

**Market Forge, STP-6E
Electric Steamer Performance Test**

Application of ASTM Standard
Test Method F 1484-99

FSTC Report 5011.01.05

**Food Service Technology Center
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Contents

	Page
Executive Summary	iii
1 Introduction	1-1
Background	1-1
Objectives	1-2
Appliance Description and Operation	1-2
2 Methods	2-1
Setup and Instrumentation	2-1
Measured Energy Input, Preheat and Idle Rate.....	2-2
Green Peas Full- and Light-Load Efficiency Tests	2-2
Red Potatoes Full- and Light-Load Efficiency Tests.....	2-3
3 Results	3-1
Manufacturer's Rated Input and Maximum Input Energy Rate	3-1
Preheat and Idle Tests.....	3-1
Cooking Tests	3-3
4 Conclusions	4-1
5 References	5-1
Appendix A Glossary	
Appendix B Appliance Specification Sheet	
Appendix C Results Reporting Sheets	
Appendix D Cooking Energy Efficiency Data	

List of Figures and Tables

Tables:	Page
ES-1 Summary of the Performance	v
1-1 Appliance Specifications	1-3
3-1 Average Input, Preheat and Idle Test Results	3-2
3-2 Green Pea, Cooking Energy Efficiency and Production Capacity Test Results.....	3-5
3-3 Green Pea, Water Consumption and Condensate Temperature Test Results.....	3-5
3-4 Red Potato, Cooking Energy Efficiency and Production Capacity Test Results.....	3-5
3-5 Red Potato, Water Consumption and Condensate Temperature Test Results.....	3-5

Figures:	Page
ES-1 Steamer Cooking Energy Efficiency Under Full- and Light-Load Scenarios	vi
ES-2 Steamer Production Capacity	vi
1-1 The Market Forge STP-6E Steamer	1-3
1-2 Principles of Operation Schematic.....	1-4
2-1 The STP-6E Instrumented and Ready for Testing.....	2-1
3-1 Preheat and Idle Characteristics.....	3-2
3-2 Steamer Cooking Energy Efficiency Under Full- and Light-Load Scenarios.....	3-6
3-3 Steamer Production Capacity	3-6

Executive Summary

The Food Service Technology Center (FSTC) tested the Market Forge STP-6E electric, pressureless steamer under the 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.

A summary of the test results is presented in Table ES-1. Figure ES-1 illustrates the STP-6E's cooking energy efficiency for different cooking scenarios. The production capacities are shown in Figure ES-2.

The Market Forge STP-6E is an energy efficient and productive steam-generator type electric, pressureless steamer. Researchers recorded an average 15.6 minutes cook time for a full-load of frozen green peas resulting in a maximum production capacity of 185 lb/h. Approximately 81% of the steamer's cooking energy was transferred to the frozen green peas. When challenged with cooking red potatoes, the unit delivered approximately 50% of its cooking energy to this "tough" food product.

¹American 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

Not only did the STP-6E achieve high productivity and energy efficiencies; the steamer exhibited low water consumption rates for each of the test method's cooking scenarios. Typical light-load (1-pan) water consumption was 2 gal/h. A slightly greater water consumption rate was recorded during the full-load (6-pan) tests, 3-6 gal/h. Previously FSTC tested steam-generator and boiler-based steamers typically consumed between 20 and 60 gal/h.

The unit's patented steam control system effectively regulates steam production in accordance with the food product's ability to condense steam and absorb the heat energy. The technology relies upon pressure fluctuations within the cooking compartment to determine when steam generation is necessary. When a cooking event begins, the unit's cooking compartment is sealed, allowing no steam to escape. As the food product cooks and condenses less steam, the compartment pressure increases slightly, opening a pressure switch that in turn opens the circuit supplying energy to the steam generator's heating elements. Only when the pressure drops within the cooking compartment does the circuit close and activate the heating elements. Closure of the system allows the unit to emulate a pressure steamer reducing the quantity of useful steam released down the drain. The steam control system of the STP-6E prevents over production of steam, resulting in lower cooking energy rates and water consumption.

Low water consumption is also furthered by the unit's patented tempering tank, which cools any excess steam and/or condensate that may leave the cooking compartment by way of the condensate drain. The tempering tank not only eliminates the need for a dedicated water line to cool condensate and/or steam, it ensures that any water leaving the system is below 140°F.

Executive Summary

Table ES-1. Performance Summary, Market Forge STP-6E.

Preheat and Idle

Rated Energy Input Rate (kW)	18 (9 kW per compartment)
Measured Energy Input Rate (kW)	17.9
Preheat Time (min)	10.8
Preheat Energy (kWh)	1.3
Idle Energy Rate (kW)	0.9

Full-Load Frozen Green Peas (6 pans)

Cook Time (min)	15.6
Cooking Energy Rate (kW)	17.7
Cooking Energy Efficiency (%)	80.9
Production Capacity (lb/h)	185
Water Consumption (gal/h)	6

Light-Load Frozen Green Peas (1 pan)*

Cook Time (min)	9.4
Cooking Energy Rate (kW)	6.9
Cooking Energy Efficiency (%)	57.5
Water Consumption (gal/h)	2

Full-Load Red Potatoes (6 pans)

Cook Time (min)	22.3
Cooking Energy Rate (kW)	8.1
Cooking Energy Efficiency (%)	52.3
Production Capacity (lb/h)	131
Water Consumption (gal/h)	3

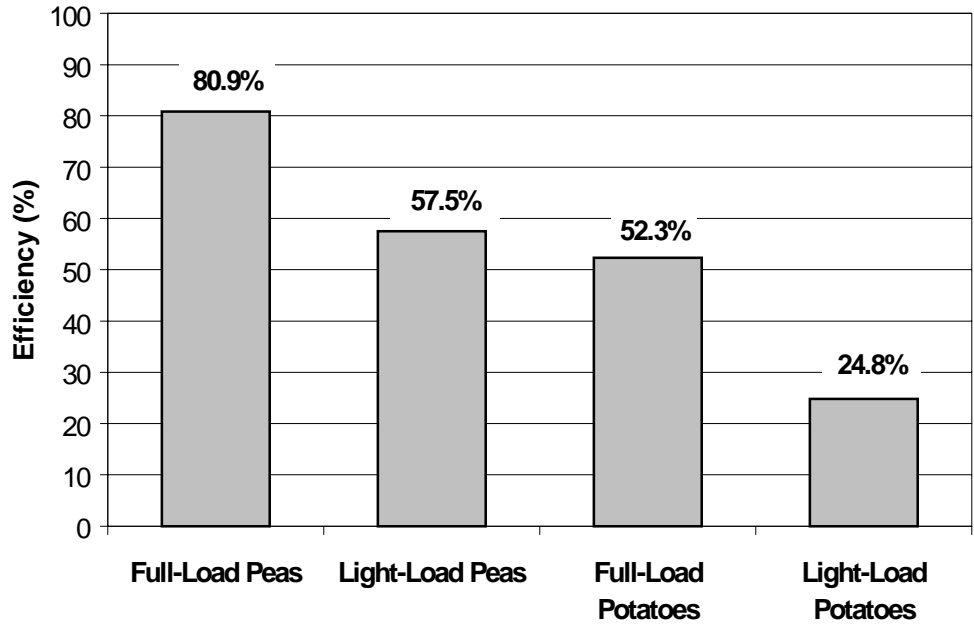
Light-Load Red Potatoes (1 pan)*

Cook Time (min)	21.0
Cooking Energy Rate (kW)	2.9
Cooking Energy Efficiency (%)	24.8
Water Consumption (gal/h)	1

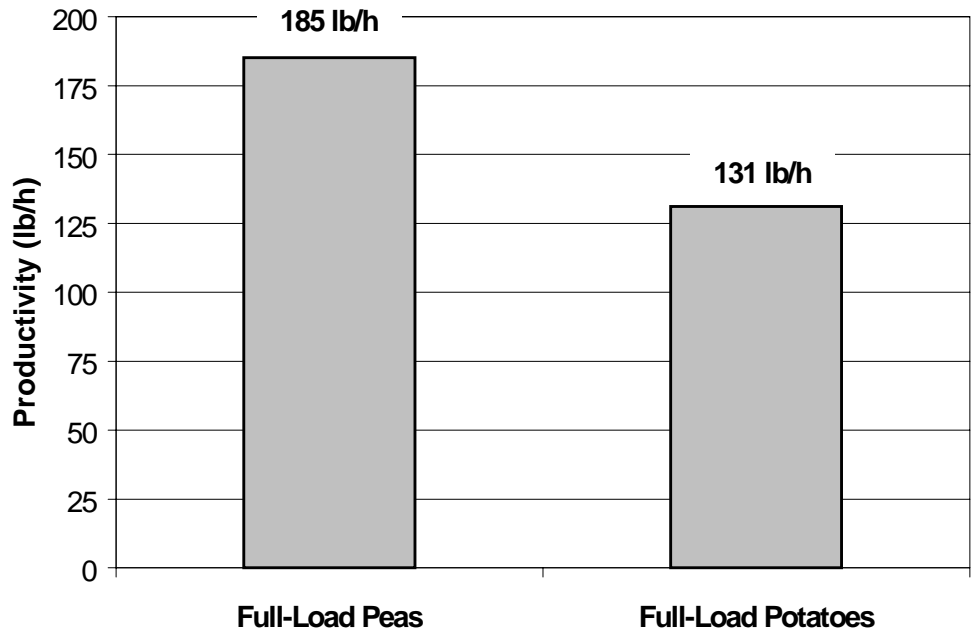
*Light-load tests were conducted with the top compartment operational only.

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.

The Market Forge STP-6E is a two-compartment, electric, pressureless steam-generator type steamer. The appliance has two steam generators, one for each cooking compartment. Each compartment has its own set of controls and can be operated independently. The STP-6E 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 STP-6E steamer, under the controlled conditions of the ASTM Standard Test Method. The scope of this testing is as follows:

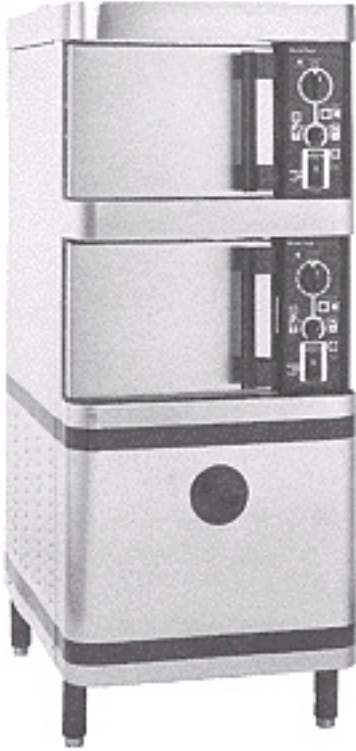
1. Verify that the appliance is operating at the manufacturer's rated energy input.
2. Determine the preheat duration and energy consumption of the steamer.
3. Measure the idle energy rate.
4. Determine the cooking energy efficiency under 4 scenarios: full-load frozen green peas (6 pans), light-load frozen green peas (1 pan), full-load red potatoes (6 pans) and light-load red potatoes (1 pan).
5. Determine the production capacity, cooking energy rate, water consumption, condensate temperature and cook time for each loading scenario.

Appliance Description and Operation

The Market Forge STP-6E is a two-compartment, electric steam-generator type pressureless steamer. The appliance has two steam-generators, one for each cooking compartment. Each compartment has its own set of controls allowing for independent operation. Typical of steam-generator type steamers, water and drain lines are required. The STP-6E has a unique steam control system that monitors minimal water column pressure fluctuations within the cooking compartment that reflect how much steam is being condensed by the food product. As less steam is condensed by the food during the cooking process and the pressure builds within the cooking compartment, the unit's steam-generator suspends steam production. Only when the compartment pressure lowers, indicating that the food has absorbed heat from the steam, will the steam-generator reactivate to produce more steam.

Appliance specifications are listed in Table 1-1. The steamer's principles of operation schematic is shown in Figure 1-2. The manufacturer's literature is in Appendix B.

Introduction



*Figure 1-1.
The Market Forge STP-6E Steamer.*

Table 1-1. Appliance Specifications.

Manufacturer	Market Forge
Model	STP-6E
Generic Appliance Type	Two compartment, dual electric steam-generator pressureless steamer.
Rated Input	18.0 kW (9.0 kW per compartment)
Technology	Electric steam generator
Construction	300 series stainless steel exterior. Stainless steel cooking compartment.
Controls	"ON/OFF" power switch. 60-minute electromechanical timer. "Constant Steam" button. "Steam" and "Steam and Hold" selector switch.
Compartment Capacity	6 (12" x 20" x 1") pans 3 (12" x 20" x 2 ¹ / ₂ ") pans 2 (12" x 20" x 4") pans
Dimensions	24" x 33" x 60.2"(wxdxh)

Introduction

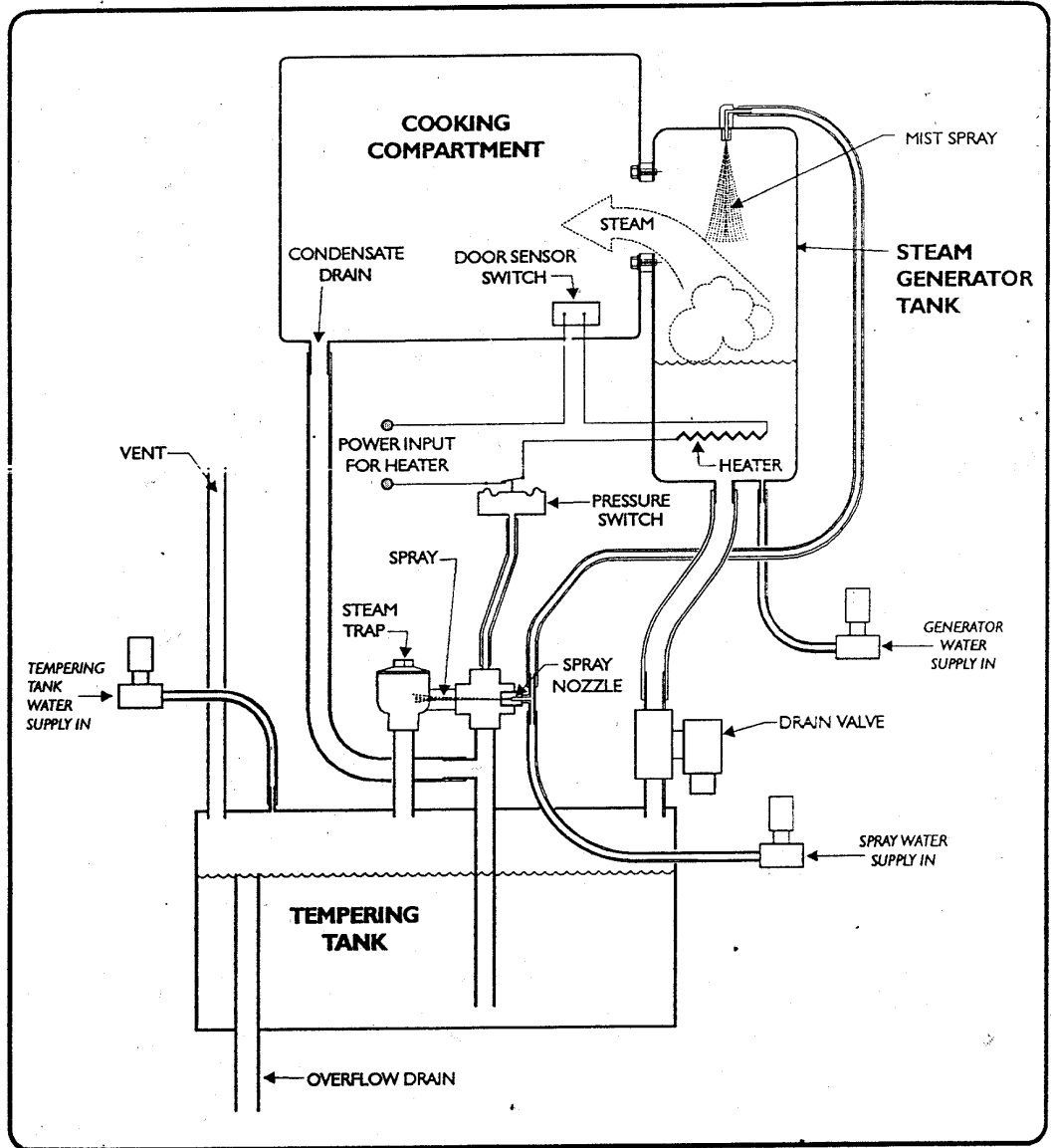


Figure 1-2.
Principles of Operation Schematic.

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 STP-6E instrumented with the data acquisition system.



*Figure 2-1.
The STP-6E 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 both of the steamer's steam generators to reach full operational capacity from a cold start, as when turned on for the first time in a day. Recording began when the steamer was turned on and ended when the steam-generators' heating elements cycled off. 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 STP-6E required 6 pans of green peas for a full load, while 1 pan, placed on the center rack of the top compartment, comprised a light load. The bottom compartment was turned *off* during the light-load cooking tests. 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 prior to the test. 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 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 STP-6E required 6 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. Again, only the top compartment was operational during the light-load cooking tests.

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.

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 STP-6E drew a maximum input rate of 17.9 kW, 0.6% lower than the nameplate rate of 18.0 kW, well within the 5% tolerance specified in the ASTM standard.

Preheat and Idle Tests

Preheat Energy and Time

The "ON/OFF" switch for each compartment was placed in the "ON" position, activating the steam generators. The preheat consumed 1.3 kWh during the 10.8 minute preheat period. The preheat time reflects the time required for both of the unit's steam generators to become fully operational.

Idle Energy Rate

Following the preheat period, the steamer was allowed to stabilize for one hour. Thereafter, the energy consumption of both compartment steam generators was monitored over a 2-hour period and the idle energy rate was calculated to be 0.9 kW.

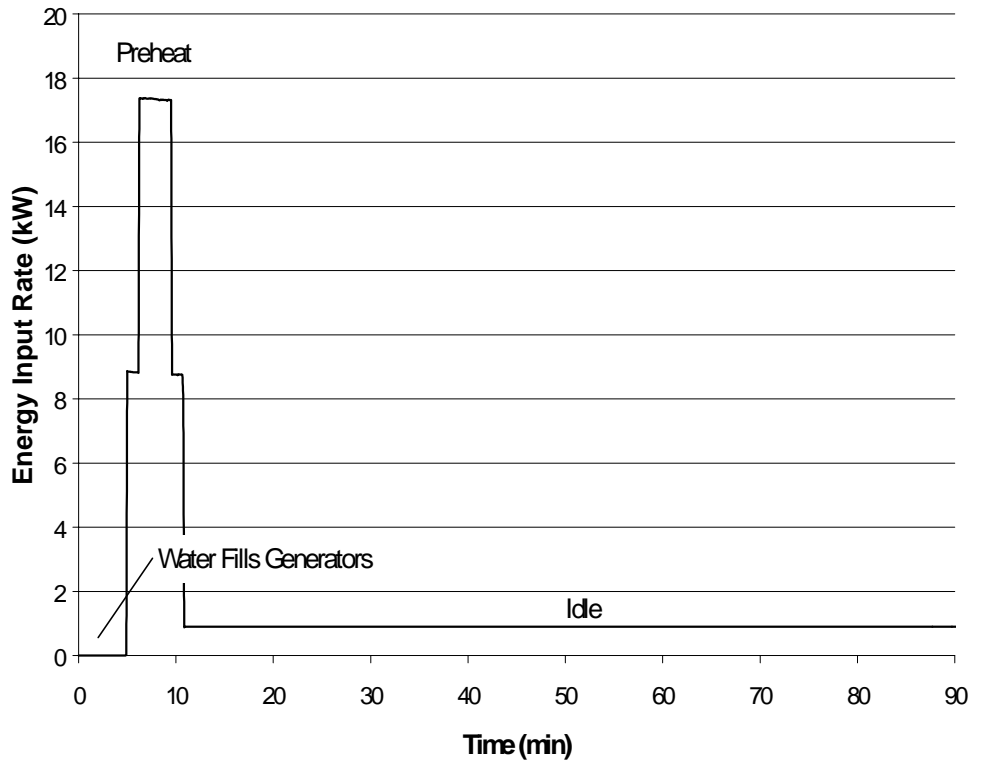
Results

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 STP-6E.

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

Rated Energy Input Rate (kW)	18.0
Measured Energy Input Rate (kW)	17.9
Preheat to Operational Capacity Time (min)	10.8
Energy (kWh)	1.3
Idle Energy Rate (kW)	0.9



*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 (6 pans), light-load green peas (1 pan), full-load red potatoes (6 pans), and light-load red potatoes (1 pan). All cooking scenarios were conducted in the unit's "Constant Steam" cooking mode.

In addition to monitoring energy consumption, water consumption was also measured. As well, the average condensate temperature over the final three minutes of each cooking test was recorded.

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 0.84 Btu/lb°F for thawed peas.⁴ The STP-6E required 15.8 minutes to cook the full load of frozen green peas and had a cooking energy efficiency of 80.9%, cooking energy rate of 17.7 kW and a production capacity of 185 lb/h. The steamer consumed water at a rate of 6 gal/h and the condensate temperature, measured at the drain, was 84.9°F.

The light-load test required an average of 9.4 minutes when cooking a single pan of frozen green peas. The cooking energy efficiency, cooking energy rate and productivity were determined to be 57.5%, 6.9 kW and 51 lb/h, respectively. Water consumption was 2 gal/h. The condensate temperature was 74.9 °F.

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°F.⁴ A full load of potatoes averaged 22.3 minutes to reach a bulk cooked temperature of $195 \pm 2^\circ\text{F}$. The cooking energy efficiency and cooking energy rate was 52.3% and 8.1 kW, respectively. Production capacity was calculated to be 131 lb/h. The steamer consumed water at a rate of 3 gal/h and exhibited a condensate temperature of 85.2°F.

Results

A single pan of red potatoes had a cook time of 21.0 minutes. Cooking energy efficiency was calculated to be 24.8%. The steamer had a cooking energy rate of 2.9 kW and a production capacity of 23 lb/h. Water consumption was 1 gal/h and the condensate temperature was 73.9°F.

Results 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 area to volume ratio and the slower rate of condensation.

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, 3-3, 3-4 and 3-5 summarize the STP-6E’s cooking performance. Figures 3-2 and 3-3 compare these results in a graphical format.

Results

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

	Full-Load Peas	Light-Load Peas
Number of Pans	6	1
Cook Time (min)	15.6	9.4
Cooking Energy Rate (kW)	17.7	6.9
Cooking Energy Efficiency (%)	80.9	57.5
Production Rate (lb/h)	185	51
Energy Consumption (Btu/lb)	328	465

Table 3-3. Green Pea, Water Consumption and Condensate Temperature Test Results.

	Full-Load Peas	Light-Load Peas
Water Consumption (gal/h)	6	2
Condensate Temperature (°F)	84.9	74.9

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

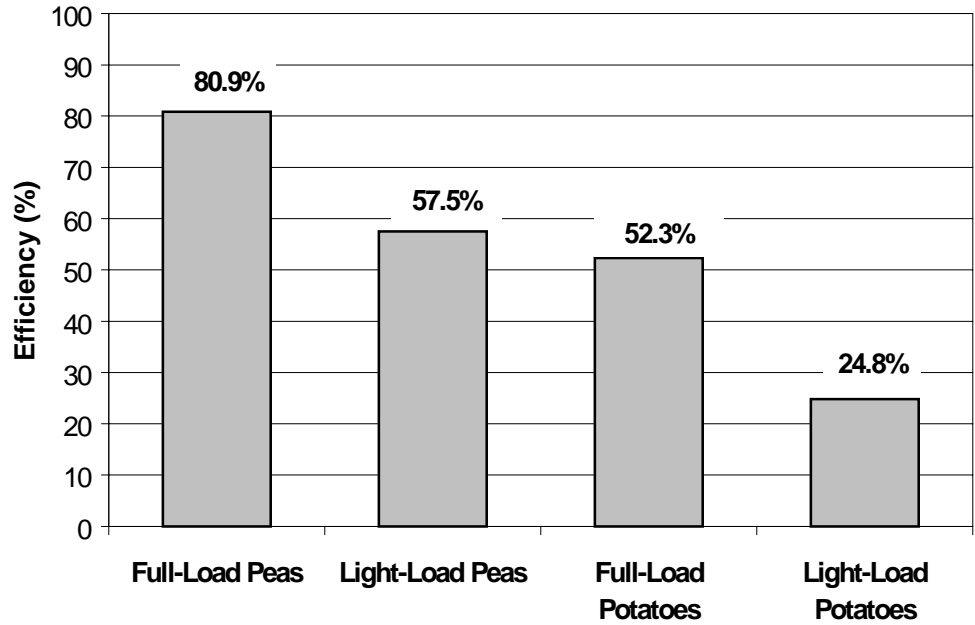
	Full-Load Potatoes	Light-Load Potatoes
Number of Pans	6	1
Cook Time (min)	22.3	21.0
Cooking Energy Rate (kW)	8.1	2.9
Cooking Energy Efficiency (%)	52.3	24.8
Production Rate (lb/h)	131	23
Energy Consumption (Btu/lb)	211	435

Table 3-5. Red Potato, Water Consumption and Condensate Temperature Test Results.

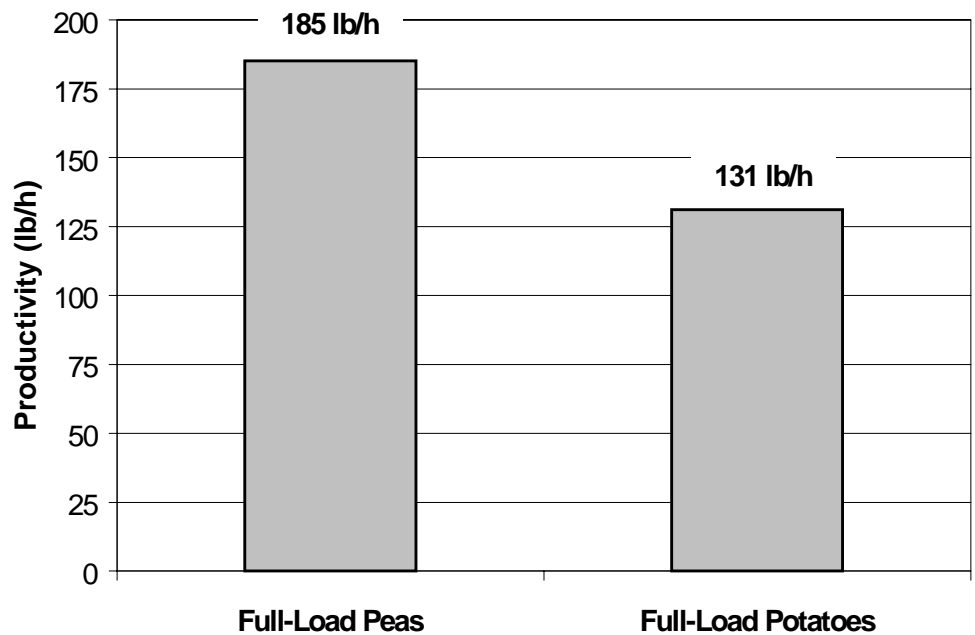
	Full-Load Potatoes	Light-Load Potatoes
Water Consumption (gal/h)	3	1
Condensate Temperature (°F)	85.2	73.9

Results

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



*Figure 3-3.
Steamer Production
Capacities.*



4 Conclusions

The Market Forge STP-6E steamer is an energy efficient and productive steam-generator type electric steamer. The unit's frozen green pea cooking energy efficiencies and production capacities were comparable to previously FSTC tested steam-generator type steamers, 80.9% for a full load and 57.5% for light. Production capacity was calculated so be 185 lb/h for full loads and 51 lb/h for light.^{1,8,16}

Most notable, however, were the cooking energy efficiencies exhibited during both full- and light- load red potato cooking scenarios. The STP-6E had a cooking energy efficiency of 52.2% for full loads (6 pans) and 24.8% for a light load (1 pan) when cooking this “tough” food product. Both efficiencies are significantly higher than those of other steam-generator type steamers tested to date at the FSTC.^{1,8,16} These high efficiencies can be attributed to the STP-6E's steam management system's pressure switch, which periodically seals the cooking compartment much like a pressure steamer, limiting the amount of useful steam released down the drain.

The light-load cooking scenario allows for ease of comparison between appliances of varying maximum loading capacities. For both single-pan scenarios, the STP-6E demonstrated lower cooking energy rates than that of previously tested steam-generator type steamers.^{1,8,16} Researchers calculated a cooking energy rate of 6.9 kW for a single pan of frozen green peas. A single pan of red potatoes had a lower cooking energy rate of 2.9 kW. The unit's steam management system effectively controls steam production, cycling the steam generators' heating elements on and off as needed as opposed to continuously producing surplus steam that would otherwise be vented out of the cooking compartment.

Conclusions

Low water consumption also separated the STP-6E from other steam-generator type and boiler based steamers previously tested at the FSTC.^{1,8,16,9,11} The Market Forge steamer consumed as little as 2 gal/h during the light-load cooking tests for both food products. At most, the steamer consumed 6 gal/h during the full-load frozen green peas tests. Previously tested steam-generator and boiler based steamers typically exhibited water consumption rates between 20 and 60 gal/h.^{1,8,9,11} Again, the unit's patented steam control system effectively regulated steam production, thus lowering the appliance's demand for water to replenish the steam-generator. Also, the condensate drain leads to a tempering tank that cools excess steam and/or condensate released from the cooking compartment. An overflow drain transports the small amount of cooled condensate to the sewer drain when the tempering tank's holding capacity has been exceeded. This patented system eliminates the need for a dedicated water line to cool condensate and ensures that any condensate leaving the system is below 140°F.

The Market Forge STP-6E can be characterized as a "smart" steamer; able to regulate steam production in accordance with the food's ability to condense the steam the appliance produces. As a result, less energy and water is consumed during the cooking process. For kitchens with moderately heavy steaming requirements and limited hotline space, the STP-6E is a viable candidate.

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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, STP-6E steamer.

C Results Reporting Sheets

Manufacturer: Market Forge
Model: STP-6E
Date: December 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: To activate either of the unit's steam generators, the "ON/OFF" switch is placed in the "ON" position. The steam-generator's water reservoir fills and the heating elements activate. Once full operational capacity has been reached, the operator can manually control steam cooking by depressing the "Constant Steam" button. The unit also features a "Timed" mode of operation by which an electromechanical timer terminates steam production once the desired cook time has elapsed. Shutting the unit off commences an automatic generator blow-down.

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	17.9 kW
Rated	18.0 kW
Percent Difference between Measured and Rated	0.6%

Section 11.5 Appliance Preheat Energy Consumption and Duration

Energy Consumption	1.3 kWh
Duration	10.8 min

Section 11.6 Appliance Idle Energy Rate

Idle Energy Rate	0.9 kW
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Results Reporting Sheets

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

Full Load:

Cooking Time	15.6 min
Cooking Energy Efficiency	80.9 ±1.3%
Cooking Energy Rate	17.7 ± 0.2 kW
Production Capacity	185.2 ±5.1 lb/h
Water Consumption Rate	5.7 gal/h

Light Load:

Cooking Time	9.4 min
Cooking Energy Efficiency	57.5 ±1.7%
Cooking Energy Rate	6.9 ± 0.5 kW
Production Rate	51.3 ± 1.7 lb/h
Water Consumption Rate	2.4 gal/h

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

Full Load:

Cooking Time	22.3 min
Cooking Energy Efficiency	52.3 ±2.1%
Cooking Energy Rate	8.1 ± 0.8 kW
Production Capacity	131.0 ± 9.4 lb/h
Water Consumption Rate	2.6 gal/h

Results Reporting Sheets

Light Load:

Cooking Time	21.0 min
Cooking Energy Efficiency	$24.8 \pm 0.9\%$
Cooking Energy Rate	$2.9 \pm 0.3\text{kW}$
Production Capacity	$23.3 \pm 8 \text{ lb/h}$
Water Consumption Rate	0.8 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)	10.75	10.75	10.83
Preheat Energy (kWh)	1.34	1.34	1.34
Idle Time (min)	120.0	120.0	120.0
Idle Energy (kWh)	1.8	1.8	1.8
Calculated Values			
Preheat Energy Rate (kW)	7.43	7.48	7.48
Idle Energy Rate (kW)	0.92	0.92	0.92

Cooking Energy Efficiency Data

Table D-2. Full-Load Peas Data

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	6	6	6
Cook Time (min)	15.5	15.8	15.4
Initial Water Temperature (°F)	57.1	45.1	50.9
Final Water Temperature (°F)	105.9	100.2	102.4
Frozen Food Temperature (°F)	-4.0	-4.0	-4.0
Weight of Empty Calorimeter (lb)	45.6	44.9	44.3
Weight of Full Calorimeter (lb)	152.9	153.1	152.7
Weight of Calorimeter Water (lb)	60.0	60.0	60.2
Weight of Cooked Food (lb)	47.3	48.1	48.2
Weight of Frozen Food (lb)	48.0	48.0	48.0
Weight of Stainless-Steel Pans (lb)	15.4	17.6	15.4
Moisture Content (%)	81	81	81
Condensate Temperature (°F)	86.6	87.5	85.9
Water Consumption (gal/h)	5.5	6.2	5.4
Calculated Values			
Moisture Weight in Green Peas (lb)	38.9	38.9	38.9
Final Food Temperature (°F)	179.0	181.2	178.2
Cooking Energy (Wh)	4600.0	4660.0	4540.0
Energy Consumed by Green Peas (Btu)	12345.7	12439.2	12313.2
Energy Consumed by Pans (Btu)	310.8	358.6	308.8
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	15699.8	15904.6	15495.0
Cooking Energy Rate (kW)	17.8	17.8	17.7
Productivity (lb/h)	185.8	182.9	186.8
Energy Efficiency (%)	80.6	80.5	81.5

Cooking Energy Efficiency Data

Table D-3. Light-Load Peas Data

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	6	6	6
Cook Time (min)	9.3	9.5	9.3
Initial Water Temperature (°F)	41.8	44.3	50.4
Final Water Temperature (°F)	77.2	79.8	83.0
Frozen Food Temperature (°F)	-4.0	-4.0	-4.0
Weight of Empty Calorimeter (lb)	45.2	45.0	45.1
Weight of Full Calorimeter (lb)	73.4	73.2	73.3
Weight of Calorimeter Water (lb)	20.0	20.0	20.1
Weight of Cooked Food (lb)	8.2	8.2	8.1
Weight of Frozen Food (lb)	8.0	8.0	8.0
Weight of Stainless-Steel Pans (lb)	2.6	2.8	2.6
Moisture Content (%)	81	81	81
Condensate Temperature (°F)	86.6	87.5	85.9
Water Consumption (gal/h)	2.3	2.3	2.4
Calculated Values			
Moisture Weight in Green Peas(lb)	6.5	6.5	6.5
Final Food Temperature (°F)	179.6	181.8	178.2
Cooking Energy (Wh)	1060.0	1080.0	1100.0
Energy Consumed by Green Peas (Btu)	2061.9	2076.7	2052.8
Energy Consumed by Pans (Btu)	52.7	57.4	52.5
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	3617.8	3686.0	3754.3
Cooking Energy Rate (kW)	6.8	6.8	7.1
Productivity (lb/h)	51.4	50.5	51.9
Energy Efficiency (%)	58.5	57.9	56.1

Cooking Energy Efficiency Data

Table D-4. Full-Load Potatoes Data

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	6	6	6
Cook Time (min)	22.00	22.00	22.75
Temperature of Uncooked Potatoes (°F)	71.9	70.0	72.0
Temperature of Cooked Potatoes (°F)	195.0	195.0	195.0
Weight of Stainless-Steel Pans (lb)	17.6	15.1	15.5
Weight of Potatoes (lb)	48.7	49.0	48.0
Total Potato Count	289	286	287
Moisture Content (%)	81	81	81
Condensate Temperature (°F)	81.8	89.2	84.7
Water Consumption (gal/h)	2.7	2.5	2.6
Calculated Values			
Moisture Weight in Potatoes (lb)	40.9	41.2	40.4
Average Weight of Each Potatoes (lb)	0.17	0.17	0.17
Cooking Energy (Wh)	10034.2	10580.3	10170.7
Energy Consumed by Potatoes (Btu)	5231.7	5347.6	5158.2
Energy Consumed by Pans (Btu)	238.2	207.3	209.0
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	10286.9	10654.6	10429.0
Cooking Energy Rate (kW)	7.9	8.0	8.5
Productivity (lb/h)	132.8	133.6	126.7
Energy Efficiency (%)	53.2	52.1	51.5

Cooking Energy Efficiency Data

Table D-5. Light-Load Potatoes Data

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	1	1	1
Cook Time (min)	21.33	20.67	0.00
Temperature of Uncooked Potatoes (°F)	71.9	72.0	0.0
Temperature of Cooked Potatoes (°F)	195.0	195.0	195.0
Weight of Stainless-Steel Pans (lb)	2.4	2.8	2.4
Weight of Potatoes (lb)	8.2	8.1	8.2
Total Potato Count	49	47	47
Moisture Content (%)	81.0	82.0	83.0
Condensate Temperature (°F)	74.0	73.3	74.4
Water Consumption (gal/h)	0.6	0.7	1.0
Calculated Values			
Moisture Weight in Potatoes (lb)	6.9	6.8	6.9
Average Weight of Each Potatoes (lb)	0.17	0.17	0.17
Cooking Energy (Wh)	3413.0	3481.3	3754.3
Energy Consumed by Potatoes (Btu)	876.7	875.4	876.6
Energy Consumed by Pans (Btu)	32.7	37.9	32.7
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	3651.8	3711.7	3988.9
Cooking Energy Rate (kW)	2.8	3.0	3.1
Productivity (lb/h)	22.9	23.5	23.3
Energy Efficiency (%)	24.9	24.6	24.2

