

Imperial Gas Griddle Performance Tests

Application of ASTM Standard
Test Method F 1275-99

FSTC Report 5011.03.06

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Prepared by:
**David Cowen
David Zabrowski
Fisher-Nickel Inc.**

Contributors:
**Scott Miner
Greg Sorensen
Fisher-Nickel Inc.**

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Executive Summary

Imperial griddles feature all-stainless steel construction and snap action thermostats, which are placed in a semicircular groove along the underside of the one-inch thick griddle plate. Imperial offers two types of controls: a mechanical snap-action (millivolt) control (ITG) and an electric snap-action (120 volt) control (ISAE). Food Service Technology Center (FSTC) engineers tested the pair of matched 3-foot griddles under the tightly controlled conditions of the American Society for Testing and Materials' (ASTM) Standard Test Method for the Performance of Griddles.¹ Griddle performance is characterized by temperature uniformity, preheat time and energy consumption, idle energy consumption rate, cooking-energy efficiency, and production capacity.

Cooking-energy efficiency and production capacity was determined by cooking frozen ¼ pound hamburgers under two different loading scenarios (heavy—24 hamburgers, and light—4 hamburgers). The heavy-load cook times for the ITG and ISAE griddles were 7.33 minutes and 8.54 minutes, respectively. Production capacity includes the cooking time and the time required for the cooking surface to return within 25°F of the thermostats set point.

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:

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

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

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

Table ES-1. Summary of Griddle Performance.

	ITG	ISAE
Rated Energy Input Rate (Btu/h)	72,000	72,000
Measured Energy Input Rate (Btu/h)	69,103	69,697
Temperature Uniformity (°F) ^a	± 25.3	± 25.3
Preheat Time to 375°F (min)	18.7	19.3
Preheat Energy to 375°F (Btu)	20,004	20,527
Idle Energy Rate @ 375°F (Btu/h)	18,960	18,210
Heavy-Load Cooking-Energy Efficiency (%)	38.6 ± 1.0	39.6 ± 1.2
Light-Load Cooking-Energy Efficiency (%)	12.5 ± 0.8	13.5 ± 1.1
Production Capacity ^b (lb/h)	42.7 ± 4.3	37.8 ± 1.6
Cooking Surface Recovery Time ^b (min)	1.15	1.02

^aTemperature uniformity reflects the absolute temperature variance across the cooking surface to within 3 inches from each edge.

^bBased on the heavy-load cooking test with a minimum 30-second preparation time between loads.

Figure ES-1 illustrates the relationship between cooking-energy efficiency and production rate for both the ITG and ISAE griddles. Griddle production rate is a function of both the hamburger patty cook time and the cooking surface recovery time.

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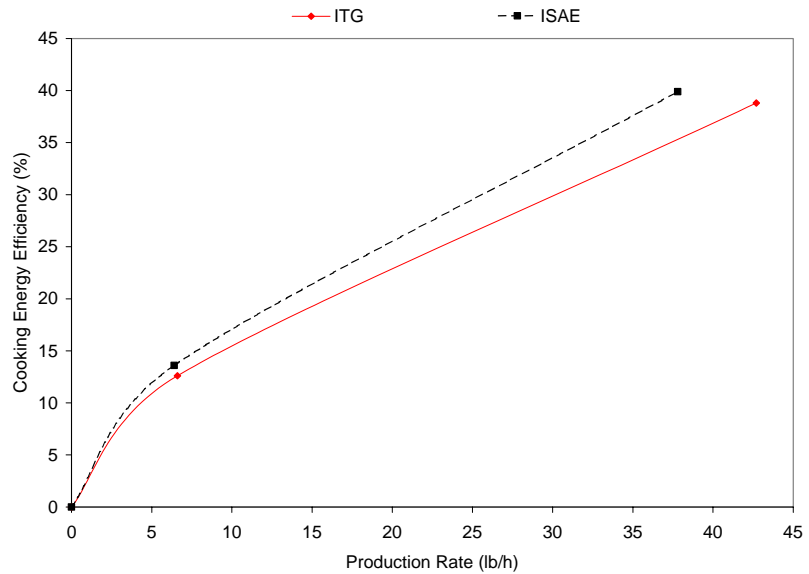


Figure ES-1.
Griddle part-load cooking-energy efficiency.

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 for Imperials mechanical thermostat griddle at 10, 20, and 30 pounds per hour are 27,170 Btu/h, 35,140 Btu/h, and 43,110 Btu/h, 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 average energy consumption for this griddle would be 35,140 Btu/h. Table ES-3 summarizes the estimated energy consumption at 10, 20, and 30 lb/h for both ITG and ISAE gas griddles.

Imperial’s ITG griddle uses a mechanical snap-action thermostat while the ISAE griddle, requiring 120 volts to operate, uses an electric snap-action thermostat. Both the griddles demonstrated competitive cooking energy efficiencies (38.8% and 39.9%) and production capacities (42.7 and 37.8 lb/h) when compared with other griddles in their class. Imperial's foresight in

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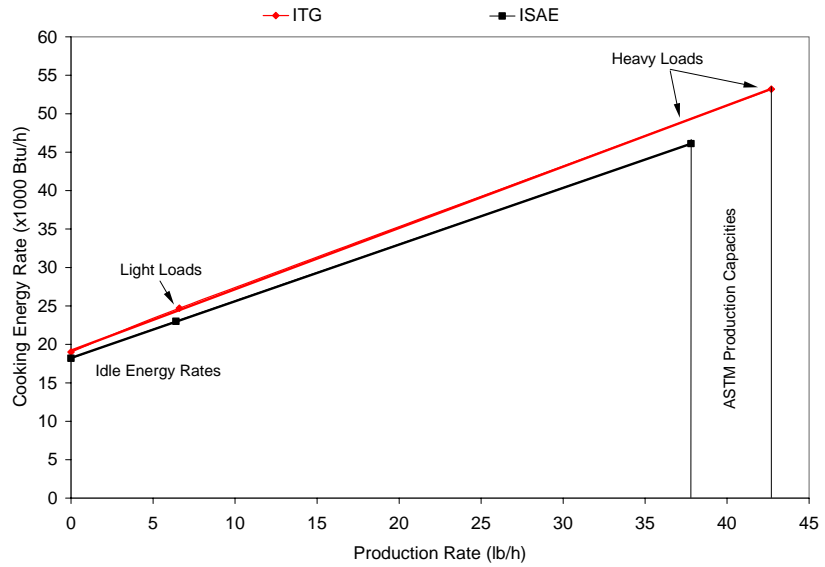


Figure ES-2.
Griddle cooking energy consumption profile.

Note: Light-load = 4 hamburgers/load; Heavy-load = 24 hamburgers/load.

Table ES-3. Energy Consumption Estimations.

Production Rate	ITG	ISAE
10 lbs/h	27,170 Btu/h	25,610 Btu/h
20 lbs/h	35,140 Btu/h	32,980 Btu/h
30 lbs/h	43,110 Btu/h	40,360 Btu/h

thermostat location proved to be a major factor in their griddles’ ability to produce competitive performance figures. By placing the thermostat-sensing bulbs in grooves in the bottom of the cooking plate, the sensing bulbs made solid contact with the cooking surface and allowed for increased sensitivity to temperature changes during cooking. This is evident from the very low recovery times. Quick preheats, low idle rates and a good temperature uniformity ($\pm 25^{\circ}\text{F}$) set these griddles firmly in the class of cost effective per-

Executive Summary

formance gas griddles when compared to other griddles tested at the Food Service Technology Center. ² Since Imperial offers griddles with or without an electric supply for the thermostats, restaurateurs are given greater flexibility to fit their kitchen requirements. This is an appealing option for many establishments.

² Kaufman, D.A., Fisher, D.R., Nickel, J. and Saltmarch M., 1989. *Development and Application of a Uniform Testing Procedure for Griddles*. Pacific Gas and Electric Company Department of Research and Development Report 008.1-89.2, March.

1 Introduction

Background

Griddles are used throughout the hospitality industry from their first order of bacon at breakfast to the last seared steak at dinner. The griddle is a work-horse that usually occupies a central position on the short order line. 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 1989,¹ the FSTC has tested a wide range of gas and electric griddles.^{2,3,4,5,6,7,8,9,10,13}

Introduction

Imperial griddles feature all-stainless steel construction and snap action thermostats, which are placed in a semicircular groove along the underside of the one-inch thick griddle plate. Imperial offers two types of controls: a mechanical snap-action (millivolt) control (ITG) and an electric snap-action (120 volt) control (ISAE). Food Service Technology Center (FSTC) engineers tested the matched pair of 3-foot griddles 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. 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 performance of a matched pair of Imperial ITG and ISAE gas griddles, 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.

Introduction

Appliance Description

Imperial's ITG and ISAE gas griddles feature mechanical snap-action and electric snap-action (120V) thermostats, respectively, each controlling a 27,000 Btu/h U-shaped burner-one burner for every twelve linear inches of griddle surface. The cooking surface is one-inch thick polished finish steel surrounded by stainless steel splashguards and back splash.

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

Table 1-1. Appliance Specifications.

Manufacturer	Imperial
Model	ITG-36
Generic Appliance Type	Thermostatically Controlled Griddle
Rated Input	72,000 Btu/h
Dimensions	36" x 30 ½" x 19"
Construction	1"-thick ground and polished steel plate
Controls	Three mechanical snap action thermostats with a temperature range of 150 to 450°F
Manufacturer	Imperial
Model	ISAE-36
Generic Appliance Type	Thermostatically Controlled Griddle
Rated Input	72,000 Btu/h
Dimensions	36" x 30 ½" x 19"
Construction	1"-thick ground and polished steel plate
Controls	Three 120 V electric snap action thermostats with a temperature range of 150 to 450°F

2 Methods

Setup and Instrumentation

FSTC researchers installed the griddles 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 each 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 griddles 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-Figure 2-2) were used for the remainder of the tests.

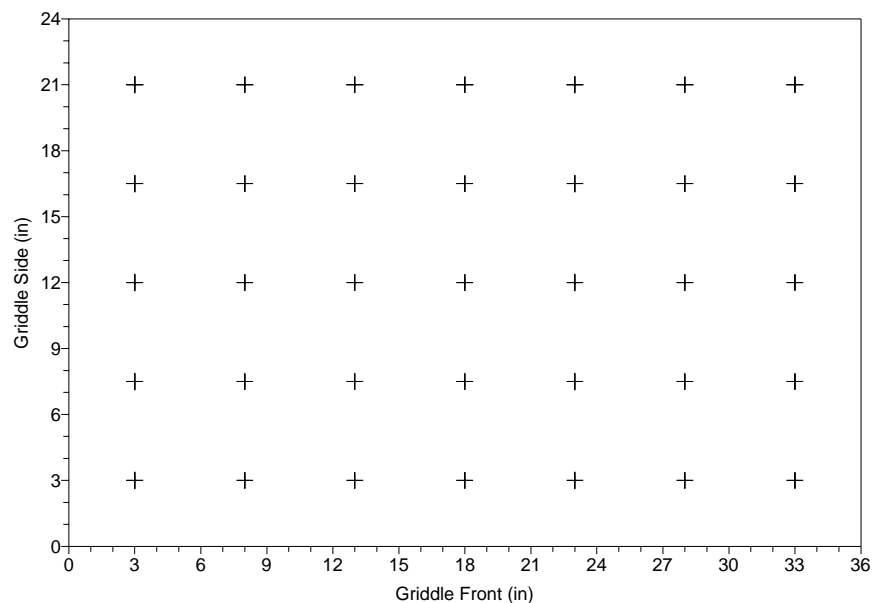


Figure 2-1.
Thermocouple grid for temperature uniformity test.

Methods

Natural gas consumption was measured using a positive displacement-type gas meter that generated a pulse every 0.1 ft³. The gas meter and the thermocouples were connected to an automated data acquisition unit that recorded data every 5 seconds. A chemical laboratory used a gas chromatograph to determine the gas heating value on each day of testing. All gas measurements were corrected to standard conditions.

Measured Energy Input Rate

Rated energy input rate is the maximum or peak rate at which the griddle consumes energy—as specified on the griddle’s nameplate. Measured energy input rate is the maximum or peak rate of energy consumption, which is recorded during a period when the burners are operating (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

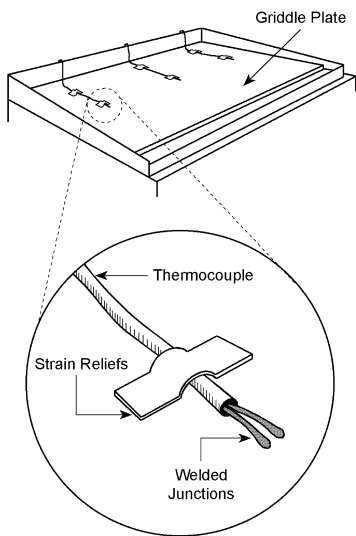


Figure 2-2.
Thermocouple placement for testing.

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), 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 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

Methods

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.

Each loading scenario (heavy and light) was repeated a minimum of three times. This procedure ensured that the reported cooking-energy efficiency and production capacity results had an uncertainty of less than $\pm 10\%$. 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 for both griddles 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 for the ITG and ISAE griddles were 69,103 Btu/h and 69,697 Btu/h, respectively (a difference of 4.02% and 3.20% from the nameplate ratings).

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 $375 \pm 5^\circ\text{F}$ 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. Since both griddles were the same with the exception of thermostat types, the uniformity test was run on one griddle only. The temperature sensing points are illustrated in Figure 3-1 and the resulting temperature profile is presented in 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.

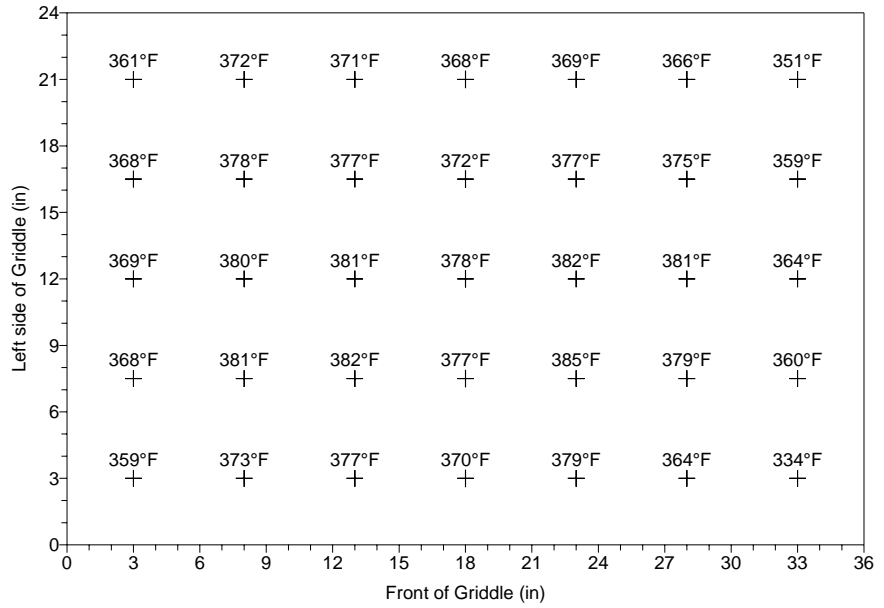
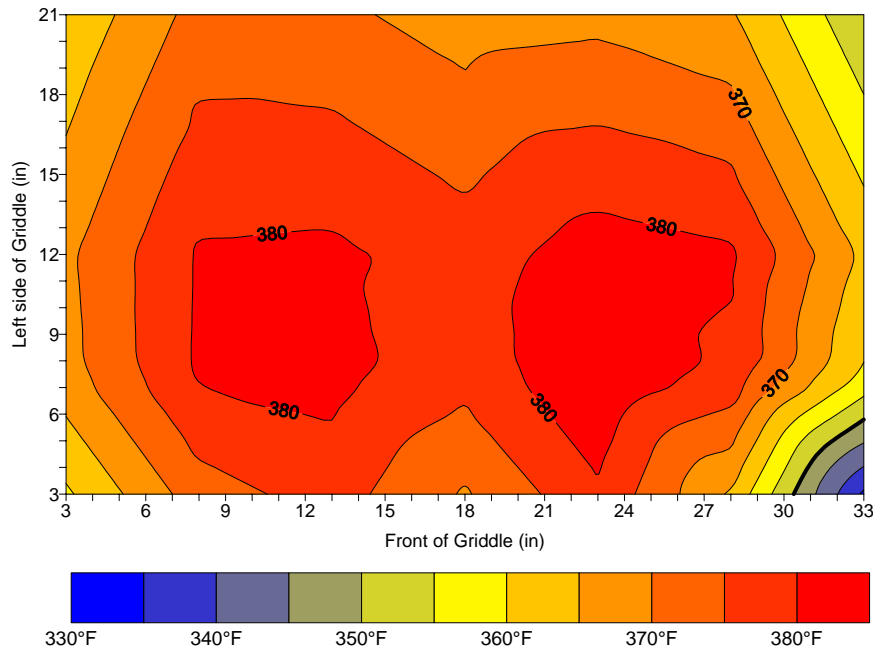


Figure 3-2.
Temperature map of the cooking surface.



Results

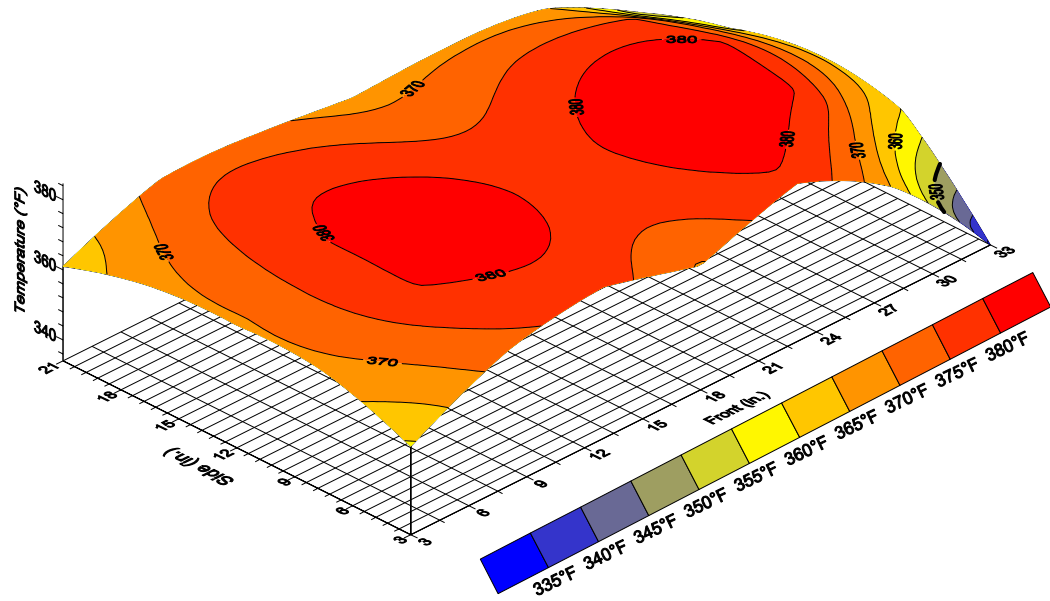


Table 3-1. Temperature Uniformity and Thermostat Accuracy.^a

	ITG	ISAE
Control Settings ^b :		
Left Control (°F)	380	380
Center Control (°F)	378	378
Right Control (°F)	378	360
Average Surface Temperature (°F)	371	371
Maximum Temperature Difference Across Plate (°F)	50.6	50.6
Standard Deviation of Surface Temperatures (°F)	10.4	10.4

^aThermostat design is the only physical difference so the temperature uniformity was assumed equal for both units.

^bThermostat accuracy is the control setting required to maintain $375 \pm 5^\circ\text{F}$ on the cooking surface directly above the thermostat sensor.

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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 $75 \pm 5^\circ\text{F}$ 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 . Imperial's ITG and ISAE griddles consumed 20,004 Btu in 18.7 minutes and 20,527 Btu and 19.3 minutes, respectively. Figure 3-3 and 3-4 show the energy consumption rate in conjunction with the cooking surface temperature for each griddle during the preheat tests.

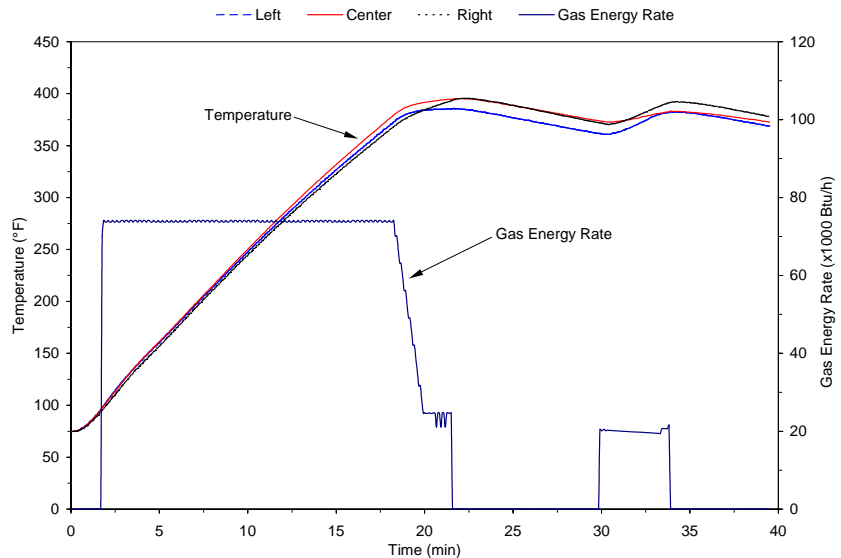
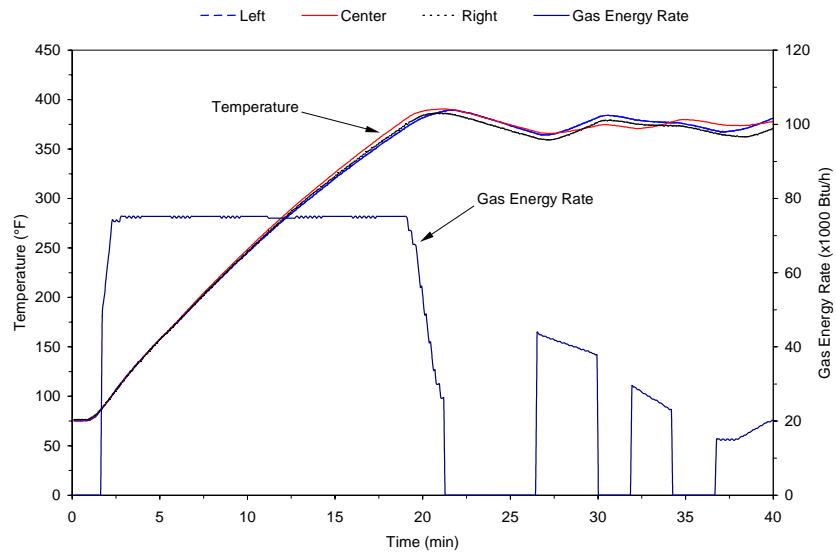


Figure 3-3.
ITG preheat characteristics.

Results

Figure 3-4.
ISAE 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 for the ITG griddle (mechanical thermostats) was 18,960 Btu/h and 18,210 for the ISAE griddle (electric thermostats).

Test Results

During the preheat and idle testing for the matched pair of griddles it was observed that the electric snap-action thermostats on the ISAE griddle provided a lower temperature overshoot for preheat and a tighter temperature control during idle than the mechanical snap-action thermostats on the IGT griddle. Input, preheat, and idle test results are summarized in Table 3-2.

Results

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

	ITG	ISAE
Rated Energy Input Rate (Btu/h)	72,000	72,000
Measured Energy Input Rate (Btu/h)	69,103	69,697
Percentage Difference (%)	4.02	3.20
Preheat to 375°F		
Time (min)	18.7	19.3
Energy (Btu)	20,004	20,527
Rate (°F/min)	16.1	15.5
Idle Rate @ 375°F (Btu/h)	18,960	18,210
Idle Duty Cycle (%)	27.4	26.1

Cooking Tests

The griddles were 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. Figures 3-5 and 3-6 show the average cooking surface temperature during a heavy-load test for the two griddles. One load was used to stabilize the griddle, and six loads were used to calculate cooking-energy efficiency and production capacity.

Results

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

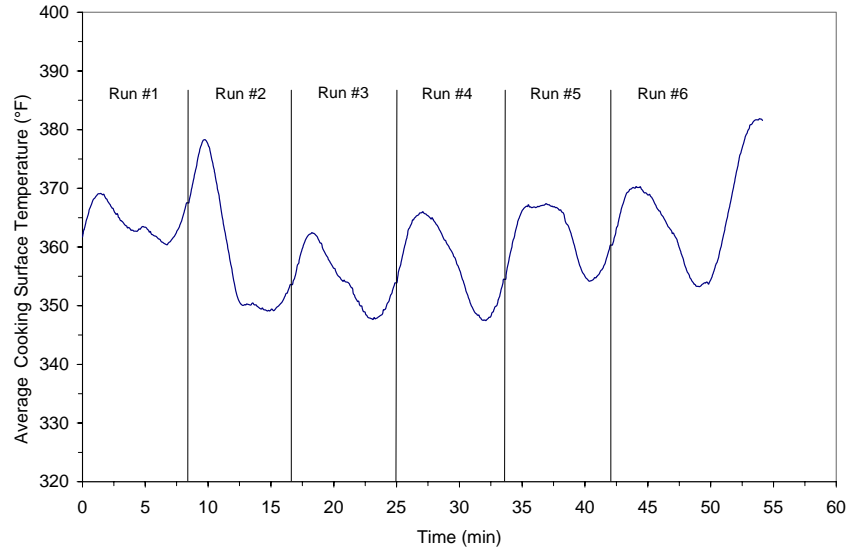
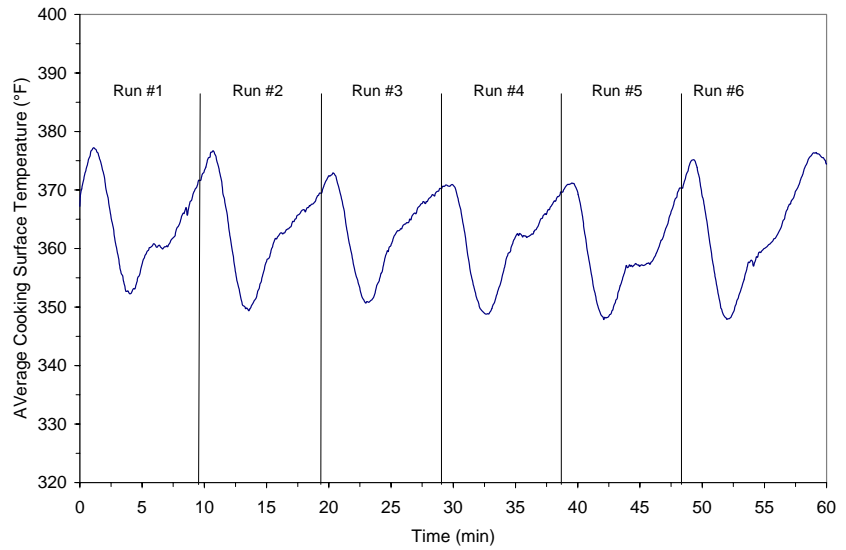


Figure 3-6.
ISAE average cooking surface temperature during a heavy-load test.



Results

Figure 3-5 illustrates mechanical thermostat's tendency to drift in temperature during the heavy load cooking tests. This slow upward creep in temperature leads to a less uniform food product. As the average temperature increases, food will require less time to cook, requiring an operator to monitor and adjust the cook time from load to load. The ISAE griddle (Figure 3-6) maintains a more constant response to each load during the heavy-load cooking tests. This reliable response to each load gives an operator a more consistent and uniformly cooked product. Figure 3-7 and 3-8 illustrate the temperature response for each griddle while a load of 24 frozen hamburger patties was being cooked. Production capacity includes the time required for the cooking surface to recover to 350°F (recovery time). Production rate varies with the amount of food being cooked at one time.

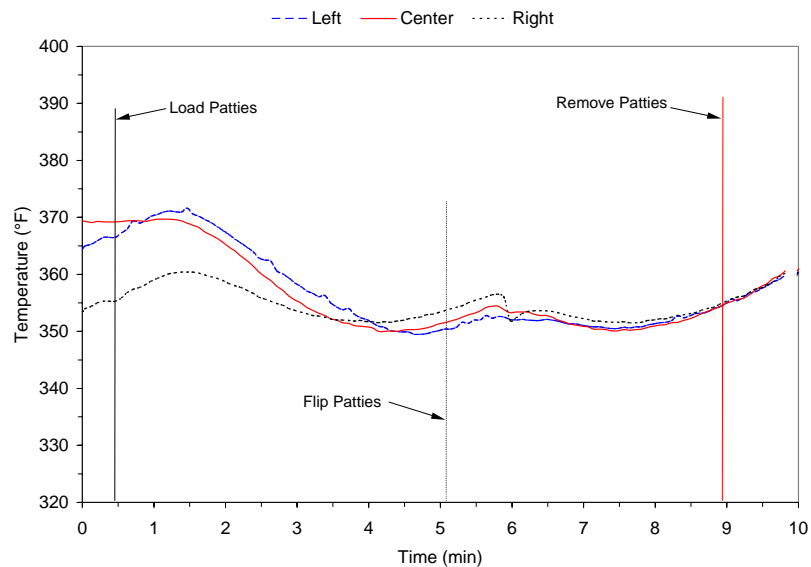
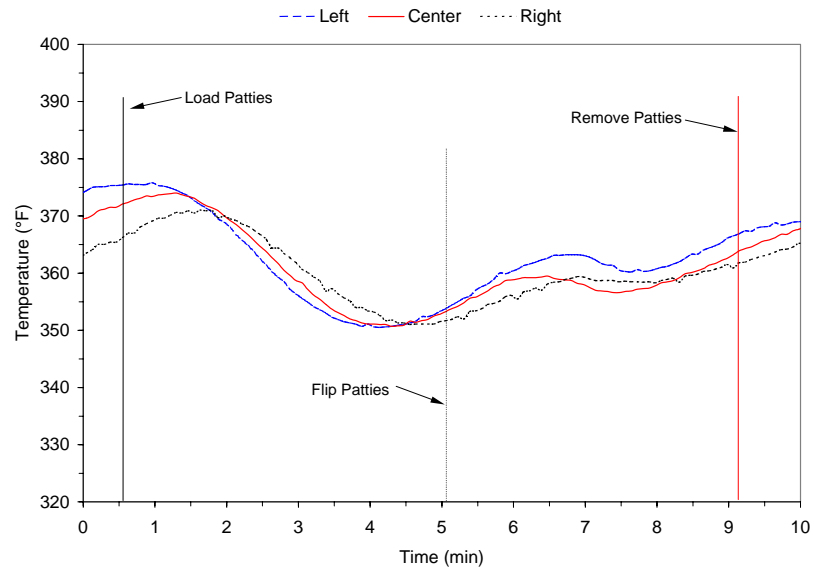


Figure 3-7.
ITG heavy-load cooking temperature signature with a 350°F reload.

Results

Figure 3-8.
ISAE heavy-load cooking temperature signature with a 350°F reload.



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, these part-load efficiencies can be used to estimate griddle performance in an actual operation.

Light-load tests were conducted on the left half of the cooking surface. Since the entire griddle was heated to 375°F, the energy consumed during these part-load tests includes radiant heat losses from the unused half of the griddle. Cooking energy efficiencies for the ITG and ISAE griddles were 12.6% and 13.6% with production rates of 6.6 lb/h and 6.4 lb/h, 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 en-

Results

ergy 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 on the Imperial ITG griddle were 38.2%, 39.3%, and 38.9%, yielding a maximum uncertainty of 1.4%. Imperial's ISAE griddle exhibited cooking-energy efficiency results of 39.5%, 40.2%, and 40.0%, yielding a maximum uncertainty of 0.9%. Table 3-3 and 3-4 summarize the results of the ASTM cooking-energy efficiency and production capacity tests.

Table 3-3. Heavy-Load Test Results.

	ITG	ISAE
Hamburger Patty Cook Time (min)	7.33	8.54
Average Recovery Time (min)	1.15	1.02
Production Rate (lb/h)	42.7 ± 4.3	37.8 ± 1.6
Energy Consumption (Btu/lb)	1,249	1,220
Cooking Energy Rate (Btu/h)	53,235	46,109
Cooking-energy efficiency (%)	38.6 ± 1.0	39.6 ± 1.2

Table 3-4. Light-Load Test Results.

	ITG	ISAE
Hamburger Patty Cook Time (min)	8.53	8.81
Average Recovery Time (min)	< 1.0	< 1.0
Production Rate (lb/h)	6.6 ± 0.5	6.4 ± 0.5
Energy Consumption (Btu/lb)	3,840	3,602
Cooking Energy Rate (Btu/h)	24,741	23,034
Cooking-energy efficiency (%)	12.5 ± 0.8	13.5 ± 1.1

Results

Figure 3-9 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 cooking surface recovery time. Appendix D contains a synopsis of test data for each replicate of the cooking tests.

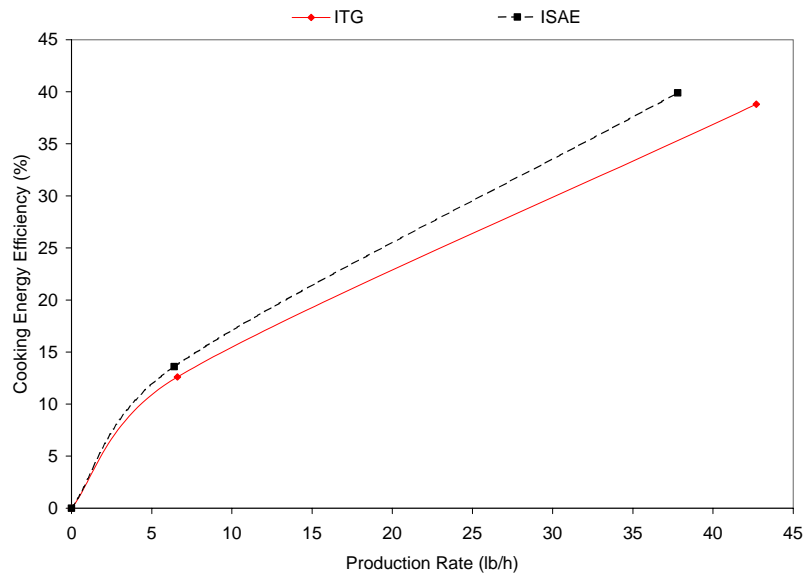


Figure 3-9.
Griddle part-load cooking-energy efficiency.

Figure 3-10 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 average energy rate for the griddle in a real-world operation. Average energy consumption rates for Imperial’s ITG griddle at 10, 20, and 30 pounds per hour are 27,170 Btu/h, 35,140 Btu/h, and 43,110 Btu/h, 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 average energy consumption rate for the ITG

Results

griddle would be 35,140 Btu/h. Table 3-5 represents the estimated energy daily consumption for both the ITG and ISAE gas griddles.

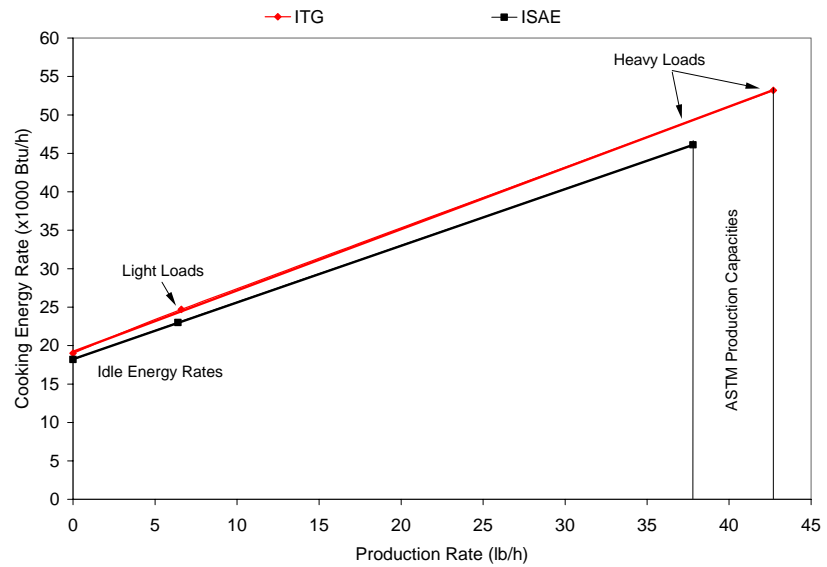


Figure 3-10.
Griddle cooking energy consumption profile.

Note: Light-load = 4 hamburgers/load; Heavy-load = 24 hamburgers/load.

Table 3-5. Energy Consumption Estimations.

Production Rate	ITG	ISAE
10 lbs/h	27,170 Btu/h	25,610 Btu/h
20 lbs/h	35,140 Btu/h	32,980 Btu/h
30 lbs/h	43,110 Btu/h	40,360 Btu/h

4 Conclusions

Imperial's ITG and ISAE 3-foot gas griddles are virtually identical except for the thermostat design. The ITG griddle employed a mechanical snap-action thermostat and the ISAE used an electric snap-action thermostat (requiring 120 volt). Both griddles share the same burner design, griddle plate and thermostat placement. The thermostat placement was an important design feature for these Imperial griddles. Each thermostat was placed in a groove along the bottom of the griddle plate. This brings the thermostat-sensing bulb closer to the cooking surface, allowing for a greater sensitivity to changes in temperature during cooking.

Both griddles demonstrated very good cooking-energy efficiencies and production capacities compared to other griddles in their class.^{2,3,4,5,6,8,9,10,13} The ITG griddle produced 42.7 lb/h with a cooking-energy efficiency of 38.8% under heavy-load conditions. Similarly, the ISAE griddle produced 37.8 lb/h with a cooking-energy efficiency of 39.9% under heavy-load conditions. Both griddles were essentially ready to cook after removal of the previous load and scraping the cooking surface.

The two griddles exhibited similar preheat times and energy consumptions placing them in the middle range of griddles tested at the FSTC. The ITG griddle was ready to cook in 18.7 minutes, consuming 20,004 Btu, while the ISAE griddle was ready to cook in 19.3 minutes after consuming 20,527 Btu. Idle rates again were very similar and in the middle range for atmospheric gas griddles.

The electric snap-action thermostats used on the ISAE griddle provided greater control during preheat with a reduced temperature overshoot and a tighter temperature swing while idling around the thermostat set point. During cooking tests the ISAE griddle maintained a more consistent griddle surface temperature than the IGT griddle (see Figures 3-5 and 3-6). This tighter tem-

Conclusions

perature control during cooking provided a more uniform food product. While it exhibited a nominal improvement in cooking-energy efficiency, the electric thermostat did not necessarily provide a higher production capacity than the version with mechanical thermostats.

Since the burner design and overall construction was identical between griddles, a single uniformity test was done. A maximum temperature range of 50°F from hottest to coldest makes Imperial's uniformity on par with other standard 3-foot griddles. ^{2,3,4,5,6,8,9,10,13}

Both griddles proved to be great all around performers. Competitive cooking-energy efficiencies and production capacities, fast recovery times from the thermostat placement and good temperature uniformity will give a food service operator a work horse appliance that will inspire confidence and speed in their food preparation. By offering an electrical and non-electrical version, Imperial gives a food service operator a valuable option when considering these two work horses for purchasing.

5 References

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A Glossary

Cooking Energy (kWh or kBtu)

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

Cooking Energy Consumption Rate (kW or kBtu/h)

The average rate of energy consumption during the cooking period.

Cooking-Energy Efficiency (%)

The quantity of energy input to the food products; expressed as a percentage of the quantity of energy input to the appliance during the heavy-, 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 pre-heat.

Heating Value (Btu/ft³)

Heating Content

The quantity of heat (energy) generated by the combustion of fuel. For natural gas, this quan-

tity 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”).

Glossary

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 cooking surface heats during a preheat.

Preheat Time (minute)

Preheat Period

The time required for an appliance to “pre-heat” 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 food until the surface temperature is within 25°F of the thermostat set point and the griddle is ready to be reloaded.

Test Method

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

Typical Day

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

B Appliance Specifications

Appendix B includes the product literature for the Imperial griddles.

Appliance Specifications.

Manufacturer	Imperial
Model	ITG-36
Generic Appliance Type	Thermostatically Controlled Griddle
Rated Input	72,000 Btu/h
Dimensions	36" x 30 ½" x 19"
Construction	1"-thick ground and polished steel plate
Controls	Three mechanical snap action thermostats with a temperature range of 150 to 450°F

Manufacturer	Imperial
Model	ISAE-36
Generic Appliance Type	Thermostatically Controlled Griddle
Rated Input	72,000 Btu/h
Dimensions	36" x 30 ½" x 19"
Construction	1"-thick ground and polished steel plate
Controls	Three 120 V electric snap action thermostats with a temperature range of 150 to 450°F

IMPERIAL

Item # _____

Heavy Duty Griddles and Open Burner Combinations Thermostat Controlled



Model # ITG-36

2000 SERIES

2000 Series Standard Features

- NEW** Aeration baffles between burners spreads heat across griddle for more even heating.
- NEW** Full width rear flue aids uniform heat distribution across griddle plate.
- NEW** 4" tapered stainless steel splash guard.
- NEW** Open burner combinations have 28,000 BTU/hr. lift-off burners and 12" x 12" cast iron top grates.
- NEW** Quad Burner options: (1) Anti-Clogging burner with full flame and a 7,000 BTU low simmer (2) All-Purpose (3) Saute' and (4) Wok Jet.
 - 30,000 BTU/hr. "U" type burner located every 12" for even cooking on entire griddle surface.
 - Thermostat maintains selected griddle temperature during peak cooking periods.
 - Energy saving thermostat is adjustable from 150° to 450°F.
 - Each burner has a continuous pilot for instant ignition.
 - Stainless steel front, ledge and sides.
 - Thick 1" highly polished steel griddle plate maintains temperatures and assures quick recovery.
 - Full 24" depth plate for more cooking surface.
 - Stainless steel grease trough, one piece rolled front.
 - Large capacity, removable grease can.
 - 24", 36", 48", 60" and 72" width models available.
 - One year parts and labor warranty.
 - AGA and CGA design certified, NSF and CE Certified.

The 2000 Series Heavy Duty Griddles

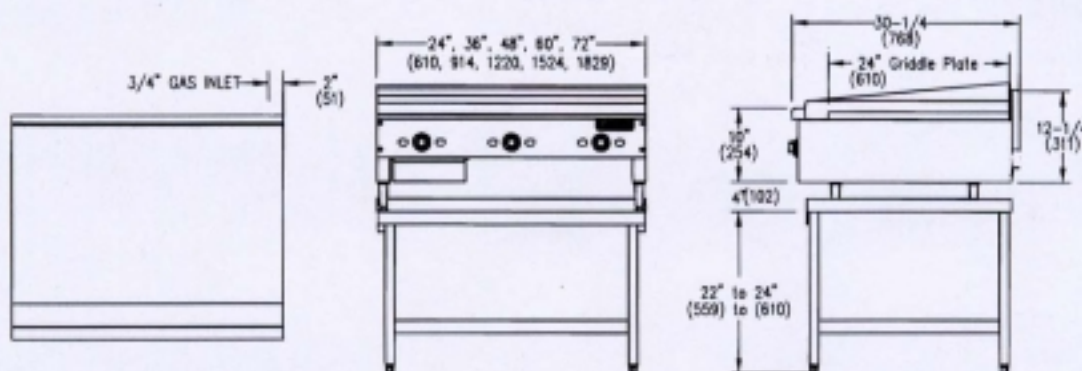
Imperial provides as standard many of the optional upgrades normally offered at a premium on other Griddle lines. The new look features a stainless steel front, ledge and sides. A new 4" high stainless steel tapered splash guard promotes cleanliness.

Imperial Heavy Duty Griddles with thermostat controls are designed to maintain your selected temperature during peak cooking periods. The 1" thick highly polished griddle plate is ideal for a wide variety of cooking requirements and the 24" depth provides maximum cooking surface. New features have been added to improve uniform temperatures: aeration baffles are located between burners and a full width rear flue. The 30,000 BTU/hr. "U" type burners are strategically located to provide even heating across the entire griddle surface. The high BTU output, total cooking surface and griddle quality assure the best value on the market.

The front stainless steel profile of the griddle is designed to match the IRB Broiler and IHPA Hot Plate series.



2000 SERIES Heavy Duty Griddles - Thermostat Controlled



2000 Series Heavy Duty Griddles, Thermostat Controlled

Model#	Griddle Width	Griddle Burners	Overall Width	Total B.T.U.	Ship Weight		Ship Weight Stand	
Model#	(Kg)	(Lbs)	Thermostat Controlled Griddles		(Kg)	(Lbs)		
ITG-24	24"	2	24"	60,000	136	300	ITGS-24	23 50
ITG-36	36"	3	36"	90,000	195	430	ITGS-36	32 70
ITG-48	48"	4	48"	120,000	261	575	ITGS-48	39 85
ITG-60	60"	5	60"	150,000	328	725	ITGS-60	48 105
ITG-72	72"	6	72"	180,000	396	875	ITGS-72	62 135
Thermostat Controlled Griddles with (2) Open Burner Combinations								
ITG-24-OB-2	24"	2	36"	116,000	159	350	ITGS-36	32 70
ITG-36-OB-2	36"	3	48"	146,000	222	490	ITGS-48	39 85
ITG-48-OB-2	48"	4	60"	176,000	288	635	ITGS-60	48 105
ITG-60-OB-2	60"	5	72"	206,000	355	785	ITGS-72	62 135
ITG-72-OB-2	72"	6	84"	236,000	423	935	ITGS-84	77 170

Note: Add "OB-4" to model number and 12" to overall width for 4 Open Burner/Griddle Combination.

Open burners are located on right side unless specified.

Crated Dimensions: Height = 14" (356) Depth = 33" (838) Width: add 2 1/2" to Griddle width.

Standard Exterior Finish

■ **Stainless Steel:** Front, ledge, grease trough, splashguard and sides.

■ **Control Knobs:** Durable cast metal, polished chrome.

Griddle Top

■ **Thermostat Control:** Energy-saving thermostat is adjustable from 150° to 450° F.

■ **Griddle Burner:** 30,000 BTU/hr. "U" type located every 12" for even cooking. One standing pilot per burner. Aeration baffles between burners and a full width rear flue provide uniform griddle surface temperatures.

■ **Griddle Plate:** 1" thick, highly polished plate. No breaking-in required. 24" depth. 4" tapered splash guard.

■ **Grease Trough:** 3" wide grease trough for easy cleaning.

■ **Open Burner Top:** 28,000 BTU/hr. cast iron burners with lift-off burner heads. No gaskets, no screws. Four interchangeable burner heads available: Anti-Clogging is standard, All-Purpose, Sauté and Wok Jet are optional. One standing pilot for each burner for instant ignition.

■ **Burner Top Grates:** 12" x 12" lift-off sections, heavy duty cast iron. Cast-in bowl directs heat upward. Grate features anti-clogging pilot shield.

Optional Items

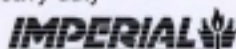
Open burners; one thermostat per burner; and manually controlled gas valves. Open burner options: All Purpose, Sauté or Wok Jet burner head. Extra capacity grease cans; quick disconnect and flexible gas hose; set of 4" legs; stainless steel stands; and casters (front two casters are locking).

Gas

Manifold pressure is 5.0" W.C. for natural gas or 10.0" for propane gas. Manifold size 3/4" NPT. Specify type of gas and elevation if over 2,000 ft.

Clearance

For use only on non-combustible surfaces. Provide 0" clearance from non-combustible surfaces and 8" from combustible walls at sides and 7" from rear walls.



Commercial Cooking Equipment

1560 Flower St., Duarte, CA 91010 Phone (626) 357-7411 FAX (626) 359-5909 E-Mail imppls@imperialrange.com Website imperialrange.com

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IMPERIAL

Item # _____

Elite Snap Action Griddles



Model # ISAE-36

Elite Standard Features

- Stainless steel front, ledge and sides.
- Snap action thermostat control (every 12").
- Fast recovery, $\pm 7^{\circ}\text{F}$ temperature variance. Solid State model, has a $\pm 2^{\circ}\text{F}$ variance.
- For high production yields, more product per square inch.
- 24,000 BTU "U" shaped burner every 12", with heat diffuser plate to speed temperature recovery.
- 4" chrome-plated legs included.
- Available in 24", 36", 48", 60" and 72" widths.
- Thick 1" highly polished steel griddle plate maintains even temperatures and assures quick recovery.
- Full 24" depth plate for more cooking surface.
- Stainless steel grease trough, one piece rolled front, 2" high splash sides and 4" rear splash for easy cleaning.
- Large capacity, removable grease pan.
- One year parts and labor warranty.
- AGA and CGA design certified and NSF Certified.

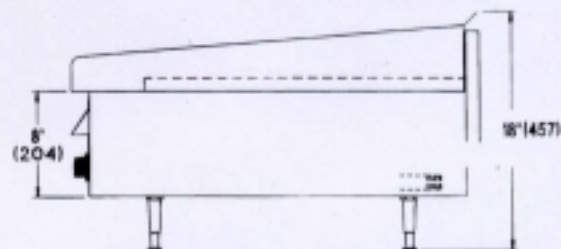
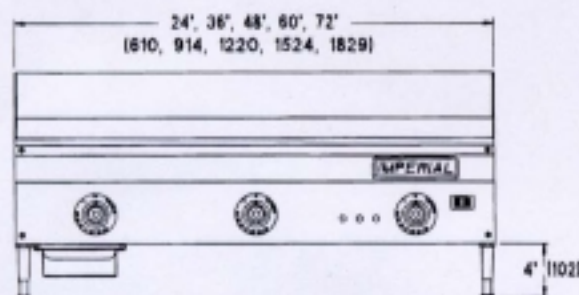
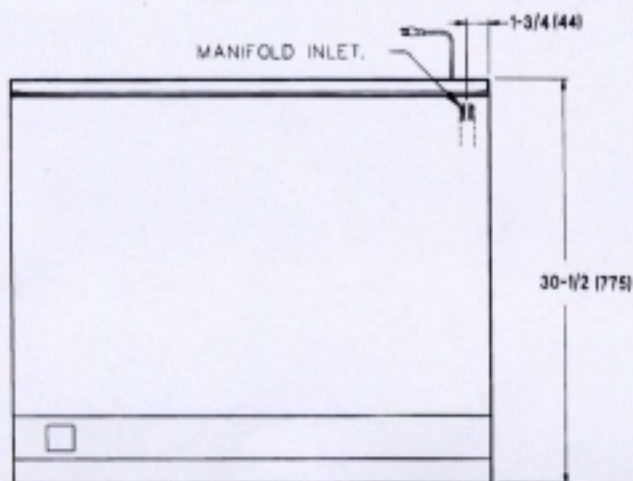
The Elite Snap Action Griddles

If high production, consistent, even heat and quick recovery are your requirements, then the Imperial Snap Action Series is the griddle for you. The Imperial Snap Action Series will outperform standard griddles that are 50% larger in size while saving valuable hood and kitchen space.

Imperial Heavy Duty Griddles with Snap Acting Thermostat controls are designed to maintain your selected temperature during peak cooking periods. The thermostat probe is positioned within the griddle plate $\frac{1}{4}$ " from the top surface; therefore, more accurately sensing the actual temperature of the cooking surface. The 1" thick highly polished griddle plate is ideal for a wide variety of cooking requirements and the 24" depth provides maximum cooking surface. The 24,000 BTU/hr "U" type burners are strategically located to provide even heating on the entire griddle surface. The high BTU output, total cooking surface and griddle quality assure the best value on the market.



Elite Snap Action Griddles



Elite Snap Action Griddles

Model#	Griddle Width	Griddle Burners	Overall Depth	Gas Output		Ship Weight	
				B.T.U.	(KW)	(Kg)	(Lbs)
ISAE-24	24"	2	30 1/2"	48,000	(14)	140	310
ISAE-36	36"	3	30 1/2"	72,000	(21)	199	440
ISAE-48	48"	4	30 1/2"	96,000	(28)	265	585
ISAE-60	60"	5	30 1/2"	120,000	(35)	333	735
ISAE-72	72"	6	30 1/2"	144,000	(42)	400	885

Crated Dimensions: Height = 15" (381); Depth = 33 1/2" (852); Width: add 2 1/2" to Griddle width.
Griddle Height with 4" legs = 13 1/2" (343).

Note: Custom side and rear splash design available, contact Imperial.

Electrical Requirements: 120VAC - 60Hz with 2 amp draw. Provided with a 3-prong plug and 6' (1829) power cord.

Standard Exterior Finish

- **Stainless Steel:** Front, ledge and sides.

Griddle Top

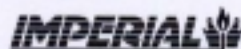
- **Thermostat Control:** Snap-acting thermostat is adjustable from 200°F to 400°F.
- **Griddle Burner:** 24,000 BTU/hr. "U" type located every 12" for even cooking. One standing pilot per burner.
- **Griddle Plate:** 1" thick, highly polished plate. No breaking-in required. 24" depth. Stainless steel 2" high splash sides and 4" rear splash.
- **Grease Trough:** 3" wide grease trough for easy cleaning.

Gas

Manifold pressure is 5.0" W.C. for natural gas or 10.0" for propane gas. Manifold size 3/4" NPT. Specify type of gas and elevation if over 2000 ft.

Clearance

For use only on non-combustible surfaces. Provide 0" clearance from non-combustible surfaces and 8" from combustible walls at sides and 7" from rear walls.



Commercial Cooking Equipment

1560 Flower Street, Duarte, CA 91010 Phone (626) 357-7411 FAX (626) 359-5909

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C Results Reporting Sheets

Manufacturer: Imperial
Models: ITG-36 and ISAE-36
Date: May 2002

Test Griddle

Description of operational characteristics: 1-inch Polished finish steel plate with thermostats placed in groove beneath cooking surface. Three thermostats (mech., ITG and elec., ISAE) control three 27,000 Btu/h U- shaped burners. Stainless steel construction on the splash guards, grease, trough and front panel.

Apparatus

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

Deviations: None.

Energy Input Rate

	ITG	ISAE
Heating Value (Btu/h)	72,000	72,000
Measured (Btu/h)	69,103	69,697
Percent Difference between Measured and Rated (%)	4.02	3.20

Results Reporting Sheets

Temperature Uniformity and Thermostat Accuracy

	ITG	ISAE
Control Settings ^a :		
Left Control (°F)	380	380
Center Control (°F)	378	378
Right Control (°F)	378	360
Maximum Temperature Difference Across the Plate (°F)	50.6	50.6

^aThermostat accuracy is the control setting required to maintain $375 \pm 5^\circ$ on the cooking surface directly above the thermostat sensor.

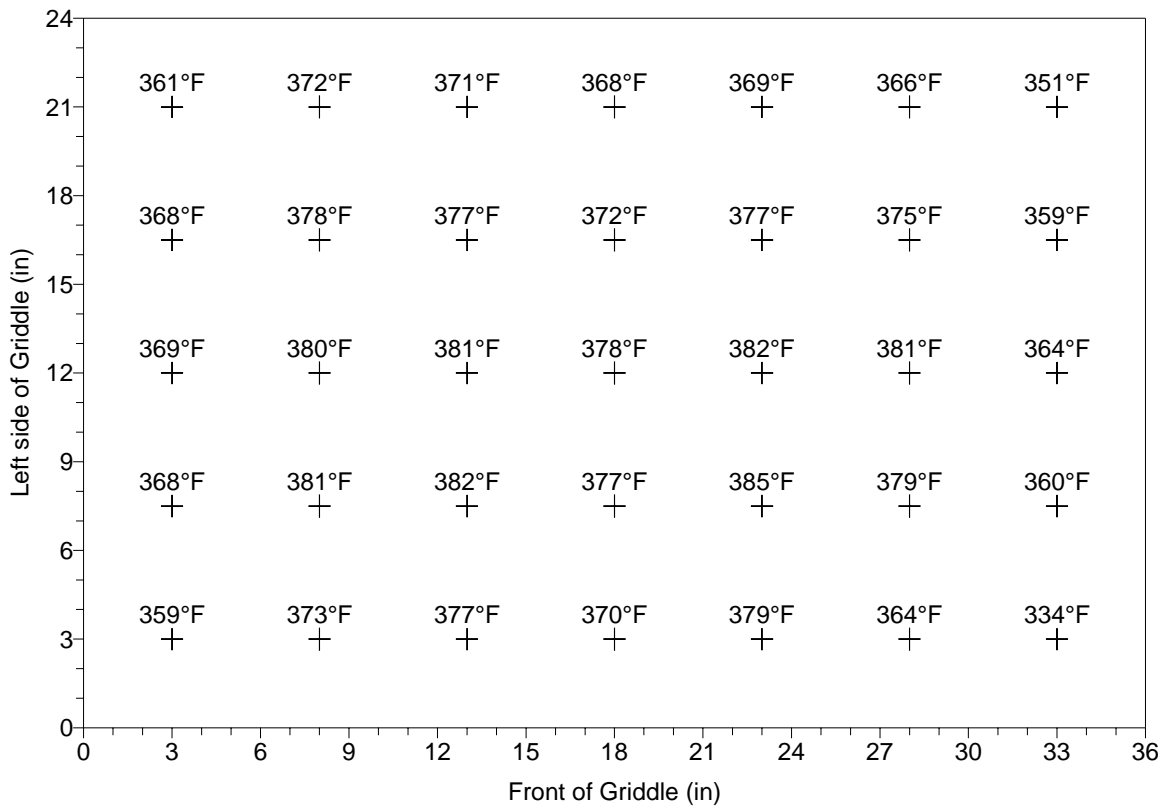


Figure C-1. Average cooking surface temperatures.

Results Reporting Sheets

Preheat Energy and Time

	ITG	ISAE
Heating Value (Btu/scf)	1024	1027
Starting Temperature (°F)	74	75
Energy Consumption (Btu)	20,004	20,527
Duration (min)	18.7	19.3
Preheat Rate (°F/min)	16.1	15.5

Idle Energy Rate

	ITG	ISAE
Heating Value (Btu/scf)	1024	1027
Idle Energy Rate @ 375°F (Btu/h)	18,960	18,20

Heavy-Load Cooking-Energy Efficiency and Cooking Energy Rate

	ITG	ISAE
Heating Value (Btu/scf)	1027	1025
Cooking Time (min)	7.33	8.54
Average Cooking Surface Recovery Time (min)	1.15	1.02
Production Capacity (lb/h)	42.7 ± 4.3	37.8 ± 1.6
Energy to Food (Btu/lb)	482	483
Cooking Energy Rate (Btu/h)	53,235	46,109
Energy per Pound of Food Cooked (Btu/lb)	1,249	1,220
Cooking-Energy Efficiency (%)	38.6 ± 1.0	39.6 ± 1.2

Results Reporting Sheets

Light-Load Cooking-Energy Efficiency and Cooking Energy Rate

	ITG	ISAE
Heating Value (Btu/scf)	1017	1025
Cooking Time (min)	8.53	8.81
Average Cooking Surface Recovery Time (min)	< 1.0	< 1.0
Production Capacity (lb/h)	6.6 ± 0.5	6.4 ± 0.5
Energy to Food (Btu/lb)	469	485
Cooking Energy Rate (Btu/h)	24,741	23,034
Energy per Pound of Food Cooked (Btu/lb)	3,763	3,602
Cooking-Energy Efficiency (%)	12.5 ± 0.8	13.5 ± 1.1

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. ITG Heavy-Load Test Data.

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Total Energy (Btu)	46,671	43,925	44,706
Cook Time (min)	7.50	7.16	7.33
Total Test Time (min)	53.2	49.2	50.1
Weight Loss (%)	35.5	33.7	33.9
Initial Weight (lb)	36.115	36.115	36.115
Final Weight (lb)	23.277	23.954	23.856
Initial Fat Content (%)	18.5	18.5	18.5
Initial Moisture Content (%)	61.5	61.5	61.5
Final Moisture Content (%)	49.6	50.7	50.3
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	164	159	160
Calculated Values			
Initial Weight of Water (lb)	22.209	22.209	22.209
Final Weight of Water (lb)	11.553	12.136	12.003
Weight of Fat (lb)	6.683	6.683	6.683
Weight of Solids (lb)	7.223	7.223	7.223
Sensible to Ice (Btu)	355	355	355
Sensible to Water (Btu)	2,932	2,829	2,843
Sensible to Fat (Btu)	438	426	428
Sensible to Solids (Btu)	237	230	231
Latent - Water Fusion (Btu)	3,198	3,198	3,198
Latent - Fat Fusion (Btu)	302	304	304
Latent - Water Vaporization (Btu)	10,336	9,771	9,900
Total Energy to Food (Btu)	17,799	17,114	17,259
Energy to Food (Btu/lb)	493	474	478
Total Energy to Griddle	46,671	43,926	44,707
Energy to Griddle (Btu/lb)	1,292	1,216	1,238
Cooking-Energy Efficiency (%)	38.1	39.0	38.6
Cooking Energy Rate (Btu/h)	52,607	53,590	53,509
Production Rate (lb/h)	40.7	44.1	43.2
Average Recovery Time (min)	1.4	1.0	1.0

Cooking-Energy Efficiency Data

Table D-3. ITG Light-Load Test Data.

	Repetition #1	Repetition #2	Repetition #3	Repetition #4
Measured Values				
Total Energy (Btu)	22,919	23,699	22,821	21,164
Cook Time (min)	8.80	8.92	8.15	8.24
Total Test Time (min)	57.0	57.2	52.6	53.1
Weight Loss (%)	33.4	35.8	35.6	33.3
Initial Weight (lb)	6.019	6.019	6.019	6.019
Final Weight (lb)	4.011	3.863	3.878	4.014
Initial Fat Content (%)	18.9	18.9	18.9	18.9
Initial Moisture Content (%)	61.1	61.1	61.1	61.1
Final Moisture Content (%)	51.0	52.9	50.3	52.1
Initial Temperature (°F)	0	0	0	0
Final Temperature (°F)	159	165	164	159
Calculated Values				
Initial Weight of Water (lb)	3.676	3.676	3.676	3.676
Final Weight of Water (lb)	2.046	2.045	1.952	2.092
Weight of Fat (lb)	1.139	1.139	1.139	1.139
Weight of Solids (lb)	1.204	1.204	1.204	1.204
Sensible to Ice (Btu)	59	59	59	59
Sensible to Water (Btu)	466	488	486	466
Sensible to Fat (Btu)	72	75	75	72
Sensible to Solids (Btu)	38	40	39	38
Latent - Water Fusion (Btu)	529	529	529	529
Latent - Fat Fusion (Btu)	53	52	52	53
Latent - Water Vaporization (Btu)	1,581	1,582	1,672	1,537
Total Energy to Food (Btu)	2,799	2,826	2,913	2,754
Energy to Food (Btu/lb)	465	469	484	458
Total Energy to Griddle	22,919	23,699	22,822	21,164
Energy to Griddle (Btu/lb)	3,808	3,937	3,808	3,808
Cooking-Energy Efficiency (%)	12.2	11.9	12.8	13.0
Cooking Energy Rate (Btu/h)	24,134	24,877	26,032	23,922
Production Rate (lb/h)	6.3	6.3	6.9	6.8
Average Recovery Time (min)	0.7	0.6	0.6	0.6

Cooking-Energy Efficiency Data

Table D-4. ISAE Heavy-Load Test Data.

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Appliance Gas (Btu)	44,806	43,810	43,612
Cook Time (min)	8.63	8.50	8.50
Total Test Time (min)	58.5	56.8	56.7
Weight Loss (%)	35.3	34.9	34.1
Initial Weight (lb)	36.115	36.115	36.115
Final Weight (lb)	23.374	23.506	23.802
Initial Fat Content (%)	17.8	17.8	17.8
Initial Moisture Content (%)	62.2	62.2	62.2
Final Moisture Content (%)	51.3	51.4	51.4
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	158	162	160
Calculated Values			
Initial Weight of Water (lb)	22.472	22.472	22.472
Final Weight of Water (lb)	12.000	12.091	12.243
Weight of Fat (lb)	6.420	6.420	6.420
Weight of Solids (lb)	7.223	7.223	7.223
Sensible to Ice (Btu)	360	360	360
Sensible to Water (Btu)	2,840	2,926	2,876
Sensible to Fat (Btu)	407	417	411
Sensible to Solids (Btu)	229	234	231
Latent - Water Fusion (Btu)	3,236	3,236	3,236
Latent - Fat Fusion (Btu)	283	281	283
Latent - Water Vaporization (Btu)	10,158	10,069	9,922
Total Energy to Food (Btu)	17,512	17,523	17,318
Energy to Food (Btu/lb)	485	485	480
Total Energy to Griddle	44,806	43,811	43,611
Energy to Griddle (Btu/lb)	1,241	1,213	1,208
Cooking-Energy Efficiency (%)	39.1	40.0	39.7
Cooking Energy Rate (Btu/h)	45,947	46,246	46,133
Production Rate (lb/h)	37.0	38.1	38.2
Average Recovery Time (min)	1.1	1.0	1.0

Cooking-Energy Efficiency Data

Table D-5. ISAE Light-Load Test Data.

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Total Energy (Btu/h)	20,941	22,304	21,805
Cook Time (min)	8.50	8.93	9.00
Total Test Time (min)	54.6	57.3	57.6
Weight Loss (%)	33.3	34.0	33.9
Initial Weight (lb)	6.019	6.019	6.019
Final Weight (lb)	4.016	3.973	3.977
Initial Fat Content (%)	17.8	17.8	17.8
Initial Moisture Content (%)	62.2	62.2	62.2
Final Moisture Content (%)	49.6	50.7	50.3
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	159	160	160
Calculated Values			
Initial Weight of Water (lb)	3.745	3.745	3.745
Final Weight of Water (lb)	1.993	2.013	2.001
Weight of Fat (lb)	1.070	1.070	1.070
Weight of Solids (lb)	1.204	1.204	1.204
Sensible to Ice (Btu)	60	60	60
Sensible to Water (Btu)	475	480	478
Sensible to Fat (Btu)	68	69	68
Sensible to Solids (Btu)	38	39	38
Latent - Water Fusion (Btu)	539	539	539
Latent - Fat Fusion (Btu)	47	47	47
Latent - Water Vaporization (Btu)	1,699	1,681	1,692
Total Energy to Food (Btu)	2,927	2,914	2,924
Energy to Food (Btu/lb)	486	484	486
Total Energy to Griddle	20,942	22,304	21,806
Energy to Griddle (Btu/lb)	3,479	3,705	3,623
Cooking-Energy Efficiency (%)	14.0	13.1	13.4
Cooking Energy Rate (Btu/h)	23,021	23,363	22,718
Production Rate (lb/h)	6.6	6.3	6.3
Average Recovery Time (min)	0.6	0.6	0.6

Cooking-Energy Efficiency Data

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

	Cooking-Energy Efficiency		Production Capacity
	Heavy Load	Light Load	
Replicate #1	38.1	12.2	40.7
Replicate #2	39.0	11.9	44.1
Replicate #3	38.6	12.8	43.2
Replicate #4	---	13.0	--
Average	38.6	12.5	42.7
Standard Deviation	0.41	0.50	1.75
Absolute Uncertainty	1.02	0.79	4.33
Percent Uncertainty	2.66	6.36	10.1

Table D-7 ISAE Cooking-Energy Efficiency and Production Capacity Statistics.

	Cooking-Energy Efficiency		Production Capacity
	Heavy Load	Light Load	
Replicate #1	39.1	14.0	37.0
Replicate #2	40.0	13.1	38.1
Replicate #3	39.7	13.4	38.2
Average	39.6	13.5	37.8
Standard Deviation	0.47	0.46	0.65
Absolute Uncertainty	1.16	1.14	1.62
Percent Uncertainty	2.92	8.46	4.28