

**Market Forge, ET-3E
Electric Steamer Performance Test**

Application of ASTM Standard
Test Method F 1484-99

FSTC Report 5011.01.99

**Food Service Technology Center
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Executive Summary

The Food Service Technology Center (FSTC) tested the Market Forge, Model ET-3E connectionless, electric steamer under the tightly controlled conditions of the American Society for Testing and Materials (ASTM) Standard Test Method for the Performance of Steam Cookers.¹ Steamer performance is characterized by preheat energy consumption and duration, idle energy rate, cooking energy rate and efficiency, production capacity, water consumption and condensate temperature from product testing. The spectrum of test products includes: full-load frozen green peas, light-load frozen green peas, full-load red potatoes and light-load red potatoes. The ET-3E was tested in both “Low” and “High” power settings which control the energy input to the appliance’s single heating element. The ET-3E is without a condensate drain; the measurement of condensate temperature was not applied. Water usage was less than 2 gallons per hour for any given cooking scenario.

A summary of the test results is presented in Table ES-1. Figure ES-1 illustrates the ET-3E’s cooking energy efficiency for different cooking scenarios. The production capacities are shown in Figure ES-2.

¹ American Society for Testing and Materials. 1999. *Standard Test Method for the Performance of Steam Cookers*. ASTM Designation F1484-99, in the *Annual Book of ASTM Standards*, Philadelphia: American Society for Testing and Materials.

Executive Summary

The Market Forge ET-3E is a highly energy efficient connectionless, electric steamer. The approximate 90% cooking energy efficiency in either of its two power settings while cooking a full-load (3 pans) of frozen green peas is the highest energy efficiency of any steamer tested to date at the FSTC. The same can be said of the 77% cooking energy efficiency attained in both power settings during a light-load (1 pan) frozen green pea cooking test. The unit's "High" power setting increased production capacity for each cooking scenario but did not compromise cooking energy efficiency.

The steamer also exhibited low cooking energy rates. On average, the ET-3E's cooking energy rates never exceeded 4.0 kW for any given cooking event, except for the full-load frozen pea test conducted in the "High" power setting. Its measured energy rate of 5.2 kW was still well below the unit's maximum rated input of 6.0 kW. In the "Low" power setting the same cooking scenario demonstrated a cooking energy rate of 3.8 kW. The light-load potato tests had the lowest cooking energy rates, with an approximate energy consumption rate of 1.5 kW for each power setting.

A low idle energy rate of 0.2 kW and negligible water consumption while using the unit's "Idle/Hold" feature complements the ET-3E's high cooking energy efficiencies.

Executive Summary

Table ES-1. Performance Summary, Market Forge, Model ET-3E.

Preheat and Idle (Idle Performed in "Idle/Hold" Mode)

Rated Energy Input Rate (kW)	6.0
Measured Energy Input Rate (kW)	6.1
Preheat Time (min)	17.1
Preheat Energy (kWh)	1.2
Idle Energy Rate (kW)	0.2

Full-Load Frozen Green Peas (3 pans) ***Low Power*** ***High Power***

Cook Time (min)	33.3	23.8
Cooking Energy Rate (kW)	3.8	5.2
Cooking Energy Efficiency (%)	89.1	90.1
Production Capacity (lb/h)	43	61
Water Consumption (gal/h)	<2.0	<2.0

Light-Load Frozen Green Peas (1 pan)

Cook Time (min)	15.3	13.8
Cooking Energy Rate (kW)	3.2	3.5
Cooking Energy Efficiency (%)	77.2	77.0
Water Consumption (gal/h)	<2.0	<2.0

Full-Load Red Potatoes (3 pans)

Cook Time (min)	29.1	23.2
Cooking Energy Rate (kW)	2.4	3.0
Cooking Energy Efficiency (%)	66.2	67.9
Production Capacity (lb/h)	50	63
Water Consumption (gal/h)	<2.0	<2.0

Light-Load Red Potatoes (1 pan)

Cook Time (min)	25.6	21.2
Cooking Energy Rate (kW)	1.4	1.6
Cooking Energy Efficiency (%)	44.4	45.4
Water Consumption (gal/h)	<2.0	<2.0

Executive Summary

Figure ES-1.
Steamer Cooking
Energy Efficiency
Under Two Loading
Scenarios.

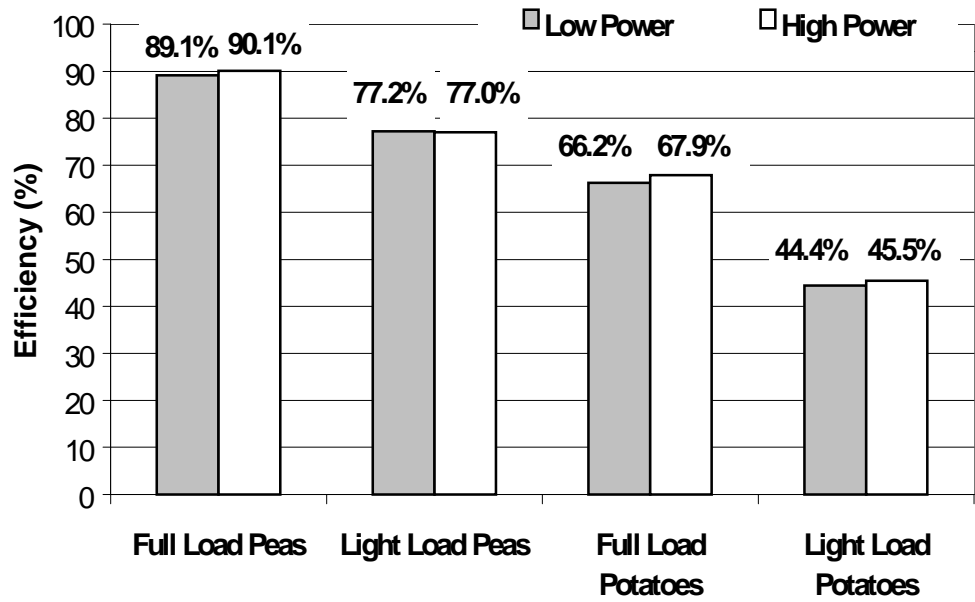
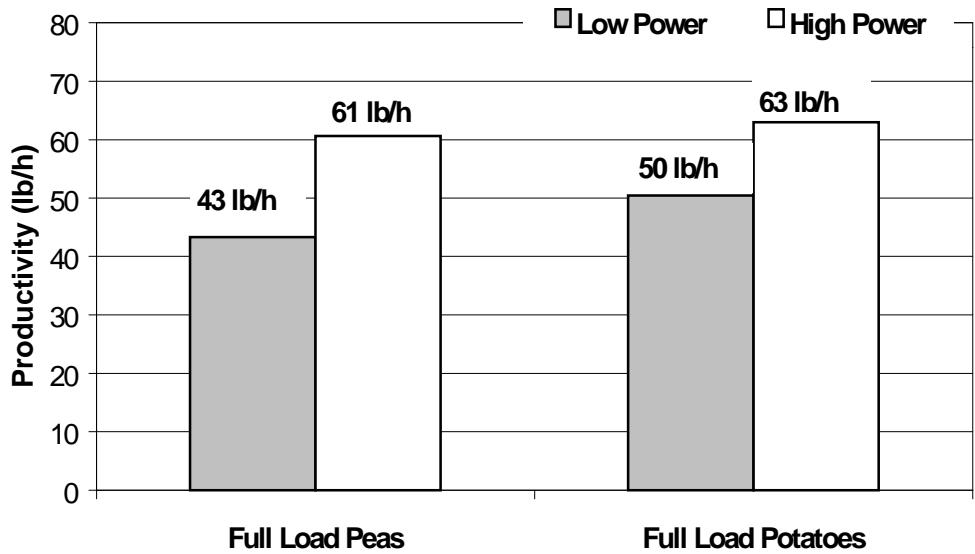


Figure ES-2.
Steamer Production
Capacity.



1 Introduction

Background

Steaming provides a fast-cook option for preparing large quantities of food while retaining vital nutrients in the cooked product. Beyond the capital cost, steamers should be evaluated with regard to long-term performance and operational costs characterized by cooking energy efficiency, production capacity and water consumption.

The Pacific Gas and Electric Company's Food Service Technology Center (FSTC) developed a uniform testing procedure to evaluate the performance of gas and electric steam cookers.¹ This test procedure was submitted to the American Society for Testing and Materials (ASTM) and accepted as a standard test method in December 1993.² In keeping with ASTM's policy that a standard be periodically reviewed, the FSTC revised the steamer test method in February 1999 under Designation F 1484-99³ (originally published as F 1484-93²). Modification to the test method included replacing the ice-load test with frozen green peas to emulate real-world application and reducing the three loading scenarios to two. Pacific Gas & Electric Company's *Development and Validation of a Uniform Testing Procedure for Steam Cookers* documents the developmental procedures and presents test results for both gas and electric steamers.¹

The Market Forge, ET-3E is a single-compartment, electric connectionless steamer. The heating element is positioned in the cooking compartment's water reservoir, eliminating the need for a separate boiler. The ET-3E steamer was tested according to the ASTM procedure, and this report documents the results. The glossary in Appendix A provides a quick reference to the terms used in this report.

Introduction

Objectives

The objective of this report is to examine the operation and performance of the Market Forge ET-3E steamer, 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. Determine the preheat duration and energy consumption of the steamer.
3. Measure the idle energy rate with the appliance in the "Idle/Hold" mode.
4. Determine the cooking energy efficiency under 4 scenarios: full-load frozen green peas (3 pans), light-load frozen green peas (1 pan), full-load red potatoes (3 pans) and light-load red potatoes (1 pan) in both "Low" and "High" power settings.
5. Determine the production capacity, cooking energy rate and cook time of each loading scenario in both "Low" and "High" power settings.

Appliance Description and Operation

The ET-3E is a stainless steel, electric connectionless steamer with a single 6 kW heating element placed in the bottom of the cooking compartment's water reservoir (Figure 1-1). Steam is generated within the cooking compartment without a separate boiler. Water is added and drained manually at the beginning and end of the day. The cooking chamber accommodates six 12" x 20" x 1", three 12" x 20" x 2½" or two 12" x 20" x 4" perforated steamer pans. The ET-3E has two power settings, "Low" power and "High" power. In "Low" power the steamer's heating element has a maximum energy input rate of 4 kW. In the "High" power setting the heating element is fully activated, with a maximum energy input of 6 kW. The unit also has a "Idle/Hold" mode that maximizes water and energy conservation between cooking events.

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

Introduction



Table 1-1. Appliance Specifications.

Manufacturer	Market Forge Industries, Inc.
Model	ET-3E
Generic Appliance Type	1-compartment, natural-convection, electric connectionless steamer.
Rated Input	6 kW
Technology	Boiler-less steamer with natural-convection.
Construction	300 Series 16-gauge stainless steel.
Controls	Main ON-OFF switch. "Low" power, "High" power setting selector switch. "Constant Steam" and "Idle/Hold" modes of operation coupled to a 60-minute mechanical timer with buzzer. Low water signal.
Compartment Capacity	6 (12" x 20" x 1") pans 3 (12" x 20" x 2½") pans 2 (12" x 20" x 4") pans
Dimensions	24" x 25.5" x 30"(w×h×d)

*Figure 1-1.
The Market Forge ET-3E Steamer (top appliance),
in Stacked Configuration with a
Market Forge ET-5E
(also a connectionless steamer).*

2 Methods

Setup and Instrumentation

The steamer was installed in accordance with the manufacturer's instructions under a 4-foot-deep canopy hood, with the lower edge of the hood 6 feet, 6 inches above the floor and a minimum of 6 inches inside the vertical front edge of the hood. The exhaust ventilation operated at a nominal rate of 150 cfm per linear foot of hood with the ambient temperature maintained at $75 \pm 5^\circ\text{F}$. All test apparatus were installed in accordance with Section 9 of the ASTM test method.³

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 a computerized data acquisition unit that recorded data every 5 seconds. A voltage regulator, connected to the steamer, maintained a constant voltage for all tests. Figure 2-1 shows the ET-3E instrumented with the data acquisition system.



*Figure 2-1.
The ET-3E Instrumented
for Testing.*

Methods

Measured Energy Input, Preheat and Idle Rate

The energy input rate was determined by measuring the energy consumed by the steamer during a complete preheat cycle. The maximum power draw during this period was reported as the measured energy input rate. Preheat tests recorded the time and energy required for the steamer to reach operating temperature from a cold start, as when turned on for the first time in a day. In order to follow the intent of the test method it was necessary to modify the preheat test in order to accurately judge when the preheat cycle was complete. Recording began when the steamer was turned on and ended when the cooking compartment temperature reached 210°F. A thermocouple probe was placed in the geometric center of the cooking cavity in order to determine when the steamer had reached full operational capacity. Researchers had found through observation and experience that the ET-3E's heating element cycled off prior to the cooking cavity reaching full steaming capacity. An hour after the preheat cycle, idle energy consumption was monitored for a 2-hour period.

Green Peas Full- and Light-Load Efficiency Tests

Individually flash-frozen, grade A green peas represented one of two food products for steamer performance testing. Standard, perforated, stainless-steel hotel pans (12" x 20" x 2½") are specified for cooking the green peas. The ET-3E required 3 pans of green peas for a full load, while 1 pan, placed on the center rack of the steamer cavity, comprises a light load. Each pan contained 8.0 ± 0.2 lb of green peas. Pre-weighed green peas in perforated pans were stored in sealed plastic bags at $0 \pm 5^\circ\text{F}$ for at least 24 hours. The pans of peas were transferred into an insulated box and transported to the testing location where the plastic bags were removed, and the pan(s) of green peas were loaded into the steamer according to the loading time prescribed in section 10.7.6 of the ASTM test method.³

Since probing proves difficult and erroneous in measuring temperature of the small-sized green peas, a water-bath calorimeter was utilized to measure the final bulk temperature of the cooked green peas.

Methods

Red Potatoes Full- and Light- Load Efficiency Tests

Freshly packed, size B, red potatoes served as the second food product for steamer performance testing. Again, the ET-3E required 3 pans of red potatoes for a full load and 1 pan for a light load, each pan containing 8.0 ± 0.2 lb. of potatoes.

The red potatoes were loaded into perforated pans prior to the test and stabilized to a room temperature of $75 \pm 5^\circ\text{F}$. The potatoes were cooked to $195 \pm 2^\circ\text{F}$ using a predetermined cook time. The final bulk temperature was determined by randomly probing potatoes using a hand-held digital thermocouple meter within 3 minutes after cooking was terminated.

Figure 2-2 shows the food products tested in the ET-3E steamer: frozen green peas, and red potatoes.



*Figure 2-2.
Products for Steamer
Tests: Red Potatoes
and Frozen Green
Peas.*

3 Results

Manufacturer's Rated Input and Maximum Energy Input Rate

Measured energy input rate and the manufacturer's nameplate value were compared prior to any testing to ensure that the steamer was operating within its specified parameters. The ET-3E drew a maximum input rate of 6.1 kW, 1.6% higher than the nameplate rate of 6.0 kW, but within the 5% tolerance of the ASTM standard.

Preheat and Idle Tests

Preheat Energy and Time

The cavity was manually filled with two gallons of water at $70 \pm 5^\circ\text{F}$. The steamer was placed in "Constant" steam mode, the "High" power setting was selected and the unit turned on. The preheat consumed 1.2 kWh during the 17.1 minute period. The preheat time reflects the point from when the unit was turned on until its cooking compartment reached full steaming capacity of 210°F .

Idle Energy Rate

Following the preheat period, the steamer was placed in its "Idle/Hold" mode and allowed to stabilize for one hour. Thereafter, the energy consumption was monitored over a 2-hour period and the idle energy rate was calculated to be 0.2 kW.

The "Idle/Hold" mode keeps the water temperature just below boiling to prevent excessive evaporation and energy use, but hot enough to ensure a timely return to full operational capacity. In the "Idle/Hold" mode the steamer cavity is maintained at a temperature between $150 - 190^\circ\text{F}$. Typically the appliance required 5-10 minutes to return the cavity temperature to 210°F .

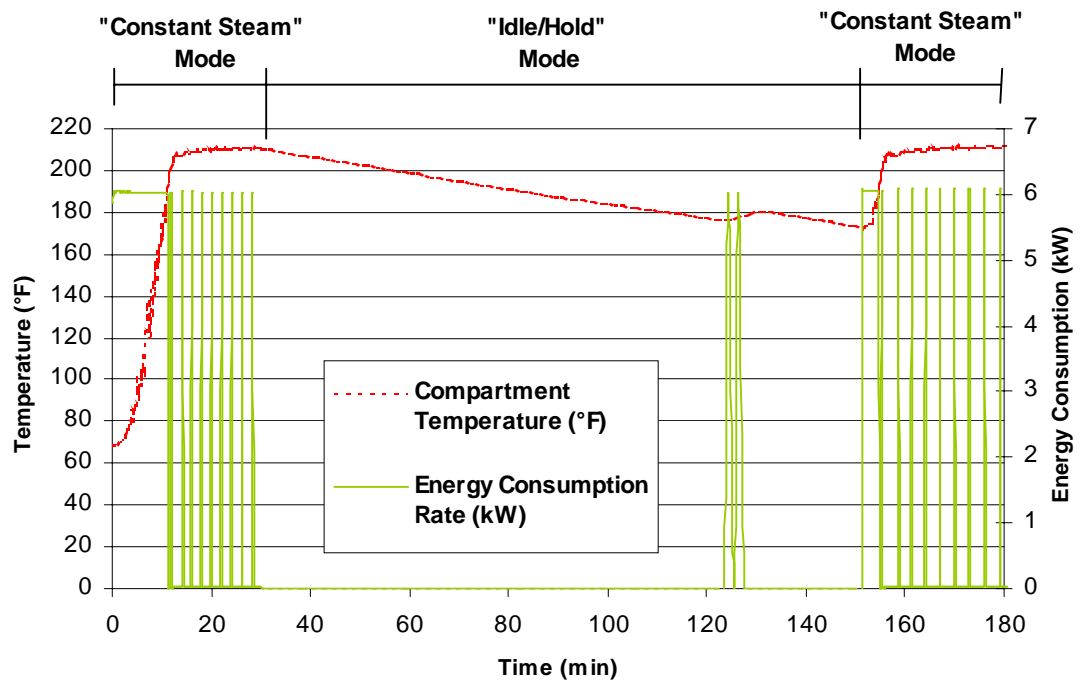
Results

Test Results

Rated energy input, preheat energy and idle rate test results are summarized in Table 3-1. Figure 3-1 illustrates the pre-heat and idle characteristics of the ET-3E.

Table 3-1. Average Input, Preheat and Idle Test Results.

Rated Energy Input Rate (kW)	6.0
Measured Energy Input Rate (kW)	6.1
Preheat to Operational Capacity	
Time (min)	17.1
Energy (kWh)	1.2
Idle Energy Rate (kW) (in "Idle/Hold" mode)	0.2



*Figure 3-1.
Preheat and Idle
Characteristics.*

Results

Cooking Tests

The steamer was tested with two test products under two loading scenarios: full-load green peas (3 pans), light-load green peas (1 pan), full-load red potatoes (3 pans), and light-load red potatoes (1 pan). Both loading scenarios for each food product were conducted in the “Low” power and “High” power settings. During all cooking tests, the “Constant Steam” mode of operation was utilized in order to ensure that the steamer’s heating element was engaged throughout the course of a cooking event. The energy consumption, elapsed cook time and ambient temperature were monitored for the duration of each test at five-second intervals.

The ET-3E does not employ a separate boiler, water connection or drain. Therefore, water consumption and condensate temperature were not monitored. Two gallons of water were poured into the bottom of the cooking compartment before testing began. The steamer was emptied at the end of the day as directed by the manufacturer’s instructions. Typical water usage was less than 2.0 gallons per hour.

Full- and Light-Load Green Peas Test

Moisture content of the frozen green peas was 81% by weight corresponding to specific heats (C_p) of 0.44 Btu/lb°F for frozen and 0.85 Btu/lb°F for thawed peas.⁴ In the “Low” power setting the ET-3E required 33.3 minutes to cook the full load of frozen green peas and had a cooking energy efficiency of 89.1% and a production capacity of 43 lb/h. When operated in the “High” power setting, the cook time dropped to 23.8 minutes, increasing the production capacity to 61 lb/h. The cooking energy efficiency remained relatively unchanged at 90.1%.

The light-load test required an average of 15.3 minutes when cooking a single pan of frozen green peas in the “Low” power setting and 13.8 minutes in the “High” power setting. Cooking energy efficiency and productivity were determined to be 77.2% and 32 lb/h, respectively in the “Low” setting, while in the “High” power setting they were determined to be 77.0% and 35 lb/h, respectively.

Results

Full- and Light-Load Potatoes Test

The red potatoes contained 84% moisture by weight with the specific heat (C_p) of 0.87 Btu/lb $^{\circ}$ F.⁴ In the “Low” power setting, a full load of potatoes averaged 29.1 minutes to reach a bulk cooked temperature of $195 \pm 2^{\circ}$ F. The cooking energy efficiency and production capacity was 66.2% and 50 lb/h, respectively. In the “High” power setting the cook time was reduced to 23.2 minutes and the cooking energy efficiency increased slightly to 67.9%. The production capacity in the “High” power setting was calculated to be 63 lb/h.

The single pan of red potatoes cooked in the “Low” power setting required 25.6 minutes to achieve an average bulk temperature of $195 \pm 2^{\circ}$ F. The light-load potato test exhibited a somewhat lower cooking energy efficiency of 44.4% and productivity to 19 lb/h. In the “High” power setting, the cook time was 21.2 minutes. The cooking energy efficiency was 45.4% and the production capacity was 23 lb/h.

Result Discussion

The rate at which steam condenses on food depends on the surface temperature and area of the food. Therefore, frozen green peas (at 0° F) and red potatoes (at room temperature) represent two extremities in steam cooking. Frozen green peas, having large surface area to volume ratio, promote condensation. The energy transfer from steam to frozen food is high, resulting in greater cooking energy efficiency and productivity. Potatoes are “tough” to cook due to low surface to volume ratio and the slower rate of condensation.

Results

Appendix D lists the physical properties and measured values of each test run. Using the detailed equations provided in section 11 of the Steamer ASTM Standard Test Method, the cooking energy efficiencies can readily be calculated. Tables 3-2 and 3-3 summarize the ET-3E's cooking performance. Figures 3-2 and 3-3 compare these results in a graphical format. Figures 3-4 and Figure 3-5 illustrate the steamer's part-load energy efficiencies. Figures 3-6, 3-7, 3-8 and 3-9 illustrate the steamer's cooking energy profile.

Table 3-2. Green Pea, Cooking Energy Efficiency and Production Capacity Test Results.

	Full Load Peas		Light Load Peas	
	Low Power	High Power	Low Power	High Power
Number of Pans	3	3	1	1
Cook Time (min)	33.3	23.8	15.3	13.8
Cooking Energy Rate (kW)	3.8	5.2	3.2	3.5
Cooking Energy Efficiency (%)	89.1	90.1	77.2	77.0
Production Rate (lb/h)	43	61	32	35
Energy Consumption (Btu/lb)	298	294	341	344

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

	Full Load Potatoes		Light Load Potatoes	
	Low Power	High Power	Low Power	High Power
Number of Pans	3	3	1	1
Cook Time (min)	29.1	23.2	25.6	21.2
Cooking Energy Rate (kW)	2.4	3.0	1.4	1.6
Cooking Energy Efficiency (%)	66.2	67.9	44.4	45.4
Production Rate (lb/h)	50	63	19	23
Energy Consumption (Btu/lb)	164	164	241	242

Results

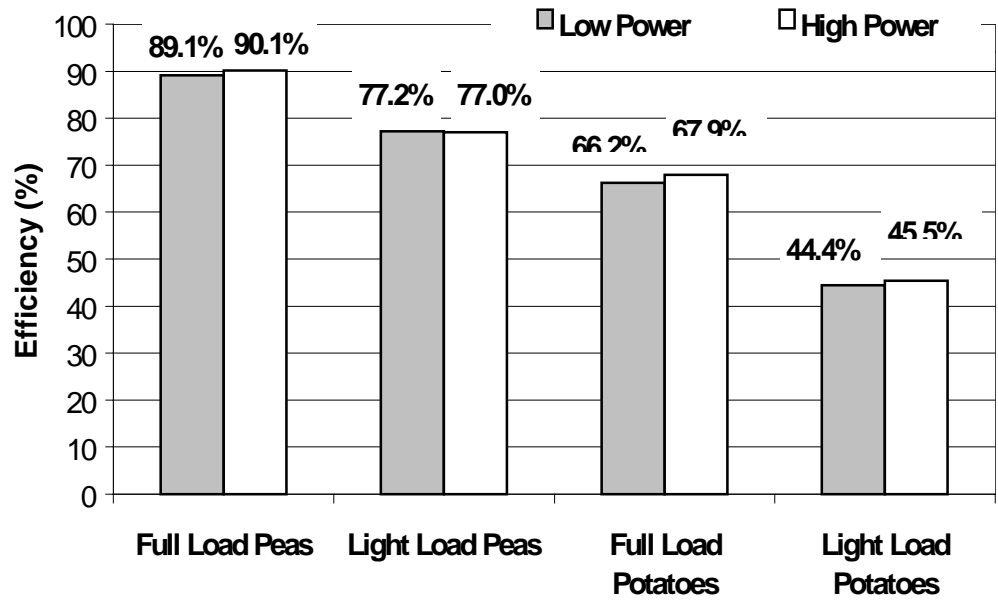


Figure 3-2.
Steamer Cooking Efficiency Under Full- and Light-Load Scenarios.

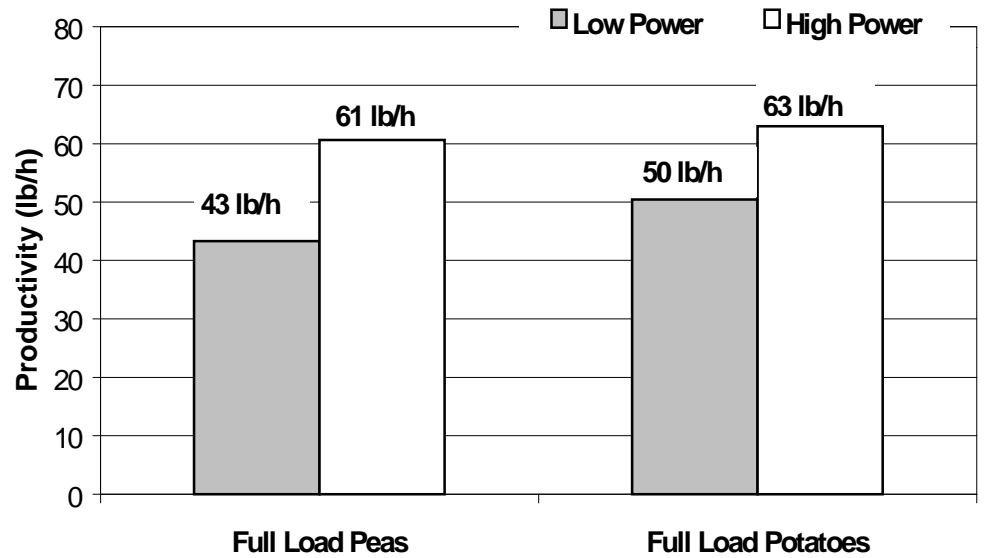


Figure 3-3.
Steamer Production Capacities.

Results

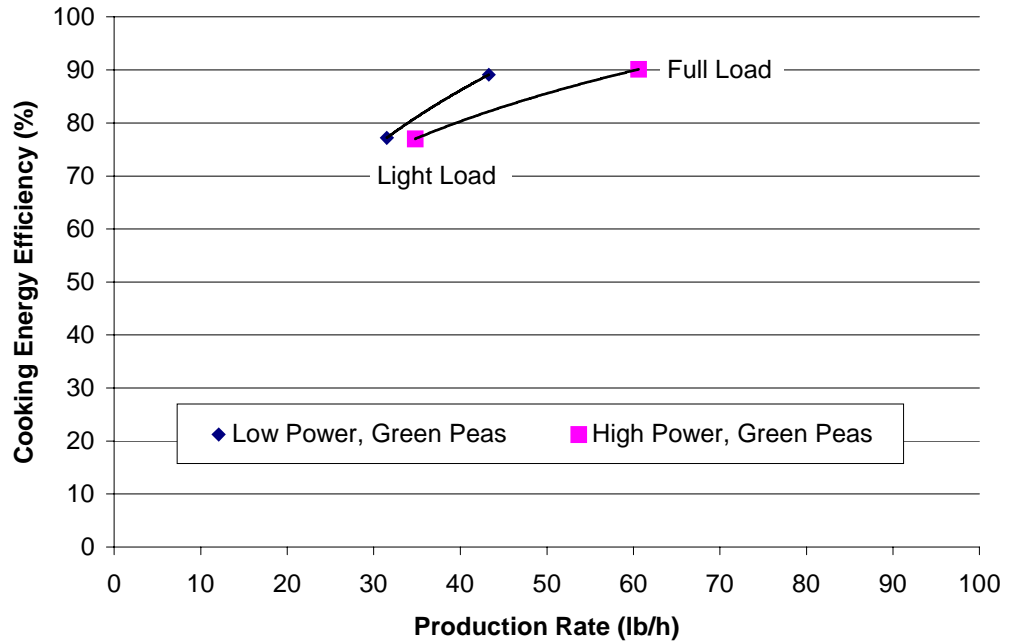


Figure 3-4.
Steamer Part-Load
Green Pea Cooking
Energy Efficiency.

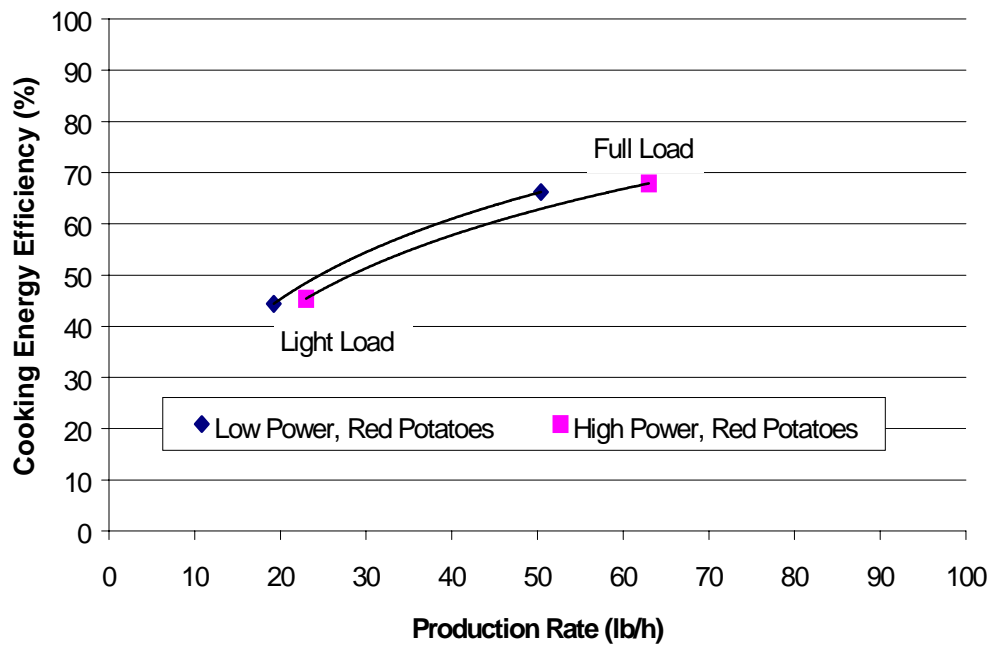


Figure 3-5.
Steamer Part-Load
Red Potato Cooking
Energy Efficiency.

Results

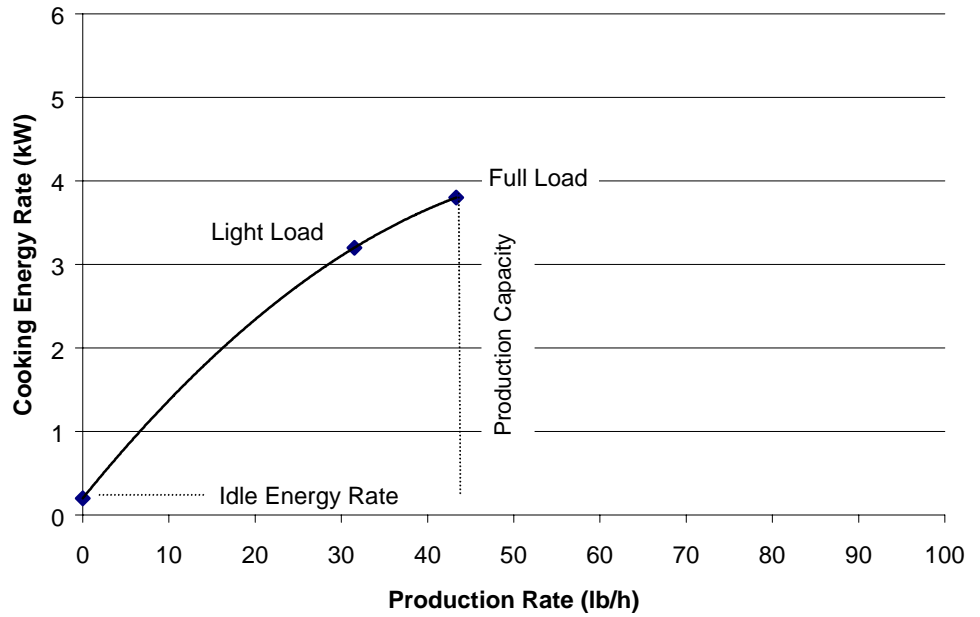


Figure 3-6.
Steamer Cooking Energy
Consumption Profile,
Green Peas, Low Power.

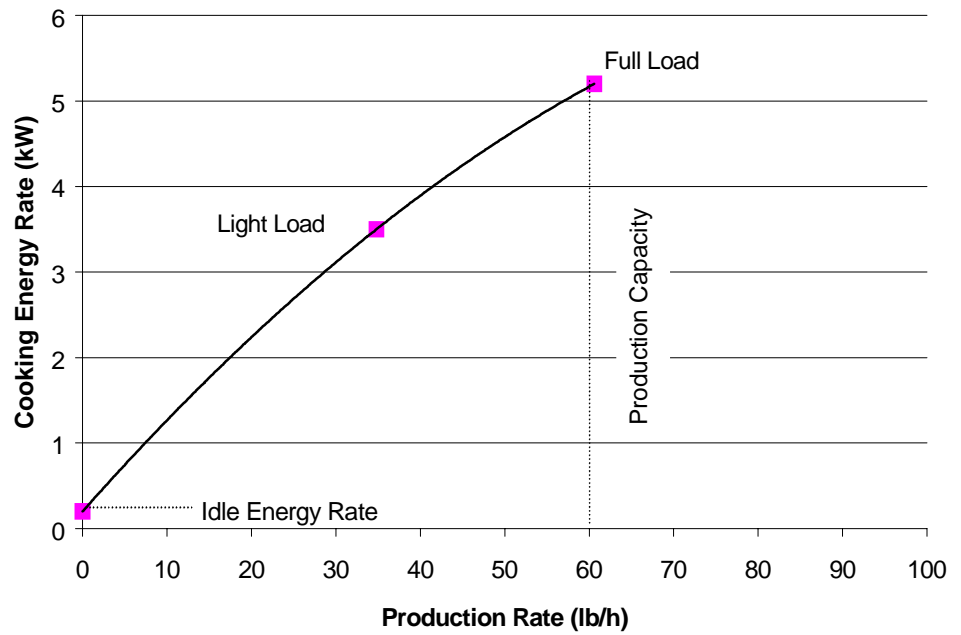


Figure 3-7.
Steamer Cooking Energy
Consumption Profile,
Green Peas, High Power.

Results

Figure 3-8.
Steamer Cooking Energy
Consumption Profile,
Red Potatoes, Low Power.

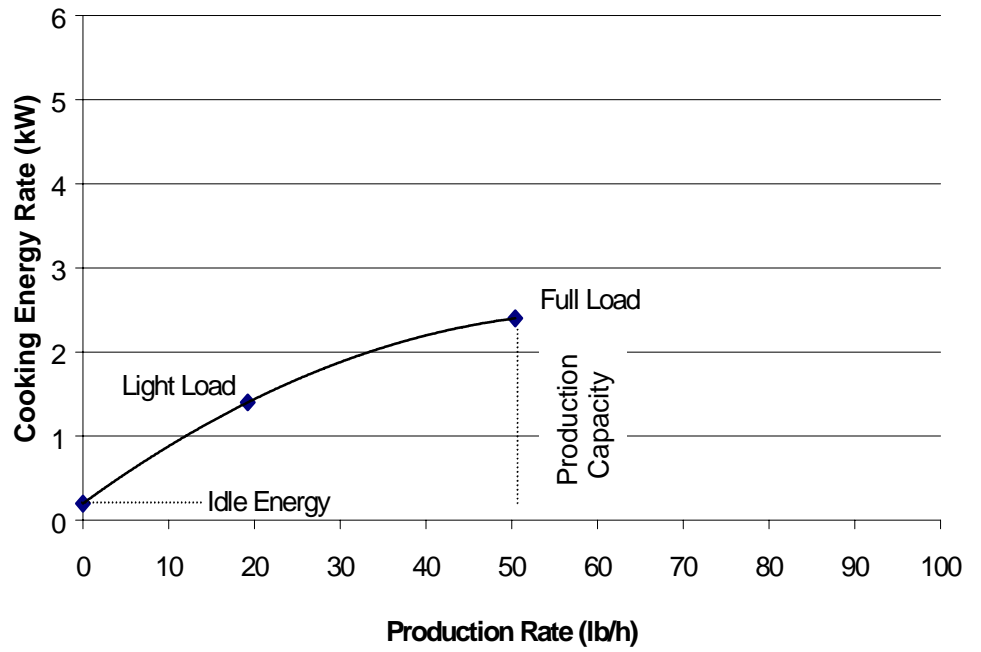
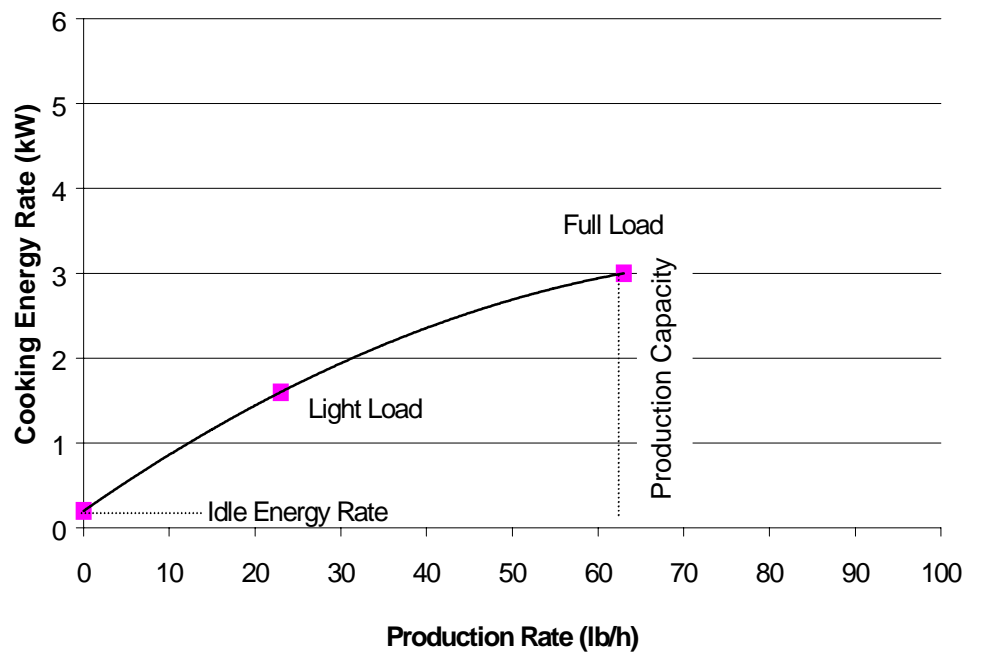


Figure 3-9.
Steamer Cooking Energy
Consumption Profile,
Red Potatoes, High Power.



4 Conclusions

The Market Forge, ET-3E electric steamer is one of the most energy efficient connectionless steamers tested to date at the FSTC. When tasked with cooking a frozen food product such as green peas the ET-3E achieved the highest cooking energy efficiency of any steamer tested to date in the laboratory, approximately 90% for full-load (3 pans) and 77% for light-load (1 pan).

1,5,6,7,8,9,10

The ET-3E's "High" power setting delivers respectable cook times during both food product cooking scenarios without compromising cooking energy efficiencies. The "Low" power setting, while lengthening cook times, reduces energy use when maximum productivity is not required. The "Low" power setting exhibited a cooking energy rate of 3.8 kW during the full load frozen pea cooking test, whereas the "High" power setting was found to have a cooking energy rate of 5.2 kW for the same cooking scenario. Further, a low idle energy rate of 0.2 kW, achieved with its "Idle/Hold" feature, maximizes the steamer's energy savings during prolonged periods between cooking events.

Compared to boiler-based steamers or those with steam generators, the ET-3E is truly a water miser.^{3,8,10} Typical water usage never exceeded 2.0 gallons per hour. With its "Idle/Hold" feature the water in the cooking compartment's reservoir is held at a low simmer, preventing excessive water loss. The cooking compartment temperature is maintained between 150 and 190°F. Operators need only allow 5 – 10 minutes for the cooking compartment to return to full operational capacity prior to a cooking event. As the ET-3E requires no water feed, or drain, appliance set-up and installation are greatly simplified.

Conclusions

The Market Forge ET-3E is ideal for kitchens with moderate steaming requirements. Compact in design and essentially a “plug and play” appliance, the Market Forge steamer provides operators with a steam cooking platform without the complexities associated with steamers requiring water hookup and drainage. With its two power settings operators can tailor cooking performance to menu demands and maximize energy savings when high productivity is not essential. Regardless of which power setting is utilized, however, high cooking energy efficiency is assured, minimizing the steamer’s impact on utility costs.

5 References

1. Food Service Technology Center. 1995. *Development and Application of a Uniform Testing Procedure for Steam Cookers*. Report 1022.95.19. Product and Services Department. San Francisco, California: Pacific Gas and Electric Company.
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A Glossary

Boiler

Self-contained electric, gas, or steam coil powered vessel wherein water is boiled to produce steam for the steam cooker. Also called a steam generator.

Boiler Idle Energy Rate

Idle Energy Rate

Idle Rate

Idle Energy Consumption Rate

Rate of energy consumed by the steam cooker while maintaining boiler operating pressure or temperature with no cooking taking place.

Boiler Preheat

Preheat

Process of bringing the boiler water from potable supply temperature to operating temperature (pressure).

Boiler Preheat Duration

Preheat Time

Preheat Period

Total time required for preheat, from preheat initiation at controls to when the steam cooker is ready to cook.

Boiler Preheat Energy

Preheat Energy Consumption

Amount of energy consumed by the steam cooker during a preheat.

Boiler Preheat Energy Rate

Preheat Energy Rate

The rate of appliance energy consumption while it is preheating to a predetermined temperature.

Condensate

A mixture of condensed steam and cooling water, exiting the steam cooker and directed to the floor drain.

Condensate Temperature

The temperature at which the condensate enters the floor drain.

Cooking Energy Efficiency

Energy Efficiency

Quantity of energy imparted to the specified food product expressed as a percentage of energy consumed by the steam cooker during the cooking event.

Cooking Energy Rate

Cooking Energy Consumption Rate

Average rate of energy consumption (kBtu/h or kW) during the cooking energy efficiency test. Refers to any loading scenario in the ice, pea or potato load tests.

Cook Time

Cooking Period

The period of time that the steamer is used for cooking.

Energy Input Rate

Peak rate at which a steamer consumes energy, typically reflects during preheat.

Glossary

Frozen Green Peas Load

12 x 20 x 2½ in. (300 x 500 x 65 mm) hotel pan filled with 8.0±0.2 lb (3630±90 g) of frozen, grade A, green peas subsequently frozen to 0±5°F (-18±2°C). One of two food product used to determine cooking energy efficiency and production capacity.

High-Pressure Steam Cooker

Steam cooker wherein cooking compartment operates between 10 and 15 psig (ASTM F1217-92 Classification Type III).

Idle Energy Consumption

Idle Energy Use

The amount of energy consumed by an appliance operating under an idle condition over the duration of an idle period.

Ice Load

12 x 20 x 2½ in. (300 x 500 x 65 mm) hotel pan filled with 8.0±0.2 lb (3630±90 g) of water and subsequently frozen to 0±5°F (-18±2°C). This is used to simulate a food product load in the ice load cooking energy efficiency and production capacity test.

Low-Pressure Steam Cooker

Steam cooker wherein the cooking compartment operates between 3 and 9.9 psig (ASTM F1217-92 Classification Type II).

Maximum Energy Input Rate

Measured Energy Input

Measured Peak Energy Input Rate

Peak Rate of Energy Input

Peak rate at which an appliance consumes energy.

Potato Load

12 x 20 x 2½ in. (300 x 500 x 65 mm) hotel pan filled with 8.0±0.2 lb (3.6±0.1 kg) of fresh, whole, US No. 1, size B, red potatoes. One of two food product used to determine cooking energy efficiency and production capacity.

Production Capacity

Maximum rate (lb(kg)/h) at which the steam cooker can bring the specified food product to a specified "cooked" condition.

Production Rate

Rate (lb(kg)/h) at which the steam cooker brings the specified food product to a specified "cooked" condition.

Rated Energy Input Rate

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.

Steam Cooker

Cooking appliance wherein heat is imparted to food in a closed compartment by direct contact with steam. The compartment can be at or above atmospheric pressure. The steam can be static or circulated.

Water Consumption

Water consumed by the steam cooker. Includes both water used in the production of steam and cooling water (if applicable) for condensing/cooling unused steam.

B Appliance Specification Sheet

Appendix B includes the product literature for the Market Forge, Model ET-3E steamer.

C Results Reporting Sheets

Manufacturer: Market Forge
Model: ET-3E
Date: February 2001

Section 11.1 Test Steam Cooker

ASTM F 1216 Classification (check one for each classification)

- Type I - Zero to 2.9 psig compartment pressure
- Type II - Three to 9.9 psig compartment pressure
- Type III - Ten to 15 psig compartment pressure

- Size 1-3 - One Compartment, 3 full-size pan capacity
- Size 1-4 - One Compartment, 4 full-size pan capacity
- Size 1-5 - One Compartment, 5 full-size pan capacity
- Size 1-6 - One Compartment, 6 full-size pan capacity
- Size 2-6 - Two Compartment, 6 full-size pan capacity
- Size 2-8 - Two Compartment, 8 full-size pan capacity
- Size 2-10 - Two Compartment, 10 full-size pan capacity
- Size 2-12 - Two Compartment, 12 full-size pan capacity
- Size 2-16 - Two Compartment, 16 full-size pan capacity
- Size 3-12 - Three Compartment, 12 full-size pan capacity
- Size 3-15 - Three Compartment, 15 full-size pan capacity
- Size 3-18 - Three Compartment, 18 full-size pan capacity
- Size 3-24 - Three Compartment, 24 full-size pan capacity

- Style A - Counter mounted
- Style B - Floor mounted on an open stand
- Style C - Floor mounted on a cabinet base
- Style D - Wall Mounted

- Class A - Direct connection to potable external steam source
- Class B - Self-contained steam coil steam generator
- Class C - Self-contained gas fired steam generator
- Class D - Self-contained electric steam generator

Results Reporting Sheets

Description of operational characteristics: Approximately two gallons of water is manually poured into the bottom of the cooking compartment. To preheat the steamer, the “Timed” steam mode is selected whereby the dial is turned to at least 15 minutes, the door is closed and the unit is turned on. For a cooking event, “Timed” or “Constant” steam mode is chosen using the mechanical timer dial. “Timed” steam mode terminates power to the heating element when the set cook time has elapsed. “Constant” steam mode maintains the cooking cavity at full operational capacity. The operator selects either the “Low” power or “High” power setting depending on menu demands. During idle periods the “Idle/Hold” feature is manually engaged. Water is manually drained at the end of the day or after each cooking event.

Section 10.7 Apparatus

The steamer was installed in accordance with the manufacturer’s instructions under a 4-foot-deep canopy hood, with the lower edge of the hood 6 feet, 6 inches above the floor and a minimum of 6 inches inside the vertical front edge of the hood. The exhaust ventilation operated at a nominal rate of 150 cfm per linear foot of hood with the ambient temperature maintained between $75 \pm 5^\circ\text{F}$. All test apparatus were installed in accordance with Section 9 of the ASTM test method.¹

The steamer was instrumented with an electric transducer to measure power and energy; a voltage regulator was used to maintain constant voltage for all tests. A computerized data acquisition system recorded test information at 10-second intervals for the red potato tests and 5-second intervals for the rest. All test apparatus were installed in accordance with Section 9 of the ASTM test method.

Section 11.4 Energy Input Rate

Measured	6.1 kW
Rated	6.0 kW
Percent Difference between Measured and Rated	1.6%

Section 11.5 Appliance Preheat Energy Consumption and Duration

Energy Consumption	1.2 kWh
Duration	17.1 min

Results Reporting Sheets

Section 11.6 Appliance Idle Energy Rate

Idle Energy Rate 0.2 kW

Section 11.8 Frozen Green Peas Cooking Time, Energy Efficiency, Energy Rate, Production Capacity, and Water Consumption Rate

Full Load:	Low Power	High Power
Cooking Time	33.3 min	23.8 min
Cooking Energy Efficiency	89.1 ± 2.9%	90.1 ± 2.4%
Cooking Energy Rate	3.8 ± 0.2 kW	5.2 ± 0.3 kW
Production Capacity	43.3 ± 0.0 lb/h	60.6 ± 2.1 lb/h
Water Consumption Rate	< 2.0 gal/h	< 2.0 gal/h

Light Load:		
Cooking Time	15.3 min	13.8 min
Cooking Energy Efficiency	77.2 ± 2.1 %	77.0 ± 4.3%
Cooking Energy Rate	3.2 ± 0.1 kW	3.5 ± 0.1 kW
Production Rate	31.5 ± 1.6 lb/h	34.8 ± 0.3 lb/h
Water Consumption Rate	< 2.0 gal/h	< 2.0 gal/h

Section 11.9 Whole Red Potatoes Cooking Time, Energy Efficiency, Energy Rate, Production Capacity, and Water Consumption Rate

Full Load:	Low Power	High Power
Cooking Time	29.2 min	23.2 min
Cooking Energy Efficiency	66.2 ± 0.3%	67.9 ± 1.6%
Cooking Energy Rate	2.4 ± 0.1kW	3.0 ± 0.2 kW
Production Capacity	50.4 ± 3.6lb/h	63.7 ± 2.0 lb/h
Water Consumption Rate	< 2.0 gal/h	< 2.0 gal/h

Results Reporting Sheets

Light Load:	Low Power	High Power
Cooking Time	25.6 min	21.2 min
Cooking Energy Efficiency	44.4 ± 2.9%	45.4 ± 3.6%
Cooking Energy Rate	1.4 ± 0.0 kW	1.6 ± 0.1kW
Production Capacity	19.2 ± 1.6 lb/h	23.0 ± 0.9 lb/h
Water Consumption Rate	< 2.0 gal/h	< 2.0 gal/h

D Cooking Energy Efficiency Data

Table D-1. Preheat and Idle Data

Measured Values	Replication 1	Replication 2	Replication 3
Preheat Time (min)	16.67	16.83	17.83
Preheat Energy (kWh)	1.22	1.20	1.32
Idle Time (min)	120.0	120.0	120.0
Idle Energy (kWh)	380.0	360.0	380.0
Calculated Values			
Preheat Energy Rate (kW)	4.98	4.39	4.44
Idle Energy Rate (kW)	0.19	0.18	0.19

Cooking Energy Efficiency Data

Table D-2. Full-Load Peas Data (Low Power)

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	3	3	3
Cook Time (min)	33.25	33.25	33.25
Initial Water Temperature (°F)	42.1	43.4	43.9
Final Water Temperature (°F)	98.0	98.9	100.7
Frozen Food Temperature (°F)	-4.4	-4.4	-4.4
Weight of Empty Calorimeter (lb)	44.5	44.5	44.2
Weight of Full Calorimeter (lb)	99.1	98.7	98.7
Weight of Calorimeter Water (lb)	30.0	30.0	29.9
Weight of Cooked Food (lb)	24.6	24.2	24.7
Weight of Frozen Food (lb)	24.0	24.0	24.0
Weight of Stainless-Steel Pans (lb)	7.6	8.6	8.6
Moisture Content (%)	81	81	81
Condensate Temperature (°F)	n/a	n/a	n/a
Water Consumption (gal/h)	<2.0	<2.0	<2.0
Calculated Values			
Moisture Weight in Green Peas (lb)	19.4	19.4	19.4
Final Food Temperature (°F)	178.3	180.0	181.9
Cooking Energy (kWh)	2.06	2.08	2.14
Energy Consumed by Green Peas (Btu)	6159.3	6194.7	6233.0
Energy Consumed by Pans (Btu)	152.6	174.0	175.7
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	7030.8	7099.0	7303.8
Cooking Energy Rate (kW)	3.7	3.8	3.9
Productivity (lb/h)	43.3	43.3	43.3
Energy Efficiency (%)	89.8	89.7	87.7

Cooking Energy Efficiency Data

Table D-3. Light-Load Peas Data (Low Power)

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	1	1	1
Cook Time (min)	16.33	15.75	15.75
Initial Water Temperature (°F)	42.1	41.4	49.7
Final Water Temperature (°F)	78.4	76.5	81.1
Frozen Food Temperature (°F)	-4.4	-4.4	-4.4
Weight of Empty Calorimeter (lb)	44.4	44.6	44.6
Weight of Full Calorimeter (lb)	72.6	72.7	72.4
Weight of Calorimeter Water (lb)	19.9	20.0	20.2
Weight of Cooked Food (lb)	8.3	8.1	7.7
Weight of Frozen Food (lb)	8.0	8.0	8.0
Weight of Stainless-Steel Pans (lb)	2.4	2.4	2.8
Moisture Content (%)	81	81	81
Condensate Temperature (°F)	n/a	n/a	n/a
Water Consumption (gal/h)	< 2.0	< 2.0	< 2.0
Calculated Values			
Moisture Weight in Green Peas(lb)	6.48	6.48	6.48
Final Food Temperature (°F)	180.8	178.3	178.5
Cooking Energy (kWh)	0.80	0.78	0.80
Energy Consumed by Green Peas (Btu)	2070.2	2053.1	2054.4
Energy Consumed by Pans (Btu)	49.1	48.1	56.5
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	2730.4	2662.1	2730.4
Cooking Energy Rate (kW)	2.9	3.0	3.0
Productivity (lb/h)	29.4	30.5	30.5
Energy Efficiency (%)	77.6	78.9	77.3

Cooking Energy Efficiency Data

Table D-4. Full-Load Potatoes Data (Low Power)

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	3	3	3
Cook Time (min)	28.17	29.58	29.67
Temperature of Uncooked Potatoes (°F)	77.0	75.3	72.9
Temperature of Cooked Potatoes (°F)	195.0	195.0	195.0
Weight of Stainless-Steel Pans (lb)	7.69	8.45	7.81
Weight of Potatoes (lb)	24.43	24.45	24.47
Total Potato Count	144	140	138
Moisture Content (%)	84	84	84
Condensate Temperature (°F)	n/a	n/a	n/a
Water Consumption (gal/h)	< 2.0	< 2.0	< 2.0
Calculated Values			
Moisture Weight in Potatoes (lb)	20.52	20.53	20.55
Average Weight of Each Potatoes (lb)	0.17	0.17	0.18
Cooking Energy (kWh)	1.16	1.18	1.20
Energy Consumed by Potatoes (Btu)	2516.89	2556.85	2610.15
Energy Consumed by Pans (Btu)	99.84	111.32	104.96
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	3959.08	4027.34	4095.60
Cooking Energy Rate (kW)	2.47	2.39	2.43
Productivity (lb/h)	52.05	49.58	49.48
Energy Efficiency (%)	66.09	66.25	66.29

Cooking Energy Efficiency Data

Table D-5. Light-Load Potatoes Data (Low Power)

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	1	1	1
Cook Time (min)	25.42	26.58	24.83
Temperature of Uncooked Potatoes (°F)	78.0	75.3	78.0
Temperature of Cooked Potatoes (°F)	195.0	195.0	195.0
Weight of Stainless-Steel Pans (lb)	2.20	2.79	2.79
Weight of Potatoes (lb)	8.20	8.20	8.20
Total Potato Count	46	48	48
Moisture Content (%)	84	84	84
Condensate Temperature (°F)	n/a	n/a	n/a
Water Consumption (gal/h)	< 2.0	< 2.0	< 2.0
Calculated Values			
Moisture Weight in Potatoes (lb)	6.89	6.89	6.89
Average Weight of Each Potatoes (lb)	0.18	0.17	0.17
Cooking Energy (kWh)	0.58	0.60	0.56
Energy Consumed by Potatoes (Btu)	837.56	857.60	837.84
Energy Consumed by Pans (Btu)	28.34	36.74	35.89
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	1979.54	2047.80	1911.28
Cooking Energy Rate (kW)	1.37	1.35	1.35
Productivity (lb/h)	19.36	18.51	19.81
Energy Efficiency (%)	43.74	43.67	45.71

Cooking Energy Efficiency Data

Table D-6. Full-Load Peas Data (High Power)

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	3	3	3
Cook Time (min)	23.75	23.42	24.08
Initial Water Temperature (°F)	48.0	47.6	48.2
Final Water Temperature (°F)	102.2	99.5	102.1
Frozen Food Temperature (°F)	-4.4	-4.4	-4.4
Weight of Empty Calorimeter (lb)	44.4	44.7	44.7
Weight of Full Calorimeter (lb)	99.3	98.3	98.6
Weight of Calorimeter Water (lb)	30.0	30.2	30.0
Weight of Cooked Food (lsb)	24.9	23.5	23.9
Weight of Frozen Food (lb)	24.0	24.0	24.0
Weight of Stainless-Steel Pans (lb)	8.4	8.4	8.0
Moisture Content (%)	81	81	81
Condensate Temperature (°F)	n/a	n/a	n/a
Water Consumption (gal/h)	< 2.0	< 2.0	< 2.0
Calculated Values			
Moisture Weight in Green Peas(lb)	19.44	19.44	19.44
Final Food Temperature (°F)	179.3	178.1	181.8
Cooking Energy (kWh)	2.06	2.08	2.06
Energy Consumed by Green Peas (Btu)	6179.6	6155.2	6231.3
Energy Consumed by Pans (Btu)	170.2	168.5	163.9
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	7030.8	7099.0	7030.8
Cooking Energy Rate (kW)	5.2	5.3	5.1
Productivity (lb/h)	60.6	61.5	59.8
Energy Efficiency (%)	90.3	89.1	91.0

Cooking Energy Efficiency Data

Table D-7. Light-Load Peas Data (High Power)

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	1	1	1
Cook Time (min)	13.75	13.75	13.83
Initial Water Temperature (°F)	49.0	43.4	42.4
Final Water Temperature (°F)	83.2	79.7	77.8
Frozen Food Temperature (°F)	-4.4	-4.4	-4.4
Weight of Empty Calorimeter (lb)	44.4	44.7	44.5
Weight of Full Calorimeter (lb)	72.6	73.0	72.6
Weight of Calorimeter Water (lb)	20.0	20.0	20.0
Weight of Cooked Food (lb)	8.2	8.4	8.1
Weight of Frozen Food (lb)	8.0	8.0	8.0
Weight of Stainless-Steel Pans (lb)	2.6	2.4	2.8
Moisture Content (%)	81	81	81
Condensate Temperature (°F)	n/a	n/a	n/a
Water Consumption (gal/h)	< 2.0	< 2.0	< 2.0
Calculated Values			
Moisture Weight in Green Peas(lb)	6.48	6.48	6.48
Final Food Temperature (°F)	181.7	182.0	181.4
Cooking Energy (kWh)	0.80	0.80	0.82
Energy Consumed by Green Peas (Btu)	2076.3	2078.0	2046.2
Energy Consumed by Pans (Btu)	53.0	49.5	55.0
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	2730.4	2730.4	2798.7
Cooking Energy Rate (kW)	3.5	3.5	3.6
Productivity (lb/h)	34.9	34.9	34.7
Energy Efficiency (%)	78.0	77.9	75.1

Cooking Energy Efficiency Data

Table D-8. Full-Load Potatoes Data (High Power)

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	3	3	3
Cook Time (min)	23.67	23.00	23.00
Temperature of Uncooked Potatoes (°F)	73.00	71.70	71.60
Temperature of Cooked Potatoes (°F)	195.0	195.0	195.0
Weight of Stainless-Steel Pans (lb)	7.22	7.65	7.79
Weight of Potatoes (lb)	24.35	24.18	24.20
Total Potato Count	144	148	143
Moisture Content (%)	84	84	84
Condensate Temperature (°F)	n/a	n/a	n/a
Water Consumption (gal/h)	< 2.0	< 2.0	< 2.0
Calculated Values			
Moisture Weight in Potatoes (lb)	20.47	20.33	20.34
Average Weight of Each Potatoes (lb)	0.17	0.16	0.17
Cooking Energy (kWh)	1.16	1.18	1.16
Energy Consumed by Potatoes (Btu)	2593.42	2603.13	2606.91
Energy Consumed by Pans (Btu)	96.90	103.71	105.80
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	3959.08	4027.34	3959.08
Cooking Energy Rate (kW)	2.94	3.08	3.03
Productivity (lb/h)	61.73	63.09	63.13
Energy Efficiency (%)	67.95	67.21	68.52

Cooking Energy Efficiency Data

Table D-9. Light-Load Potatoes Data (High Power)

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	1	1	1
Cook Time (min)	21.50	21.08	20.92
Temperature of Uncooked Potatoes (°F)	73.0	76.8	73.1
Temperature of Cooked Potatoes (°F)	195.0	195.0	195.0
Weight of Stainless-Steel Pans (lb)	2.41	2.41	2.79
Weight of Potatoes (lb)	8.10	8.11	8.13
Total Potato Count	45	48	46
Moisture Content (%)	84	84	84
Condensate Temperature (°F)	n/a	n/a	n/a
Water Consumption (gal/h)	< 2.0	< 2.0	< 2.0
Calculated Values			
Moisture Weight in Potatoes (lb)	6.80	6.81	6.83
Average Weight of Each Potatoes (lb)	0.18	0.17	0.18
Cooking Energy (kWh)	0.56	0.58	0.58
Energy Consumed by Potatoes (Btu)	862.54	837.88	865.31
Energy Consumed by Pans (Btu)	32.32	31.40	37.40
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	1911.28	1979.54	1979.54
Cooking Energy Rate (kW)	1.56	1.65	1.66
Productivity (lb/h)	22.60	23.09	23.32
Energy Efficiency (%)	46.82	43.91	45.60

