input Rate (kW)	9.27
Preheat	
Time to 375°F (min)	11.60
Energy (kWh)	1.72
Rate to 375°F (°F/min)	27
Idle Energy Rate @ 375°F (kW)	2.31

Cooking Tests

The griddle was tested under three loading scenarios: heavy (24 hamburger patties), medium (12 hamburger patties), and light (4 hamburger patties). 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 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. The hamburgers used for the heavy-load tests consisted of 20% fat and approximately 60% moisture, as specified by the ASTM procedure. Figures 3-4 and 3-5 show the cooking surface temperatures 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.

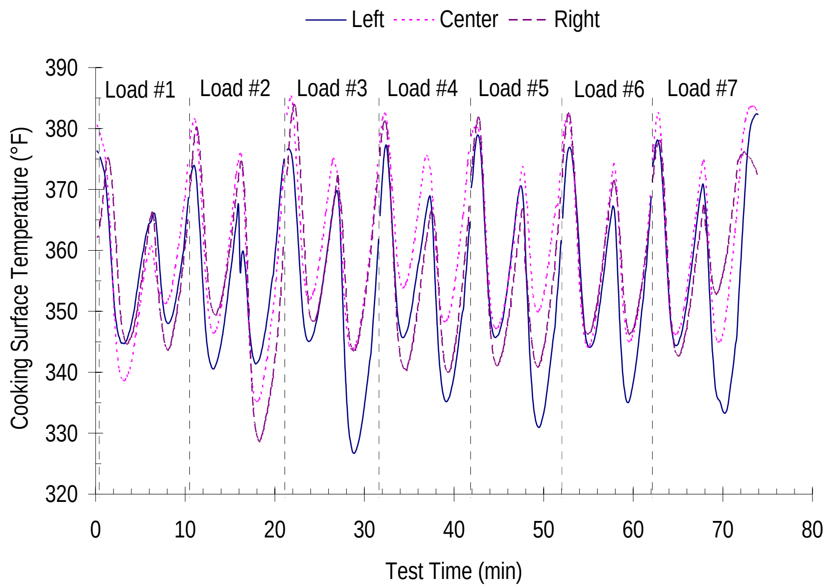

Figure 3-4.
Cooking surface temperatures during a heavy-load test.

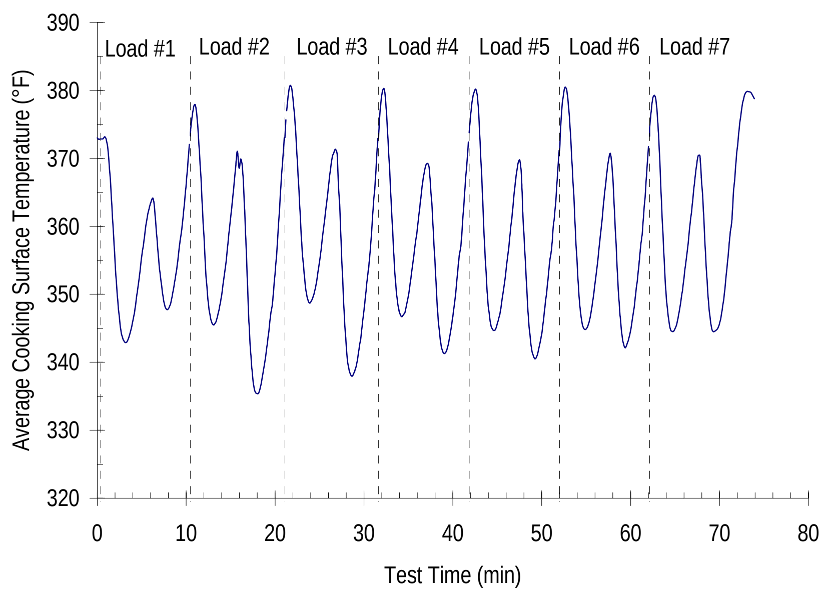

Figure 3-5.
Average cooking surface temperature during a heavy-load test.

Figure 3-6 illustrates the griddle's temperature response while a heavy load of frozen hamburger patties was cooked. The heavy-load cooking energy efficiency was 71.9%, and the production capacity was 34.8 pounds per hour.

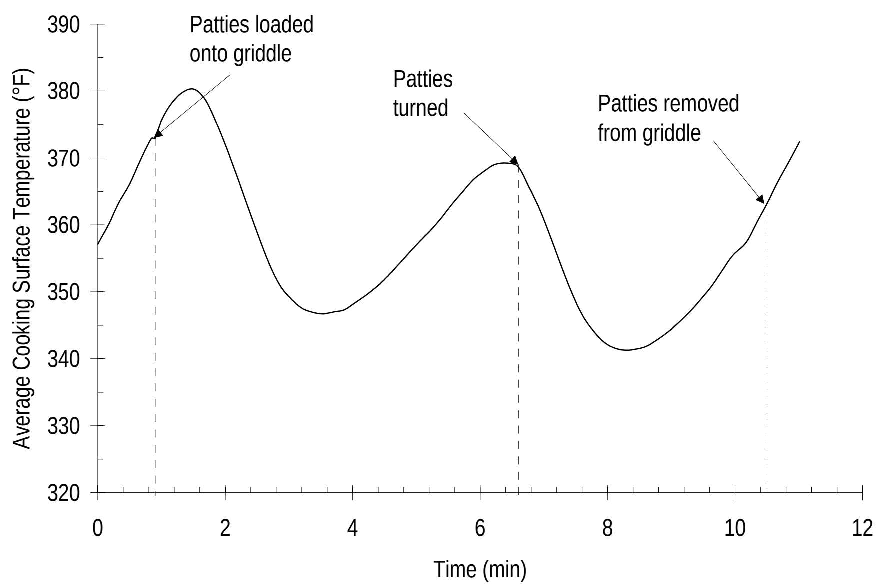

Figure 3-6.
Average griddle temperature while cooking a heavy load.

Medium- and Light-Load Tests

Medium- and light-load tests represent a more typical usage pattern for the griddle. Since a griddle is seldom fully loaded, these part-load efficiencies can be used to estimate griddle performance in an actual operation.

The medium-load tests were conducted on two of the three griddle sections (the third section was not heated); the light-load tests were conducted on only one section (the remaining two sections were not heated). Hamburgers with 19% fat[a] were cooked on the griddle's left-hand side for both sets of tests. Cooking energy efficiencies at 5.5 and 16.9 pounds per hour were 42.1% and 58.1%, respectively.

[a] The ASTM test method specifies 20 ± 2% fat content for hamburger patties.

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 73.1%, 71.0%, and 71.5%, yielding a maximum uncertainty of 3.8% in the test results. Table 3-3 presents the results of the cooking energy and production capacity tests. Figure 3-7 illustrates griddle cooking energy efficiency for different production rates. Griddle production rate is a function of both the hamburger patty cook time and the cooking surface recovery time. Part-load efficiency rapidly drops off at production rates lower than 5 pounds per hour. Appendix D contains a synopsis of test data for each replicate of the cooking tests.

Figure 3-8 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 daily energy consumption for the griddle in a real-world operation. Average energy consumption rates at 10, 20, and 30 pounds per hour are 2.65 kW, 4.40 kW, and 6.15 kW, respectively.

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

	Heavy Load	Medium Load	Light Load
Hamburger Patty Cook Time (min)	9.50	10.25	10.75
Average Recovery Time (sec)	51	21	11
Production Rate (lb/h)	34.8	16.9	5.5
Energy Consumption (Wh/lb)	199	235	1,948
Cooking Energy Rate (kW)	6.93	3.99	1.78
Cooking Energy Efficiency (%)	71.9	58.1	42.1

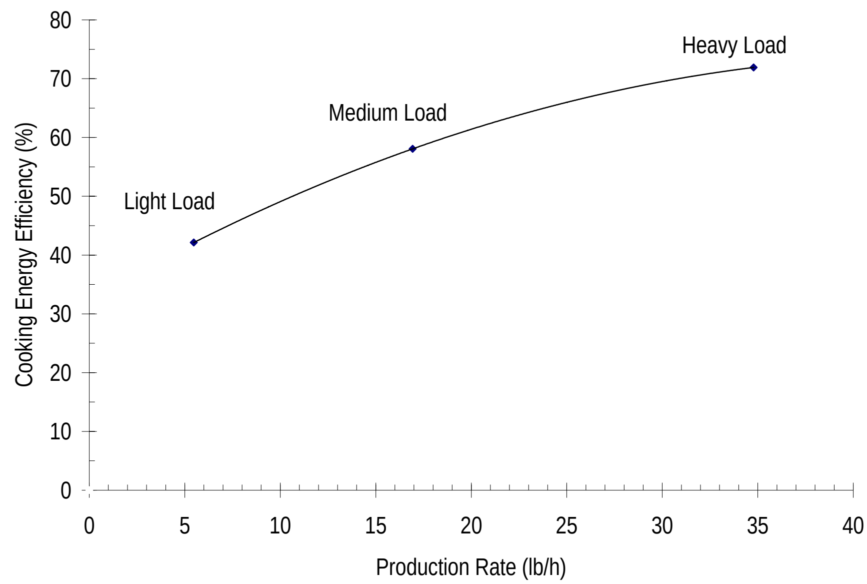

Figure 3-7.
Griddle part-load cooking energy efficiency.

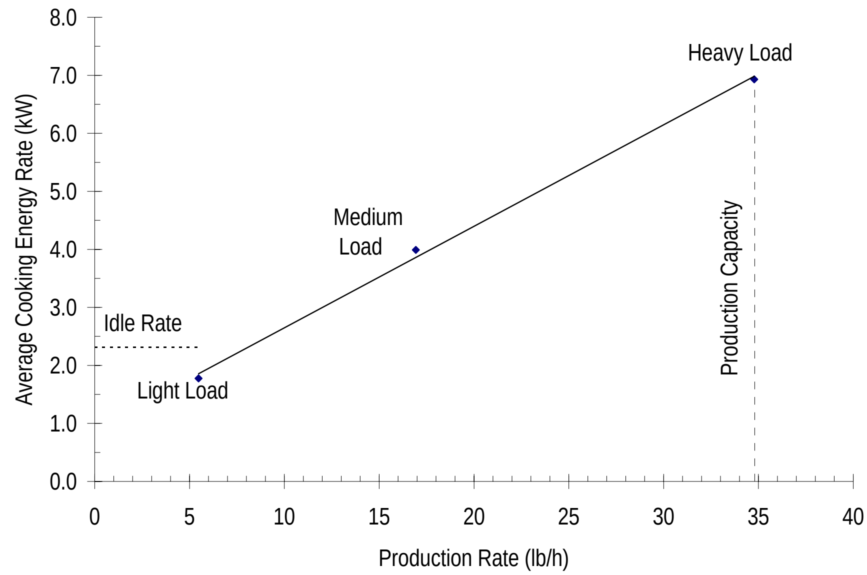

Figure 3-8.

Griddle cooking energy consumption profile.

Note: The heavy-load and idle tests were conducted with all three sections heated to 375°F, the medium-load test was conducted with two sections heated. Because the light-load test was conducted with only one section heated, the light-load cooking energy rate may be lower than the griddle's idle rate.

4 Conclusions

Its 71.9% heavy-load efficiency is the highest for any griddle tested to date.

The Toastmaster model AM36SS griddle performed well under the rigorous conditions of the ASTM standard test method. Its 71.9% heavy-load efficiency is the highest for any griddle tested to date at the Food Service Technology Center, and its production capacity (34.8 pounds per hour) compares well with other griddles.[2,3,4] The griddle's quick preheat (11.6 minutes) required half as much energy and 37% less time than other electric griddles.[2] This capability would allow unneeded sections to be turned off during slow periods while recovering quickly enough to meet sudden demands.

The high cooking energy efficiency is supported by a low cooking energy rate under all loading scenarios (heavy, medium, and light). In fact, this griddle's energy consumption rate under load is 11 to 17% lower than the average electric griddle.[2]

The Toastmaster griddle's strongest feature, however, is its remarkable temperature uniformity. While a temperature spread of 70°F or more across the cooking surface is not uncommon among griddles, the Accu-Miser spreads heat more evenly and thereby reduces the impact of hot spots and temperature falloff around the edges. The maximum temperature difference on this griddle's surface is 47°F from the corner of the plate to the center; therefore, this griddle will cook more uniformly when fully-loaded than other griddles tested.[2,3,4]

This griddle's high cooking energy efficiency, quick preheat, and uniform cooking surface make it an excellent option for short-order applications of varying load. Evaluation of this griddle in the real-world setting of PG&E's production-test kitchen was recommended and implemented.[5]

5 References

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

2. Pacific Gas and Electric Company. 1989. *Development and Application of a Uniform Testing Procedure for Griddles.* Report 008.1-89.2 prepared for Research and Development. San Ramon, California: Pacific Gas and Electric Company.

3. Food Service Technology Center. 1993. *U.S. Range Model RGTA-2436-1 Gas Griddle Application of ASTM Standard Test Method.* Report 5017.93.1 prepared for Products and Services Department. San Francisco: Pacific Gas and Electric Company.

4. Food Service Technology Center. 1993. *Keating MIRACLEAN Model 36 x 30 IBLD Gas Griddle: Application of ASTM Standard Test Method F 1275-90.* Report 5017.93.3 prepared for Products and Services Department. San Francisco: Pacific Gas and Electric Company

5. Food Service Technology Center. In progress. *Toastmaster Accu-Miser, Model AM36SS Electric Griddle In-Kitchen Appliance Performance.* Prepared for Products and Services Department. San Francisco: Pacific Gas and Electric Company.

Appendixes

A Glossary

Cooking Energy (kWh or kBtu)

The total energy consumed by an appliance as it is used to cook a specified food product.

Cooking Energy Consumption Rate (kW or kBtu/h)

The average rate of energy consumption during the cooking period.

Cooking Energy Efficiency (%)

The quantity of energy input to the food products; expressed as a percentage of the quantity of energy input to the appliance during the heavy-, medium-, and light-load tests.

Duty Cycle (%)
Load Factor

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

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

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

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

Heating Value (Btu/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 “idling” or “holding” at 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 "preheat" 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 fry baskets from the fryer until the frying medium is within 10°F of the thermostat set point and the fryer is ready to be reloaded.

Test Method

A definitive procedure for the identification, measurement, and evaluation of one or more qualities, characteristics, or properties of a material, product, system, or service that produces a test result.

B Appliance Specifications

Appendix B includes the product literature for the Toastmaster Accu-Miser griddle

C Results Reporting Sheets

Manufacturer: Toastmaster
Model: Accu-Miser AM36SS
Date: August 1995

Section 11.1 Test Griddle

Description of operational characteristics: Three operating zones, each with solid-state, snap-acting thermostats controlling infrared heat panels. The 12-inch panels heat a 1/8-inch aluminum plate that is bonded to the 3/8-inch thick steel cooking surface.

Section 11.2 Apparatus

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

Deviations: None.

Section 11.4 Energy Input Rate

Test Voltage	208.0 V
Measured	9.27 kW
Rated	9.30 kW
Percent Difference between Measured and Rated	0.33%

Section 11.5 Temperature Uniformity and Thermostat Accuracy

Thermostat settings required to maintain 375°F cooking surface temperature (from left):

Thermostat #1	370°F
Thermostat #2	365°F
Thermostat #3	380°F
Maximum Temperature Difference	47°F

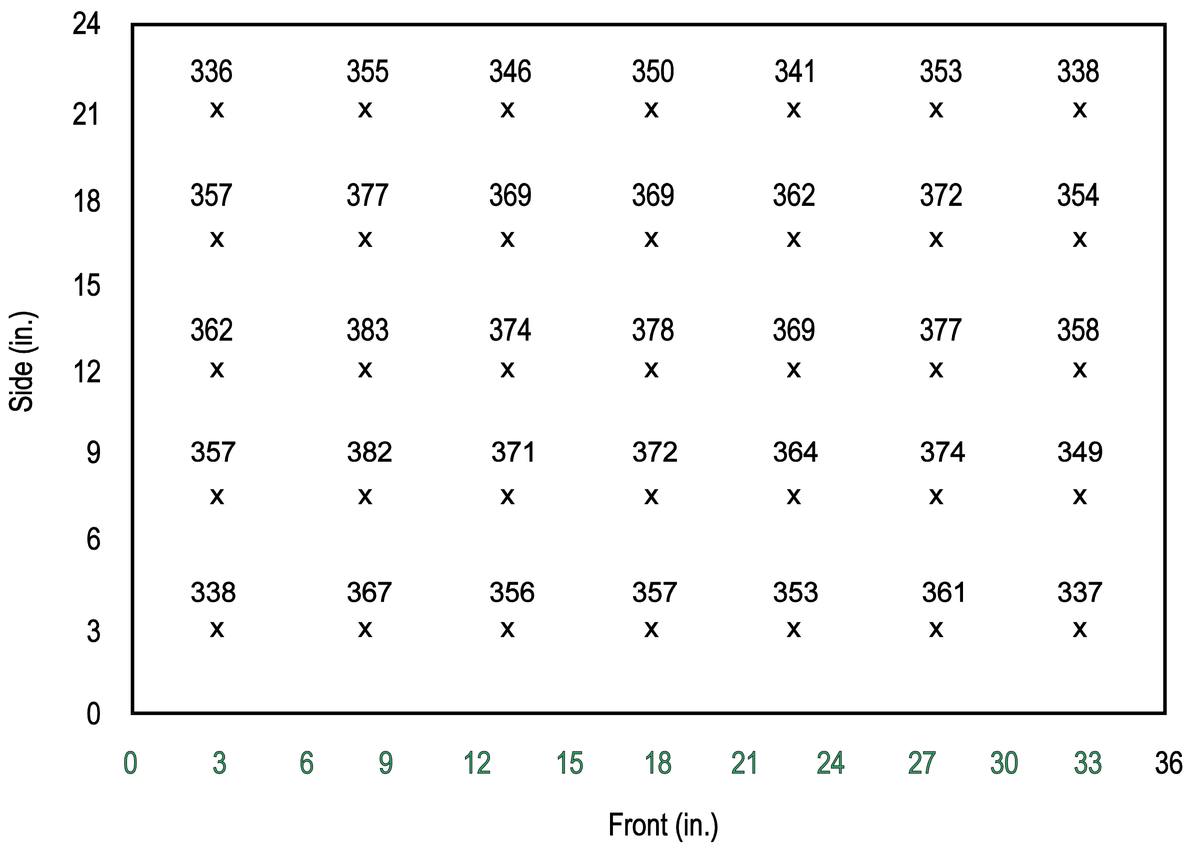

Figure C-1. Average cooking surface temperatures.

Section 11.6 Preheat Energy and Time

Test Voltage	208.6 V
Starting Temperature	72°F
Energy Consumption	1.72 kWh
Duration	11.6 min
Preheat Rate	27 °F/min

Section 11.7 Idle Energy Rate

Test Voltage	208.8 V
Idle Energy Rate @ 375°F	2.31 kW

Section 11.9 Cooking Energy Efficiency and Cooking Energy Rate

Heavy Load:

Test Voltage	208.0 V
Cooking Time	9.5 min
Average Cooking Surface Recovery Time	0.85 min
Production Capacity	34.8 ± 0.7 lb/h
Energy to Food	489 Btu/lb
Cooking Energy Rate	6.93 kW
Energy per Pound of Food Cooked	199 Wh/lb
Cooking Energy Efficiency	71.9 ± 2.7%

Medium Load:

Test Voltage	209.1 V
Cooking Time	10.25 min
Average Cooking Surface Recovery Time	0.35 min
Production Capacity	16.9 lb/h
Energy to Food	467 Btu/lb
Cooking Energy Rate	3.99 kW
Energy per Pound of Food Cooked	235 Wh/lb
Cooking Energy Efficiency	58.1 ± 2.7%

Light Load:

Test Voltage	209.4 V
Cooking Time	10.75 min
Average Cooking Surface Recovery Time	0.19 min
Production Capacity	5.5 lb/h
Energy to Food	467 Btu/lb
Cooking Energy Rate	1.78 kW
Energy per Pound of Food Cooked	1948 Wh/lb
Cooking Energy Efficiency	42.2 ± 3.4%

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

Table D-2. Heavy-Load Test Data.

	Repitition #1	Repitition #2	Repitition #3
Measured Values			
Total Energy (kWh)	7.15	7.19	7.17
Cook Time (min)	9.5	9.5	9.5
Total Test Time (min)	62.6	61.8	61.7
Weight Loss (%)	35.0	35.0	35.5
Initial Weight (lb)	36.0	36.0	36.0
Final Weight (lb)	23.4	23.4	23.2
Initial Fat Content (%)	20.2	20.2	20.2
Initial Moisture Content (%)	59.8	59.8	59.8
Final Moisture Content (%)	45.2	47.1	47.3
Initial Temperature (°F)	3.3	2.4	2.5
Final Temperature (°F)	163	163	164
Calculated Values			
Initial Weight of Water (lb)	21.5	21.5	21.5
Final Weight of Water (lb)	10.6	11.0	11.0
Weight of Fat (lb)	7.3	7.3	7.3
Weight of Solids (lb)	7.2	7.2	7.2
Sensible to Ice (Btu)	309	318	317
Sensible to Water (Btu)	2,812	2,814	2,842
Sensible to Fat (Btu)	463	466	470
Sensible to Solids (Btu)	229	231	233
Latent - Water Fusion (Btu)	3,098	3,098	3,098
Latent - Fat Fusion (Btu)	320	320	320
Latent - Water Vaporization (Btu)	10,617	10,186	10,223
Total Energy to Food (Btu)	17,850	17,435	17,504
Energy to Food (Btu/lb)	496	485	486
Total Energy to Griddle	24,403	24,539	24,471
Energy to Griddle (Btu/lb)	678	682	680
Cooking Energy Efficiency (%)	73.1	71.0	71.5
Cooking Energy Rate (kW)	6.85	6.97	6.97
Production Rate (lb/h)	34.5	34.9	35.0
Average Recovery Time (min)	0.9	0.8	0.8

Cooking Energy Efficiency Data

Table D-3. Medium-Load Test Data.

	Repitition #1	Repitition #2	Repitition #3
Measured Values			
Total Energy (kWh)	4.20	4.21	4.28
Cook Time (min)	10.25	10.25	10.25
Total Test Time (min)	64.2	63.7	63.0
Weight Loss (%)	34.4	35.2	34.4
Initial Weight (lb)	17.9	17.9	17.9
Final Weight (lb)	11.8	11.6	11.8
Initial Fat Content (%)	19.3	19.3	19.3
Initial Moisture Content (%)	60.7	60.7	60.7
Final Moisture Content (%)	51.2	50.9	51.6
Initial Temperature (°F)	1.5	1.5	1.5
Final Temperature (°F)	161	163	161
Calculated Values			
Initial Weight of Water (lb)	10.9	10.9	10.9
Final Weight of Water (lb)	6.0	5.9	6.1
Weight of Fat (lb)	3.5	3.5	3.5
Weight of Solids (lb)	3.6	3.6	3.6
Sensible to Ice (Btu)	166	166	166
Sensible to Water (Btu)	1,408	1,431	1,408
Sensible to Fat (Btu)	221	224	221
Sensible to Solids (Btu)	115	116	115
Latent - Water Fusion (Btu)	1,569	1,569	1,569
Latent - Fat Fusion (Btu)	152	152	152
Latent - Water Vaporization (Btu)	4,721	4,826	4,676
Total Energy to Food (Btu)	8,353	8,485	8,307
Energy to Food (Btu/lb)	465	473	463
Total Energy to Griddle	14,335	14,369	14,608
Energy to Griddle (Btu/lb)	798	800	814
Cooking Energy Efficiency (%)	58.3	59.1	56.9
Cooking Energy Rate (kW)	3.93	3.97	4.07
Production Rate (lb/h)	16.8	16.9	17.1
Average Recovery Time (min)	0.4	0.4	0.3

Cooking Energy Efficiency Data

Table D-4. Light-Load Test Data.

	Repitition #1	Repitition #2	Repitition #3
Measured Values			
Total Energy (kWh)	2.03	1.94	1.86
Cook Time (min)	10.75	10.75	10.75
Total Test Time (min)	65.6	65.6	65.6
Weight Loss (%)	35.5	34.7	34.2
Initial Weight (lb)	6.0	6.0	6.0
Final Weight (lb)	3.9	3.9	3.9
Initial Fat Content (%)	19.3	19.3	19.3
Initial Moisture Content (%)	60.7	60.7	60.7
Final Moisture Content (%)	51.6	50.9	51.9
Initial Temperature (°F)	1.5	1.5	1.5
Final Temperature (°F)	164	162	161
Calculated Values			
Initial Weight of Water (lb)	3.6	3.6	3.6
Final Weight of Water (lb)	2.0	2.0	2.0
Weight of Fat (lb)	1.2	1.2	1.2
Weight of Solids (lb)	1.2	1.2	1.2
Sensible to Ice (Btu)	55	55	55
Sensible to Water (Btu)	480	473	468
Sensible to Fat (Btu)	75	74	74
Sensible to Solids (Btu)	39	38	38
Latent - Water Fusion (Btu)	523	523	523
Latent - Fat Fusion (Btu)	51	51	51
Latent - Water Vaporization (Btu)	1,592	1,594	1,541
Total Energy to Food (Btu)	2,815	2,809	2,751
Energy to Food (Btu/lb)	470	469	460
Total Energy to Griddle	6,928	6,621	6,348
Energy to Griddle (Btu/lb)	1,158	1,106	1,061
Cooking Energy Efficiency (%)	40.6	42.4	43.3
Cooking Energy Rate (kW)	1.86	1.77	1.70
Production Rate (lb/h)	5.5	5.5	5.5
Average Recovery Time (min)	0.2	0.2	0.2

Cooking Energy Efficiency Data

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

	Cooking Energy Efficiency			Production Capacity
	Heavy Load	Medium Load	Light Load	
Replicate #1	73.1	58.3	40.6	34.5
Replicate #2	71.0	59.1	42.4	34.9
Replicate #3	71.5	56.9	43.3	35.0
Average	71.9	58.1	42.1	34.8
Standard Deviation	1.10	1.11	1.38	0.28
Absolute Uncertainty	2.72	2.75	3.41	0.69
Percent Uncertainty	3.79	4.73	8.09	1.99