AccuTemp, Model 2-3-14-208
Electric Griddle Performance Test

Application of ASTM Standard
Test Method F 1275-95

FSTC Report 5011.98.55

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California Café Restaurant Corp.

Fresh Choice, Inc.

Darden Restaurants, Inc.

Specific appreciation is extended to AccuTemp, for supplying the Food Service Technology Center with an electric griddle for controlled testing in the appliance laboratory.

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Executive Summary

Griddles are widely used throughout the hospitality industry to prepare a variety of menu items, from pancakes to hamburgers. As concern over food safety continues, griddle performance parameters such as temperature uniformity and productivity are becoming more important to the food service operator.

AccuTemp's revolutionary new electric griddle uses high temperature steam to evenly transfer heat to the cooking surface. Elements embedded in a sealed chamber containing water produce superheated steam. When the temperature of the cooking surface drops, steam immediately condenses along the cool spots. The condensing steam transfers the necessary heat to the cooking surface, thus maintaining temperature.

To support the market introduction of this new technology, Food Service Technology Center (FSTC) engineers tested the 3-foot, pre-production model 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 time for each of the loading scenarios was 7¾ minutes. Production capacity includes the cooking time and the time required to remove the cooked hamburger patties and

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[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.

scrape the cooking surface (reload time). Reload time 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:

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

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

Table ES-1. Summary of Griddle Performance.

Rated Energy Input Rate (kW)	14.00
Measured Energy Input Rate (kW)	13.96
Temperature Uniformity (°F) [a]	± 3.0
Preheat Time to 375°F (min)	19.6
Preheat Energy to 375°F (kWh)	4.56
Idle Energy Rate @ 375°F (kW)	2.80
Heavy-Load Cooking Energy Efficiency (%)	68.7 ± 1.6
Medium-Load Cooking Energy Efficiency (%)	51.9 ± 1.6
Light-Load Cooking Energy Efficiency (%)	25.8 ± 0.3
Production Capacity[b] (lb/h)	43.7 ± 0.5
Cooking Surface Recovery Time[b] (min)	< 0.5

[a]Temperature uniformity reflects the absolute temperature variance across the cooking surface to within 3 inches from each edge.

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

This griddle exhibited an extremely uniform cooking surface during testing—the maximum temperature difference across the griddle plate was only 6°F

(Figure ES-1). To determine if there was any significant falloff not measured by the ASTM test method, researchers attached additional thermocouples ½-inch from each of the four edges. Table ES-2 summarizes these edge temperatures along with the average griddle temperature during testing.

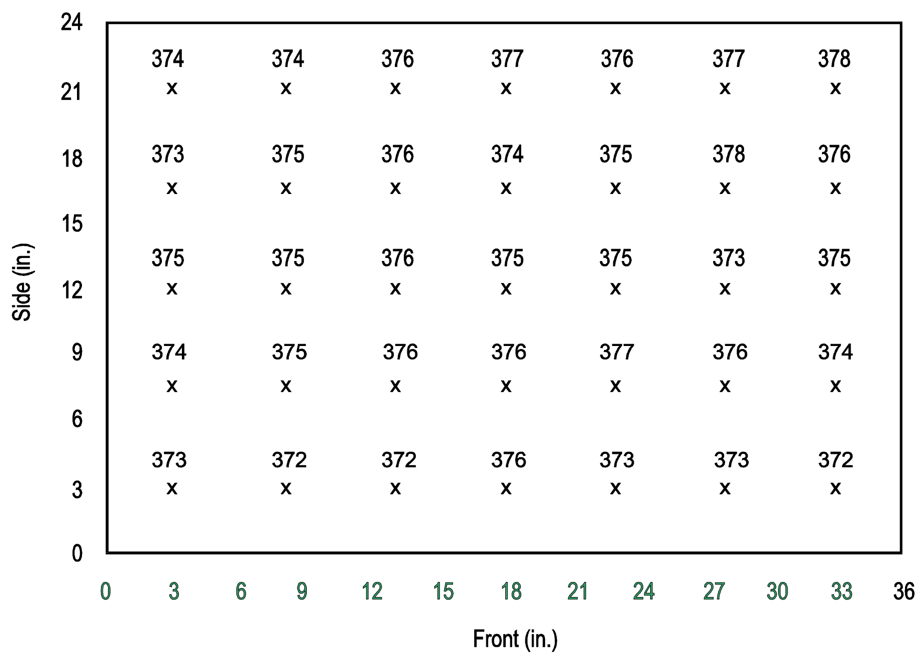

Figure ES-1. Griddle surface temperatures.

Table ES-2. Griddle Temperature Uniformity.

Average Surface Temperature (°F)	375
Front Edge[a] (°F)	376
Rear Edge[a] (°F)	375
Left Edge[a] (°F)	372
Right Edge[a] (°F)	374
Maximum Temperature Difference Across Plate (°F)	6

[a]Temperature within ½-inch from the outside edge of the cooking surface.

This dramatic temperature uniformity led researchers to attempt a series of maximum-load tests, with the cooking surface completely covered by frozen hamburger patties. Under these maximum-load conditions (35 hamburgers per load), the griddle's output increased from 43.7 pounds per hour to 59.9 pounds per hour—the same capacity as many 4-foot griddles. Table ES-3 compares the griddle's performance under the heavy- and maximum-load tests.

Table ES-3. Heavy- and Maximum-Load Test Results.

	Heavy Load	**Max Load**
Hamburger Patty Cook Time (min)	7.75	7.75
Average Recovery Time (sec)	< 30	< 60
Production Rate (lb/h)	43.7 ± 0.5	59.9 ± 1.5
Energy Consumption (Wh/lb)	189	173
Cooking Energy Rate (kW)	8.25	10.38
Cooking Energy Efficiency (%)	68.7 ± 1.6	75.9 ± 3.6

Figure ES-1 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 reloading 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 the daily energy consumption and probable demand for the griddle in a real-world operation. Average energy consumption rates at 10, 20, and 30 pounds per hour are 4.13 kW, 5.36 kW, and 6.59 kW, respectively. For an operation cooking an average of 20 pounds of food per hour over the course of the day (e.g., 200 pounds of food over a ten hour day), the probable demand contribution from this griddle would be 5.36 kW.

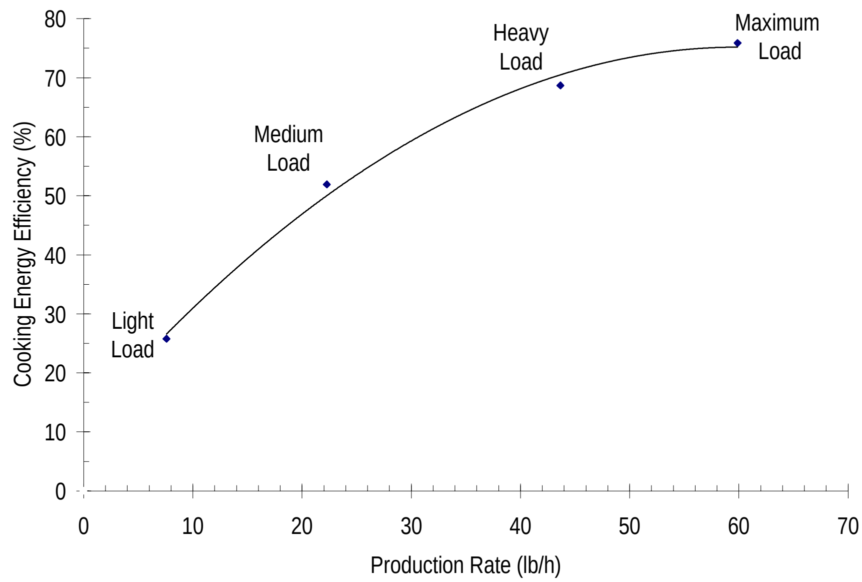

Figure ES-1.
Griddle part-load cooking energy efficiency.

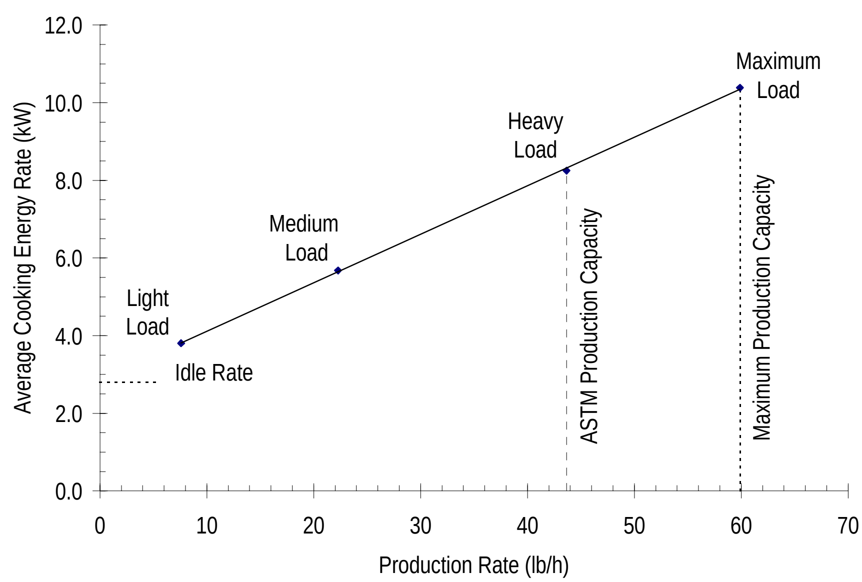

Figure ES-2.
Griddle cooking energy consumption profile.

Note: Since there was only one control, all tests were conducted with the entire griddle heated. Light-load = 4 hamburgers/load; medium-load = 12 hamburgers/load; heavy-load = 24 hamburgers/load; maximum-load = 35 hamburgers/load.

Executive Summary

The AccuTemp griddle exhibited a competitive cooking energy efficiency (68.7%), and its production capacity (43.7 pounds per hour per ASTM test method) was among the highest for any 3-foot griddle tested at the Food Service Technology Center. These results alone would be enough to commend this griddle, but its real highlight is its edge-to-edge uniformity. At ± 3°F anywhere across the cooking surface, this griddle has a tighter temperature across its entire breadth than other griddles have within a single section.[2]

The remarkable uniformity of the AccuTemp griddle, coupled with its strong performance under heavy-load conditions, make it an ideal selection for quick service and other high volume type restaurants.

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[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.

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.

AccuTemp's revolutionary new griddle uses high temperature steam to evenly transfer heat to the cooking surface.

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.[3,4,5]

AccuTemp's revolutionary new griddle uses high temperature steam to evenly transfer heat to the cooking surface. The heating unit is a sealed chamber filled with high temperature steam attached to the underside of the cooking surface. When the griddle calls for heat, steam condenses along the top of the sealed chamber, immediately transferring heat to the cooking surface. The AccuTemp electric "steam" griddle was tested according to the ASTM procedure, and this report documents the results.

Introduction

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 AccuTemp electric griddle, model 2-3-14-208, 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 AccuTemp griddle is powered by a sealed chamber containing high temperature steam, located directly beneath the griddle plate. Electric elements within the sealed chamber heat water and create superheated steam. This steam then condenses on the underside of the griddle plate, quickly transferring heat to the cooking surface.

Cooking temperatures from 200°F to 400°F are adjusted using a single solid state thermostat, located on the front panel. The griddle's construction is 1/8-inch thick stainless steel, which provides a durable, easy to clean cooking surface.

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

Table 1-1. Appliance Specifications.

Manufacturer	AccuTemp
Model	2-3-14-208, pre-production
Generic Appliance Type	Thermostatically Controlled Griddle
Rated Input	14.00 kW
Dimensions	36" x 32¾" x 13½"
Construction	1/8"-thick stainless steel
Controls	Single solid state temperature control adjustable from 200 to 400°F

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).

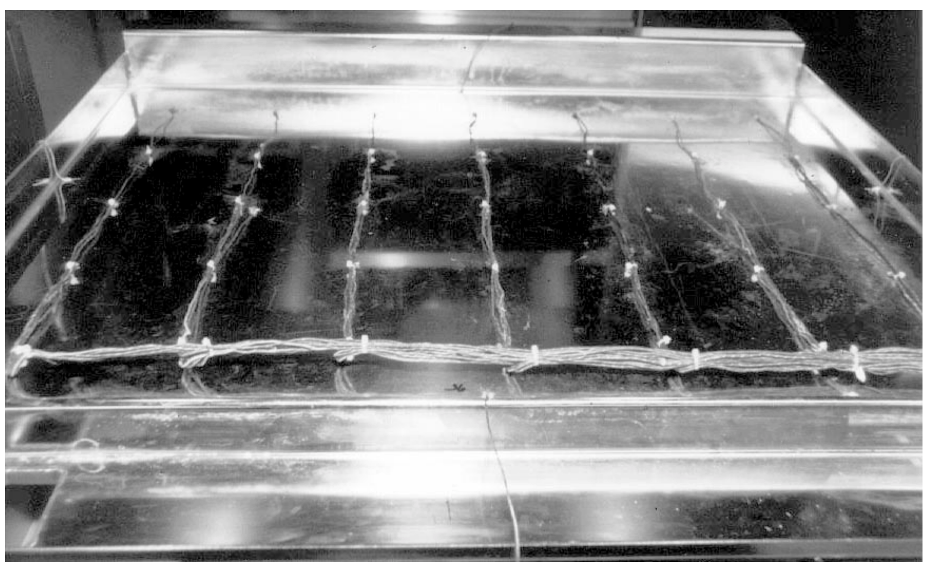

Figure 2-1. Thermocouple harness for measuring griddle temperature uniformity.

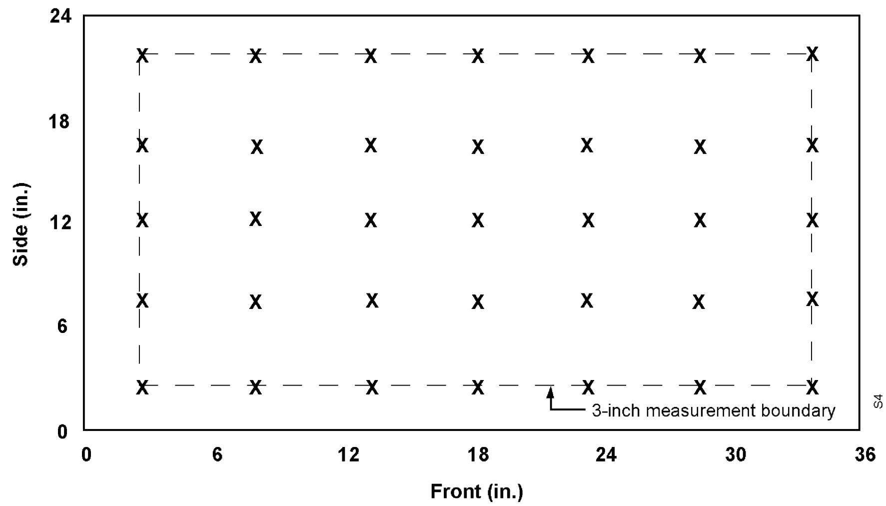

Figure 2-2.
Thermocouple grid for temperature uniformity test.

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).

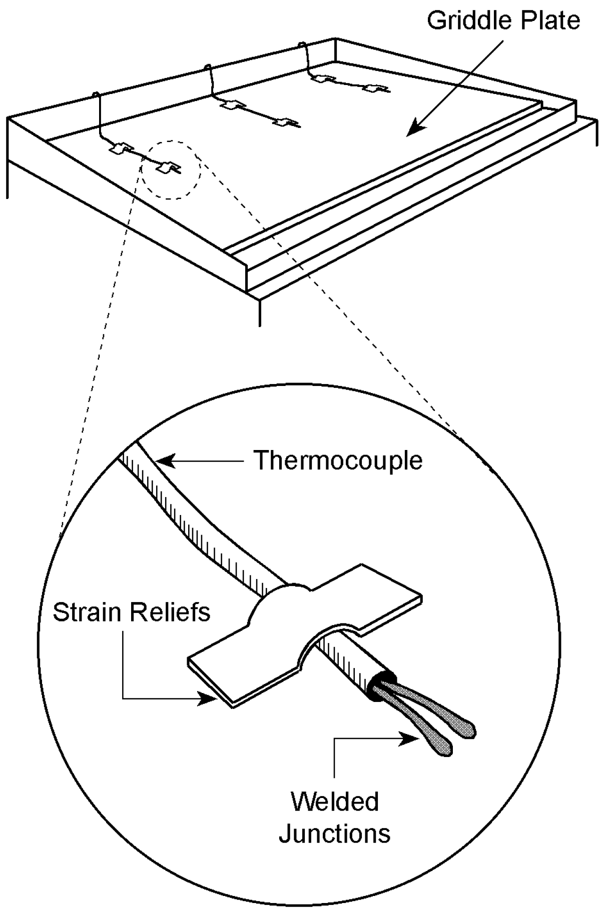

Figure 2-3.
Thermocouple placement for testing.

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 13.96 kW (a difference of 0.3% 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 35-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. The temperature sensing points and resulting profile are illustrated in Figures 3-1 and 3-2, respectively.

After examining the initial data, researchers welded additional thermocouples to the cooking surface, ½-inch from each edge, to further explore any potential temperature falloff. The results from these temperature uniformity tests are summarized in Table 3-1.

Results

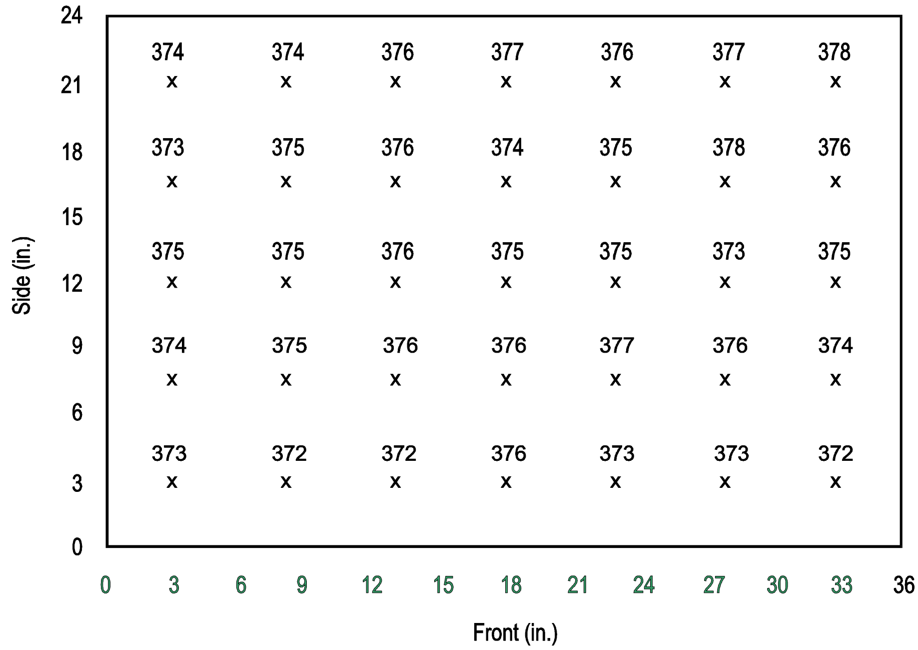

Figure 3-1.

Temperature sensing points on the griddle surface.

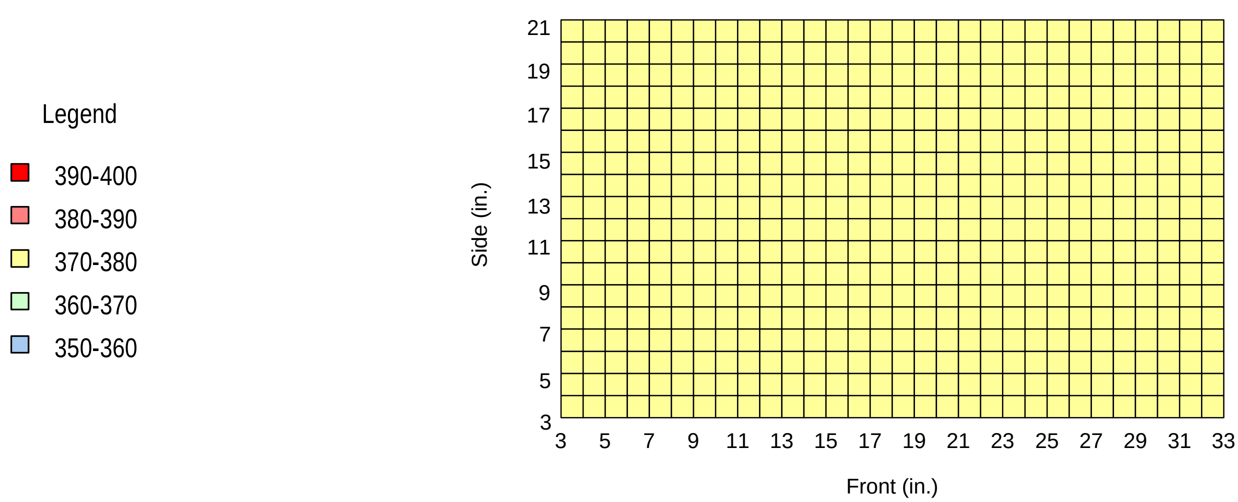

Figure 3-2.

Temperature map of the cooking surface.

Note: The entire cooking surface was within 370°F and 380°F.

Table 3-1. Temperature Uniformity and Thermostat Accuracy.

Thermostat Setting[a] (°F)	365
Average Surface Temperature (°F)	375
Front Edge[b] (°F)	376
Rear Edge[b] (°F)	375
Left Edge[b] (°F)	372
Right Edge[b] (°F)	374
Maximum Temperature Difference Across Plate (°F)	6
Standard Deviation of Surface Temperatures (°F)	2

[a]Thermostat accuracy is the thermostat setting required to maintain 375 ± 5°F on the cooking surface.
[b]Temperature within ½-inch from the outside edge of the cooking surface.

Preheat and Idle Tests

Preheat Energy and Time

Researchers removed the additional thermocouples, leaving only the points at the center of each linear foot. The cooking surface temperature was an average of 73°F at the outset of the preheat test. Researchers measured the energy consumption and time required to preheat the cooking surface to a calibrated 375°F. The griddle's preheat required 4.56 kWh and 19.6 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 2.80 kW.

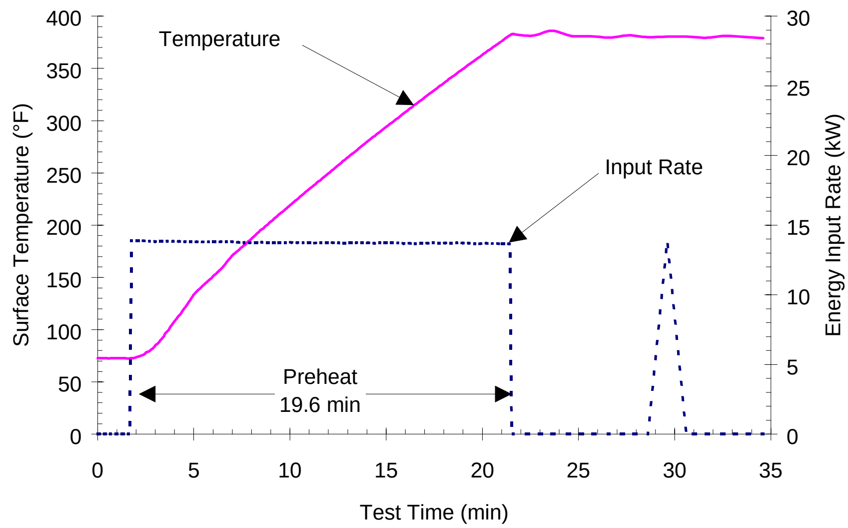

Figure 3-3.
Preheat characteristics.

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)	14.00
Measured Energy Input Rate (kW)	13.96
Preheat	
Time to 375°F (min)	19.60
Energy (kWh)	4.56
Rate to 375°F (°F/min)	15
Idle Energy Rate @ 375°F (kW)	2.80

Cooking Tests

Filling up the griddle increased the cooking energy efficiency by 10% and produced 35% more hamburgers.

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.

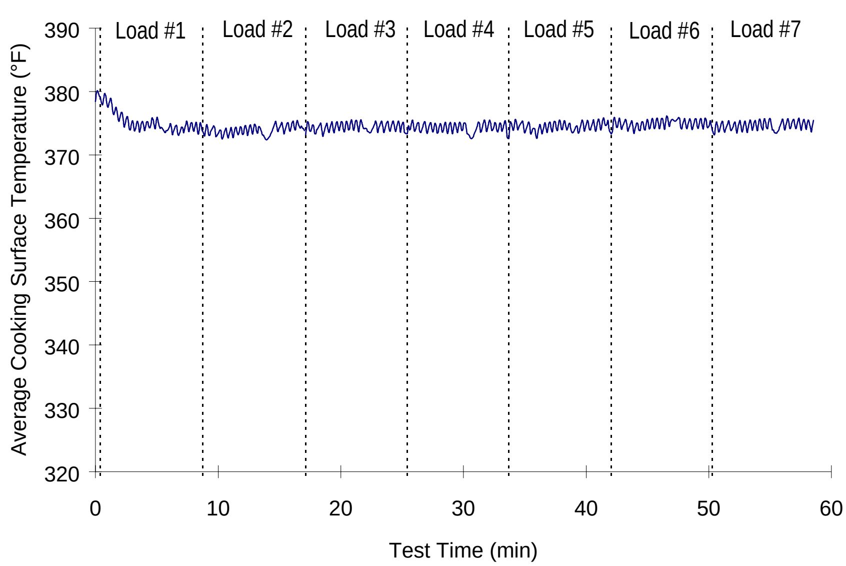

Figure 3-4. Average cooking surface temperature during a heavy-load test.

During the tests, researchers noticed that approximately 30% of the cooking surface remained unused (Figure 3-5). Since griddle was shown to maintain a 375°F cooking surface—edge-to-edge, researchers attempted a maximum-load test on the griddle by completely covering the cooking surface with hamburger patties. The 36" by 26" cooking surface allowed 35 hamburger patties to be cooked at a time.

Figure 3-5. Heavy-load cooking on the AccuTemp griddle.

The maximum-load tests showed enhanced performance over the ASTM heavy-load tests. Filling up the griddle increased the cooking energy efficiency by 10% (76.4% vs. 68.7%) and produced 35% more hamburgers (60 lb/h vs. 44 lb/h). Table 3-3 summarizes the test results for the heavy- and maximum-load tests.

Figure 3-6 illustrates the griddle's temperature response while a heavy load of frozen hamburger patties was cooked. Since the cooking surface temperature did not drop below 370°F at any point during the cooking test, the effective recovery time was zero. Production capacity includes the time required to remove the cooked hamburger patties and scrape the cooking surface (reload time). Reload time varies with the amount of food being cooked at one time.

Table 3-3. Heavy- and Maximum-Load Test Results.

	Heavy Load	Max Load
Hamburger Patty Cook Time (min)	7.75	7.75
Average Recovery Time (sec)	< 30	< 60
Production Rate (lb/h)	43.7 ± 0.5	59.9 ± 1.5
Energy Consumption (Wh/lb)	189	173
Cooking Energy Rate (kW)	8.25	10.38
Cooking Energy Efficiency (%)	68.7 ± 1.6	75.9 ± 3.6

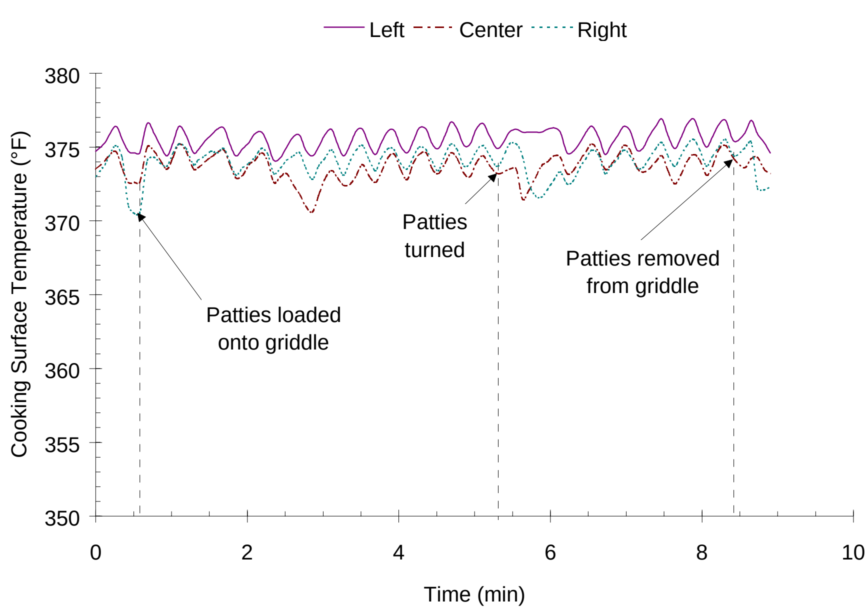

Figure 3-6.
Griddle temperatures while cooking a heavy load.

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 (only one thermostat), the energy consumed during these part-load tests includes radiant heat losses from the unused half of the griddle. Cooking energy efficiencies at 22.3 (medium) and 7.6 (light) pounds per hour were 51.9% and 25.8%, respectively.

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 69.4%, 68.1%, and 68.6%, yielding a maximum uncertainty of 2.4% in the test results. Table 3-4 summarizes the results of the ASTM cooking energy efficiency and production capacity tests.

Figure 3-7 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 reloading time. Appendix D contains a synopsis of test data for each replicate of the cooking tests.

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

	Heavy Load	Medium Load	Light Load
Hamburger Patty Cook Time (min)	7.75	7.75	7.75
Average Recovery Time (sec)	< 30	< 15	< 10
Production Rate (lb/h)	43.7 ± 0.5	22.3 ± 0.2	7.6 ± 0.1
Energy Consumption (Wh/lb)	189	255	501
Cooking Energy Rate (kW)	8.25	5.68	3.80
Cooking Energy Efficiency (%)	68.7± 1.6	51.9 ± 1.6	25.8 ± 0.3

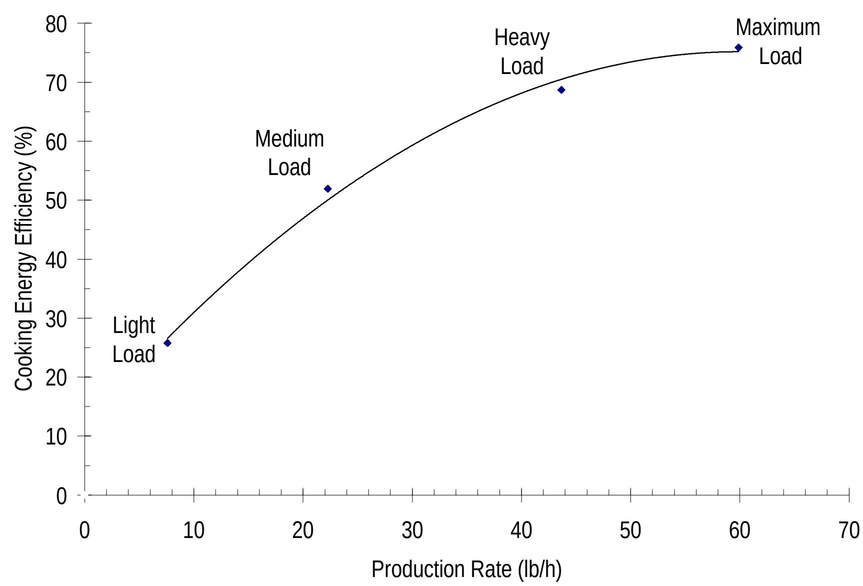

Figure 3-7.
Griddle part-load cooking energy efficiency.

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 the daily energy consumption and probable demand for the griddle in a real-world operation. Average energy consumption rates at 10, 20, and 30 pounds per hour are 4.13 kW, 5.36 kW, and 6.59 kW, respectively. For an operation cooking an average of 20 pounds of food per hour over the course of the day (e.g., 200 pounds of food over a ten hour day), the probable demand contribution from this griddle would be 5.36 kW.

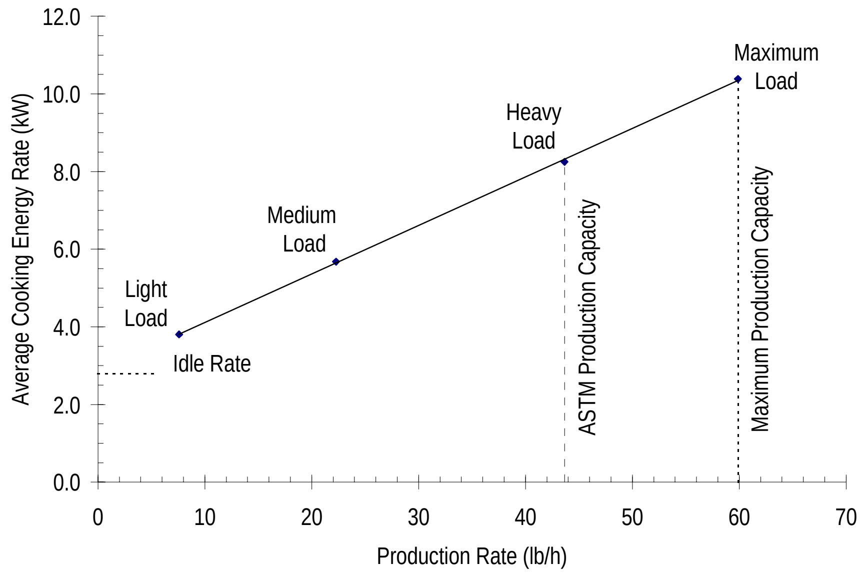

Figure 3-8. Griddle cooking energy consumption profile.

Note: Since there was only one control, all tests were conducted with the entire griddle heated. Light-load = 4 hamburgers/load; medium-load = 12 hamburgers/load; heavy-load = 24 hamburgers/load; maximum-load = 35 hamburgers/load.

4 Conclusions

The AccuTemp, model 2-3-14-208 electric griddle performed well under the rigorous conditions of the ASTM standard test method, particularly with respect to the heavy-load cooking tests. The griddle exhibited a competitive cooking energy efficiency (68.7%), and its production capacity (43.7 pounds per hour per ASTM test method) was among the highest for any 3-foot griddle tested at the Food Service Technology Center.[2,3,4,5]

This griddle has a tighter temperature across its entire breadth than other griddles have within a single section.

These results alone would be enough to commend this griddle, but its real highlight is its edge-to-edge uniformity. At ± 3°F anywhere across the cooking surface, this griddle has a tighter temperature across its entire breadth than other griddles have within a single section. In fact, this remarkable uniformity led researchers to run a series of maximum-load tests, with the cooking surface completely covered by frozen hamburger patties. Under these maximum-load conditions (35 hamburgers per load), the griddle's output increased from 43.7 lb/h to 59.9 lb/h—the same capacity as many 4-foot griddles.

Fully-loaded, this griddle registered an astounding 75.9% cooking energy efficiency. However, under part-load conditions the griddle uses more energy per pound than other electric griddles. This is partly because unused sections cannot be turned off and also due to the AccuTemp's somewhat higher idle energy rate (2.8 kW vs. 2.5 kW).[2,5]

Adding insulation around the sides of the heating unit would reduce the idle rate and improve upon part-load cooking energy efficiency. Additionally, short-order and cafeteria-style operations often turn one or more sections of a griddle off during slow periods to conserve energy. Dividing the heat source into 12 or 18-inch wide sections would provide operators with the greatest flexibility.

Conclusions

The remarkable uniformity of the AccuTemp griddle, coupled with its strong performance under heavy-load conditions, make it an ideal selection for quick service and other high volume type restaurants.

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.

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5. Food Service Technology Center. 1996. *Toastmaster Accu-Miser, Model AM36SS Electric Griddle Performance Test.* 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.

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

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 AccuTemp griddle.

Appliance Specifications

Appliance Specifications

Appliance Specifications.

Manufacturer	AccuTemp
Model	2-3-14-208, pre-production
Generic Appliance Type	Thermostatically Controlled Griddle
Rated Input	14.00 kW
Dimensions	36” x 32¾” x 13½”
Construction	1/8”-thick stainless steel
Controls	Single solid state temperature control adjustable from 200 to 400°F

C Results Reporting Sheets

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

Section 11.1 Test Griddle

Description of operational characteristics: Sealed chamber with high temperature steam underneath the griddle plate transmits heat to the cooking surface. A single dial controls the temperature of the griddle from 100 to 400°F. The griddle plate is 1/8-inch thick stainless steel, which provides a durable, easy to clean 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 V
Measured	13.96 kW
Rated	14.00 kW
Percent Difference between Measured and Rated	0.29%

Section 11.5 Temperature Uniformity and Thermostat Accuracy

Thermostat settings required to maintain 375°F cooking surface temperature:

Thermostat #1	365°F
Maximum Temperature Difference	6°F

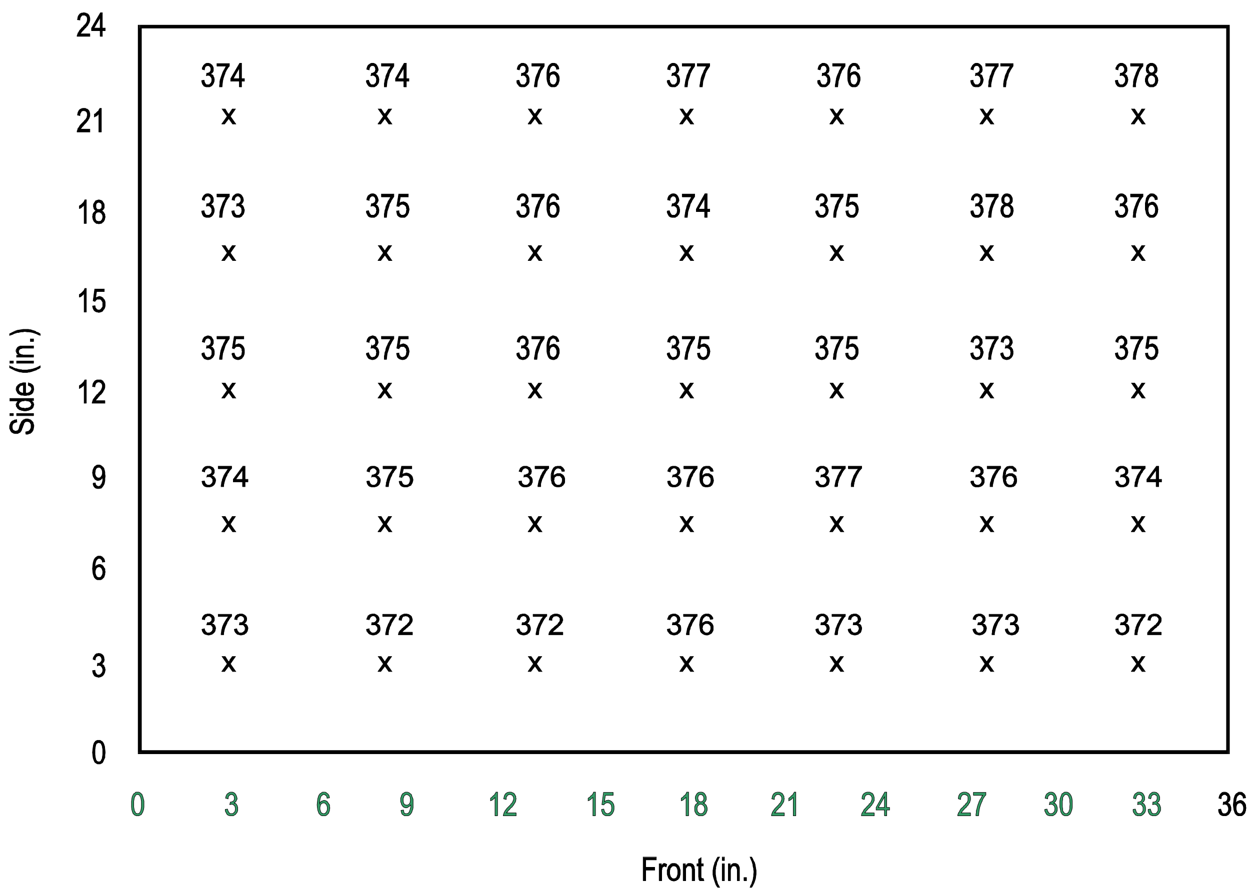

Figure C-1. Average cooking surface temperatures.

Section 11.6 Preheat Energy and Time

Test Voltage	208 V
Starting Temperature	73°F
Energy Consumption	4.56 kWh
Duration	19.6 min
Preheat Rate	15 °F/min

Results Reporting Sheets

Section 11.7 Idle Energy Rate

Test Voltage	208 V
Idle Energy Rate @ 375°F	2.80 kW

Section 11.9 Cooking Energy Efficiency and Cooking Energy Rate

Heavy Load:

Test Voltage	208 V
Cooking Time	7.75 min
Average Cooking Surface Recovery Time	< 0.5 min
Production Capacity	43.7 ± 0.5 lb/h
Energy to Food	443 Btu/lb
Cooking Energy Rate	8.25 kW
Energy per Pound of Food Cooked	645 Btu/lb
Cooking Energy Efficiency	68.7 ± 1.6%

Medium Load:

Test Voltage	208 V
Cooking Time	7.75 min
Average Cooking Surface Recovery Time	< 0.25 min
Production Capacity	22.3 ± 0.2 lb/h
Energy to Food	452 Btu/lb
Cooking Energy Rate	5.68 kW
Energy per Pound of Food Cooked	870 Btu/lb
Cooking Energy Efficiency	51.9 ± 1.6%

Light Load:

Test Voltage	208 V
Cooking Time	7.75 min
Average Cooking Surface Recovery Time	< 0.17 min
Production Capacity	7.6 ± 0.1 lb/h
Energy to Food	441 Btu/lb
Cooking Energy Rate	3.80 kW
Energy per Pound of Food Cooked	1,710 Btu/lb
Cooking Energy Efficiency	25.8 ± 0.3%

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
Measured Values			
Total Energy (kWh)	6.89	6.82	6.87
Cook Time (min)	**7.75**	**7.75**	**7.75**
Total Test Time (min)	50.2	49.7	49.8
Weight Loss (%)	34.2	33.6	34.4
Initial Weight (lb)	36.3	36.3	36.3
Final Weight (lb)	23.9	24.1	23.8
Initial Fat Content (%)	19.4	19.4	19.4
Initial Moisture Content (%)	60.6	60.6	60.6
Final Moisture Content (%)	53.5	54.9	54.6
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	161	159	161
Calculated Values			
Initial Weight of Water (lb)	22.0	22.0	22.0
Final Weight of Water (lb)	12.8	13.2	13.0
Weight of Fat (lb)	7.0	7.0	7.0
Weight of Solids (lb)	7.3	7.3	7.3
Sensible to Ice (Btu)	352	352	352
Sensible to Water (Btu)	2,838	2,794	2,838
Sensible to Fat (Btu)	454	448	454
Sensible to Solids (Btu)	234	231	234
Latent - Water Fusion (Btu)	3,168	3,169	3,170
Latent - Fat Fusion (Btu)	325	377	323
Latent - Water Vaporization (Btu)	8,946	8,946	8,946
Total Energy to Food (Btu)	16,316	16,316	16,316
Energy to Food (Btu/lb)	**449**	**449**	**449**
Total Energy to Griddle	23,516	23,277	23,447
Energy to Griddle (Btu/lb)	**648**	**641**	**646**
Cooking Energy Efficiency (%)	**69.4**	**68.1**	**68.6**
Cooking Energy Rate (kW)	**8.24**	**8.23**	**8.28**
Production Rate (lb/h)	**43.4**	**43.8**	**43.7**
Average Recovery Time (min)	**< 0.5**	**< 0.5**	**< 0.5**

Cooking Energy Efficiency Data

Table D-3. Maximum-Load Test Data.

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Total Energy (kWh)	9.16	8.94	9.21
Cook Time (min)	**7.75**	**7.75**	**7.75**
Total Test Time (min)	52.3	53.2	52.3
Weight Loss (%)	35.1	34.6	34.4
Initial Weight (lb)	52.5	52.5	52.5
Final Weight (lb)	34.1	34.3	34.4
Initial Fat Content (%)	20.0	20.0	20.0
Initial Moisture Content (%)	60.0	60.0	60.0
Final Moisture Content (%)	52.4	53.3	53.5
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	163	162	161
Calculated Values			
Initial Weight of Water (lb)	31.5	31.5	31.5
Final Weight of Water (lb)	17.9	18.3	18.4
Weight of Fat (lb)	10.5	10.5	10.5
Weight of Solids (lb)	10.5	10.5	10.5
Sensible to Ice (Btu)	504	504	504
Sensible to Water (Btu)	4,125	4,091	4,075
Sensible to Fat (Btu)	684	680	678
Sensible to Solids (Btu)	342	340	339
Latent - Water Fusion (Btu)	4,536	4,536	4,536
Latent - Fat Fusion (Btu)	504	504	504
Latent - Water Vaporization (Btu)	13,224	12,815	12,696
Total Energy to Food (Btu)	23,919	23,470	23,332
Energy to Food (Btu/lb)	**456**	**447**	**444**
Total Energy to Griddle	31,263	30,512	31,434
Energy to Griddle (Btu/lb)	**595**	**581**	**599**
Cooking Energy Efficiency (%)	**76.5**	**76.9**	**74.2**
Cooking Energy Rate (kW)	**10.50**	**10.08**	**10.57**
Production Rate (lb/h)	**60.2**	**59.2**	**60.3**
Average Recovery Time (min)	**< 1.0**	**< 1.0**	**< 1.0**

Cooking Energy Efficiency Data

Table D-4. Medium-Load Test Data.

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Total Energy (kWh)	4.66	4.63	4.57
Cook Time (min)	**7.75**	**7.75**	**7.75**
Total Test Time (min)	48.9	48.7	48.9
Weight Loss (%)	34.9	34.7	34.7
Initial Weight (lb)	18.12	18.12	18.12
Final Weight (lb)	11.8	11.8	11.8
Initial Fat Content (%)	19.4	19.4	19.4
Initial Moisture Content (%)	60.6	60.6	60.6
Final Moisture Content (%)	52.9	54.5	53.8
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	163	162	162
Calculated Values			
Initial Weight of Water (lb)	11.0	11.0	11.0
Final Weight of Water (lb)	6.2	6.5	6.4
Weight of Fat (lb)	3.5	3.5	3.5
Weight of Solids (lb)	3.6	3.6	3.6
Sensible to Ice (Btu)	176	176	176
Sensible to Water (Btu)	1,435	1,427	1,427
Sensible to Fat (Btu)	229	228	228
Sensible to Solids (Btu)	118	117	117
Latent - Water Fusion (Btu)	1,581	1,581	1,581
Latent - Fat Fusion (Btu)	165	165	165
Latent - Water Vaporization (Btu)	4,602	4,394	4,474
Total Energy to Food (Btu)	8,305	8,088	8,168
Energy to Food (Btu/lb)	**458**	**446**	**451**
Total Energy to Griddle	15,905	15,802	15,597
Energy to Griddle (Btu/lb)	**878**	**872**	**861**
Cooking Energy Efficiency (%)	**52.2**	**51.2**	**52.4**
Cooking Energy Rate (kW)	**5.72**	**5.71**	**5.61**
Production Rate (lb/h)	**22.2**	**22.3**	**22.2**
Average Recovery Time (min)	**< .25**	**< .25**	**< .25**

Cooking Energy Efficiency Data

Table D-5. Light-Load Test Data.

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Total Energy (kWh)	3.03	3.07	3.01
Cook Time (min)	**7.75**	**7.75**	**7.75**
Total Test Time (min)	48.1	47.8	47.8
Weight Loss (%)	33.6	34.3	33.3
Initial Weight (lb)	6.06	6.06	6.06
Final Weight (lb)	4.0	4.0	4.0
Initial Fat Content (%)	19.4	19.4	19.4
Initial Moisture Content (%)	60.6	60.6	60.6
Final Moisture Content (%)	53.9	54.3	54.7
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	159	161	158
Calculated Values			
Initial Weight of Water (lb)	3.7	3.7	3.7
Final Weight of Water (lb)	2.2	2.2	2.2
Weight of Fat (lb)	1.2	1.2	1.2
Weight of Solids (lb)	1.2	1.2	1.2
Sensible to Ice (Btu)	59	59	59
Sensible to Water (Btu)	467	473	464
Sensible to Fat (Btu)	75	76	74
Sensible to Solids (Btu)	39	39	38
Latent - Water Fusion (Btu)	529	529	529
Latent - Fat Fusion (Btu)	55	55	55
Latent - Water Vaporization (Btu)	1,457	1,464	1,418
Total Energy to Food (Btu)	2,680	2,695	2,637
Energy to Food (Btu/lb)	**442**	**445**	**435**
Total Energy to Griddle	10,341	10,478	10,273
Energy to Griddle (Btu/lb)	**1,707**	**1,729**	**1,695**
Cooking Energy Efficiency (%)	**25.9**	**25.7**	**25.7**
Cooking Energy Rate (kW)	**3.78**	**3.85**	**3.78**
Production Rate (lb/h)	**7.6**	**7.6**	**7.6**
Average Recovery Time (min)	**< 0.17**	**< 0.17**	**< 0.17**

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	69.4	52.2	25.9	43.4
Replicate #2	68.1	51.2	25.7	43.8
Replicate #3	68.6	52.4	25.7	43.7
Average	**68.7**	**51.9**	**25.8**	**43.7**
Standard Deviation	0.66	0.65	0.13	0.20
Absolute Uncertainty	1.65	1.60	0.32	0.50
Percent Uncertainty	2.40	3.09	1.25	1.15