

**Vulcan-Hart Gas Steamer Performance Testing
Model VHX24G-3**

Application of ASTM Standard
Test Method F 1484-99

FSTC Report 5011.01.97

**Food Service Technology Center
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Executive Summary

The Food Service Technology Center (FSTC) tested the Vulcan-Hart Company's VHX24G-3 atmospheric steamer under the tightly controlled conditions of the 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 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 steamer's cooking energy efficiency for different cooking scenarios. The production capacities are shown in Figure ES-2.

The VHX24G-3 is a compact, floor-mounted, dual-compartment, gas-powered, boiler-based steamer. It demonstrated high cooking energy efficiencies and respectable cook times that made it a highly productive steamer. The unit was found to have a cooking energy efficiency of nearly 50% when cooking a full load frozen green peas and a 21% cooking energy efficiency when tasked with cooking a full load of a "tough" food product like red potatoes. Both energy efficiencies are higher than any other gas powered steamer tested to date at the FSTC.^{2,3} Along with the VHX24G-3's high cooking energy efficiencies is a rapid preheat of 8.7 minutes and cook times of approximately 23.0 minutes for both full-load cooking scenarios, frozen green peas and red potatoes.

Executive Summary

The low cooking energy rates exhibited during all cooking scenarios also demonstrates the boiler's capacity to supply steam to peripheral steam powered appliances (i.e., steam kettles).

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

²Food 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.

³Food Service Technology Center. 2000. *Vulcan-Hart Gas Steamer Performance Testing, Model VL2GSS (Pressure) and Model VS3616G (Atmospheric)*. Report 5011.01.97. Product and Services Department. San Francisco, California: Pacific Gas and Electric Company.

Executive Summary

Table ES-1. Performance Summary: Vulcan, VHX24G-3 Atmospheric Steamer.

Preheat and Idle

Rated Energy Input Rate (Btu/h)	270,000
Measured Energy Input Rate (Btu/h)	272,900
Preheat Time (min)	8.7
Preheat Energy (Btu)	27,070
Idle Energy Rate (Btu/h)	11,640

Full-Load Frozen Green Peas (6 pans)

Cook Time (min)	23.0
Cooking Energy Efficiency (%)	49.3
Production Capacity (lb/h)	126
Water Consumption (gal/h)	11
Condensate Temperature (°F)	86.7

Light-Load Frozen Green Peas (1 pan)

Cook Time (min)	9.3
Cooking Energy Efficiency (%)	34.5
Water Consumption (gal/h)	14
Condensate Temperature (°F)	121.7

Full-Load Red Potatoes (6 pans)

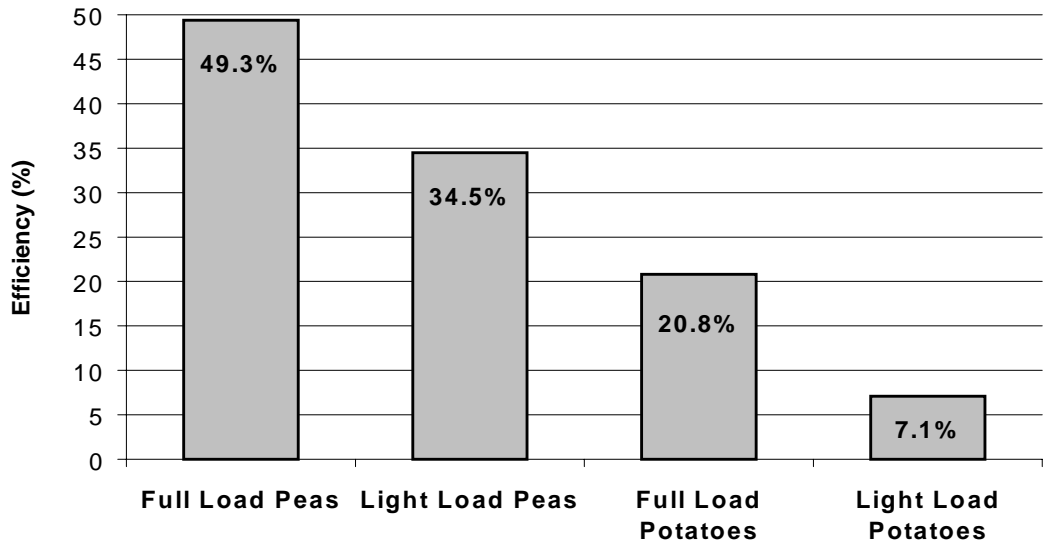
Cook Time (min)	23.3
Cooking Energy Efficiency (%)	20.8
Production Capacity (lb/h)	127
Water Consumption (gal/hr)	31
Condensate Temperature (°F)	149.2

Light-Load Red Potatoes (1 pan)

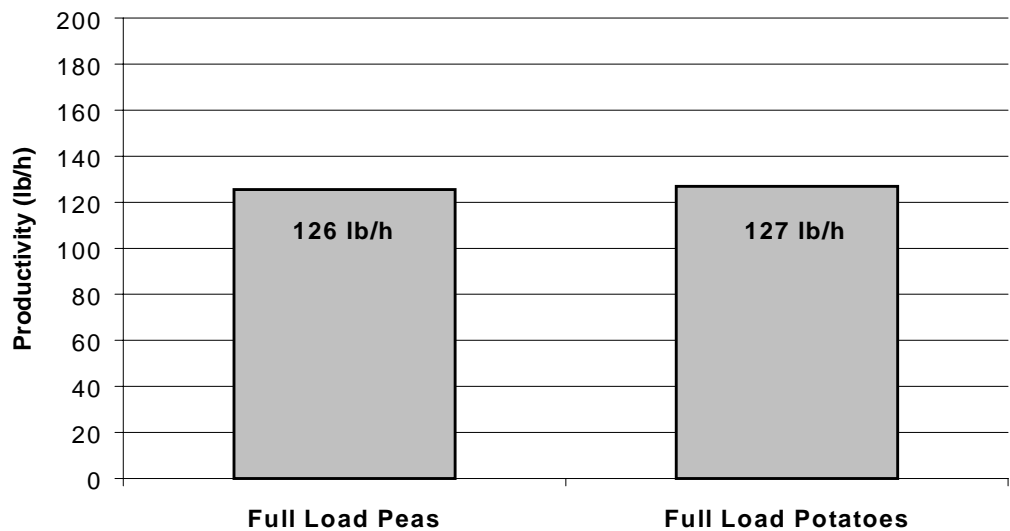
Cook Time (min)	18.6
Cooking Energy Efficiency (%)	7.1
Water Consumption (gal/hr)	35
Condensate Temperature (°F)	123.2

Executive Summary

*Figure ES-1.
Steamer Cooking
Energy Efficiency
Under Full- and Light-
Load 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.

With support from the Electric Power Research Institute (EPRI), the Gas Technology Institute (GTI), 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. This test procedure was submitted to the American Society for Testing and Materials (ASTM) and accepted as a standard test method in December 1993. 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 1484-99¹ (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.³

The VHX24G-3 atmospheric steamer is a floor-mounted, gas-powered, boiler-based steam cooker manufactured by Vulcan. The steamer utilizes a gas-powered, pressurized boiler to provide steam to its two cooking compartments.

Introduction

Objectives

The objective of this report is to examine the operation and performance of the VHX24G-3 atmospheric 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 four 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, water consumption rate and condensate temperature for full- and light-load testing scenario.

Appliance Description and Operation

The Vulcan steamer is a stainless steel, floor mounted appliance with a gas powered boiler base. Each of the VHX24G-3 steamer's two cooking compartments can accommodate five 12" x 20" x 1" pans, three 12" x 20" 2-1/2" pans and two 12" x 20" x 4" pans. Water hook up is necessary to satisfy the boiler and condenser water feed requirements. The appliance has an automatic boiler blowdown that occurs after each shutdown.

The VHX24G-3 atmospheric steamer has a total power input of 270,000 Btu/h. The boiler's powered burners are lit by an automatic, electronic ignition system. After the boiler has reached its full operational capacity, cooking can commence. A brief, manufacturer recommended preheat is performed whereby the automated timer, which controls the supply of steam to the cooking compartment, is set to one minute and the compartment door closed. Following this preheat, the appliance is ready for a cooking event.

Introduction

After closing the compartment doors, the timer is turned to the desired cook time and steam enters the cooking chamber. Food product may be inspected during the course of the cooking event as opening the door terminates the steam supply to the cooking compartment. When the preset time has elapsed, the steam supply is automatically stopped. The boiler will stand idle until the next cooking event is to occur.

The glossary in Appendix A provides a quick reference to the terms used in this report. Appliance specifications are listed in Table 1-1, and the manufacturer's literature is in Appendix B. Appendix C presents the results reporting sheets. Appendix D contains the cooking energy efficiency data.

Introduction



*Figure 1-1.
The Vulcan, VHX24G-3 Atmospheric Steamer.*

Table 1-1. Appliance Specifications.

Manufacturer	Vulcan Company
Model	VHX24G-3
Generic Appliance Type	2-Compartment, Atmospheric Steamer
Rated Input	270,000 Btu/h
Technology	Boiler Base, Gas Powered, Powered Burners
Boiler Operating Pressure	15 psi
Boiler Capacity	7.0 gal
Controls	Boiler power ON / OFF switch. Water fill/boiler activation switch 60-Minute electro-mechanical timers for each compartment.
Construction	Exterior: Heavy gauge stainless steel. Interior: Stainless steel.
Compartment Capacity	5 (12" x 20" x 1") pans 3 (12" x 20" x 2½") pans 2 (12" x 20" x 4") pans
Dimensions	24" x 60 ½" x 35 ½" (W×H×D)

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.¹ The steamer is pictured below in Figure 2-1, instrumented and ready for testing.

Natural gas consumption was measured using a positive displacement-type gas meter that generated a pulse every 0.1 ft³. The gas meter was 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.



*Figure 2-1.
The VHX24G-3 Steamer
Instrumented for Testing.*

Revisions to the ASTM Test Method

The steam cooker test method, originally published as F 1484-93, was revised as F 1484-99. The ice-load test, due to its simplicity, repeatability, and reproducibility, was applied during the developmental phase of the test procedure as a quick indicator of steamer efficiency and productivity. However, ice-load test results do not always mirror the results of food products, particularly with respect to real-world cook times and associated production capacities. The F 1484-99 test method lists the ice-load test as an optional procedure.

The potato tests remain in the revised test method with two modifications. The original method specified whole, U.S. No. 1, size B, red potatoes with an average weight of 0.14 ± 0.02 lb. Repetition of tests showed that the potatoes typically had a higher average weight of around 0.16 lb. The revised test method calls for red potatoes weighing 0.16 ± 0.02 lb. Furthermore, the prescribed cook temperature of 205°F was high since the maximum attainable temperature of steam under atmospheric pressure is 212°F. Qualitative tests, using texture, taste, and consistency as criteria, showed that potatoes were cooked to an acceptable doneness at $195 \pm 2^\circ\text{F}$.

The three loading scenarios described in the original test method were reduced to two scenarios (full- and light-load tests). The full-load test (6 pans) determines the steamer's peak cooking energy efficiency and production capacity, while the light-load test (1 pan) evaluates partial-load performance.

Full- and light-load tests of frozen green peas were incorporated into the ASTM test method as a replacement for the ice-load tests. 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. Figure 2-2 shows the food products tested in the VHX24G-3 steamer: frozen green peas, and red potatoes.

Methods

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



Measured Energy Input, Preheat and Idle Rate

The energy input rate was determined by measuring the energy consumed by the boiler during a full 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 boiler to reach its full operational capacity from a cold start, as when turned on for the first time in a day. The unit had a simple on/off power switch with which to actuate the filling of the boiler. After filling, the boiler's powered burners were ignited by pressing the ignition button. One half-hour after the preheat cycle, idle energy consumption was monitored for a 2-hour period.

Green Peas Full- and Light-Load Efficiency Tests

Individually flashed-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 steamer required 6 pans of green peas for a full load (3 pans per compartment), while 1 pan, placed in the center rack of the steamer's top cavity, constituted a light load. For both test scenarios, 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.

Methods

Red Potatoes Full- and Light- Load Efficiency Tests

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.

Freshly packed, size B, red potatoes served as the second food product for steamer performance testing. Again, the steamer required 6 pans of red potatoes for a full load and 1 pan for a light load, each pan contained 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.

For the food-load scenarios, iterative cooking time determination tests were required to establish the time necessary for the food product to reach the doneness temperature of $180 \pm 2^\circ\text{F}$ (for frozen green peas) and $195 \pm 2^\circ\text{F}$ (for red potatoes). The testing process followed this sequence: three replicates of the full-load green pea test, three replicates of the light-load green pea test, three replicates of the full-load red potatoes test and three replicates of the light-load red potatoes test.

The replicates 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, and the cooking energy efficiency data sheets appear in Appendix D.

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 VHX24G-3 atmospheric steamer, which has a nameplate rating of 270,00 Btu/h, consumed 272,900 Btu/h when its energy input was measured. Although 1.1% higher than its rated input rate, it was well within the 5% tolerance stipulated in the test method.

Preheat and Idle Tests

Preheat Energy and Time

The VHX24G-3 atmospheric steamer relies upon an electronically controlled intermittent pilot. After the boiler cavity has filled with water, the boiler's powered burners were lit with the ignition button. The steamer consumed 27,070 Btu and took 8.7 minutes to achieve a ready state of operation.

Idle Energy Rate

Following the preheat period, the steamer was allowed to stabilize for one half-hour. Thereafter, the energy consumption was monitored over a 2-hour period and the idle energy rate was calculated to be 11,640 Btu/h.

Test Results

Rated energy input, preheat energy and idle rate test results are summarized in Table 3-1.

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

Rated Energy Input Rate (Btu/h)	270,000
Measured Energy Input Rate (Btu/h)	272,900
Preheat to Operational Capacity Time (min)	8.7
Energy (Btu)	27,070
Idle Energy Rate (Btu/h)	11,640

Results

Cooking Tests

The VHX24G-3 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). For the light-load tests one pan was placed in the center rack of the top cooking compartment. The energy consumption, elapsed cook time, water consumption, condensate temperature and ambient temperature were monitored for the duration of each test at five-second intervals.

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 The steamer required 23.0 minutes to cook the full load of frozen green peas and had a cooking energy efficiency of 49.3% and production capacity of 125.5 lb/h. Water was consumed at a rate of 10.4 gal/hr.

During the single pan light-load tests, the VHX24G-3 steamer required an average of 9.3 minutes to bring the bulk temperature of the green peas to $180 \pm 2^\circ\text{F}$. Cooking energy efficiency and productivity were determined to be 34.5% and 51.6 lb/h, respectively. Water was consumed at a rate of 13.7 gal/h.

Full- and Light-Load Potato Tests

The red potatoes contained 84% moisture by weight with the specific heat (C_p) of 0.87 Btu/lb°F.⁴ The steamer was able to cook a full load of potatoes in 23.3 minutes and had a cooking energy efficiency of 20.8%. The unit had a production capacity of 126.9 lb/h. Water consumption was measured at 31.4 gal/h.

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 $75 \pm 5^\circ\text{F}$) represent two extremes in steam cooking. Frozen green peas, having a large surface area to volume ratio, promote condensation.

The rate of energy transfer from steam to frozen food is high, resulting in greater cooking energy efficiency and productivity. The cooking performance of the VHX24G-3 demonstrates the range in cooking efficiencies associated with the two food products tested. The unit had a cooking energy efficiency of 49.3% when tasked with cooking a full load of green peas, versus a cooking energy efficiency of 20.8% when cooking a full load of red potatoes. The range in the two efficiencies held true for the light-load tests as well, with the unit able to achieve a respectable 34.5% cooking energy efficiency for a light load of peas, but only a 7.1% cooking energy efficiency when challenged with a light load of potatoes.

It is important to note that partial cooking loads are always a challenge to any atmospheric appliance such as the VHX24G-3 steamer. Most of the heat energy is unused due to the small amount of food product. In this case, the steam that does not condense on the food product is simply expelled down the drain.

The VHX24G-3 steamer exhibited very low cooking energy rates in relation to its rated input of 270,000 Btu/h. During the full-load green pea test the unit consumed energy at a rate of 67,130 Btu/h, approximately the same cooking energy rate of 68,580 Btu/h. recorded during the cooking of a full-load of red potatoes. These low cooking energy rates, 25% of the appliances rated input, demonstrated the steamer's potential to supply cooking energy to peripheral, steam-powered appliances (e.g., kettles).

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 Method¹, the cooking energy efficiencies can readily be calculated. Table 3-2 summarizes the performances of the VHX24G-3 atmospheric steamer. Figures 3-1 and 3-2 depict the results in a graphical format. Table 3-3 further summarizes the appliance's water consumption and condensate temperature data. Figures 3-3 and 3-4 illustrate the steamer's part-load energy efficiency and Figures 3-5 and 3-6 show the unit's cooking energy profile.

Results

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

	Full Load	Light Load	Full Load	Light Load
	Peas	Peas	Potatoes	Potatoes
Number of Pans	6	1	6	1
Cook Time (min)	23.0	9.3	23.3	18.6
Cooking Energy Rate (Btu/h)	67,130	39,500	68,580	41,000
Energy Cooking Efficiency (%)	49.3	34.5	20.8	7.1
Production Rate (lb/h)	126	52	127	26
Energy Consumption (Btu/lb)	535	765	546	1570

Table 3-3. Water Consumption and Condensate Temperature Test Results.

	Full Load	Light Load	Full Load	Light Load
	Peas	Peas	Potatoes	Potatoes
Water consumption (gal/h)	10	14	31	35
Condensate Temperature (°F)	86.7	121.7	149.2	123.2

Results

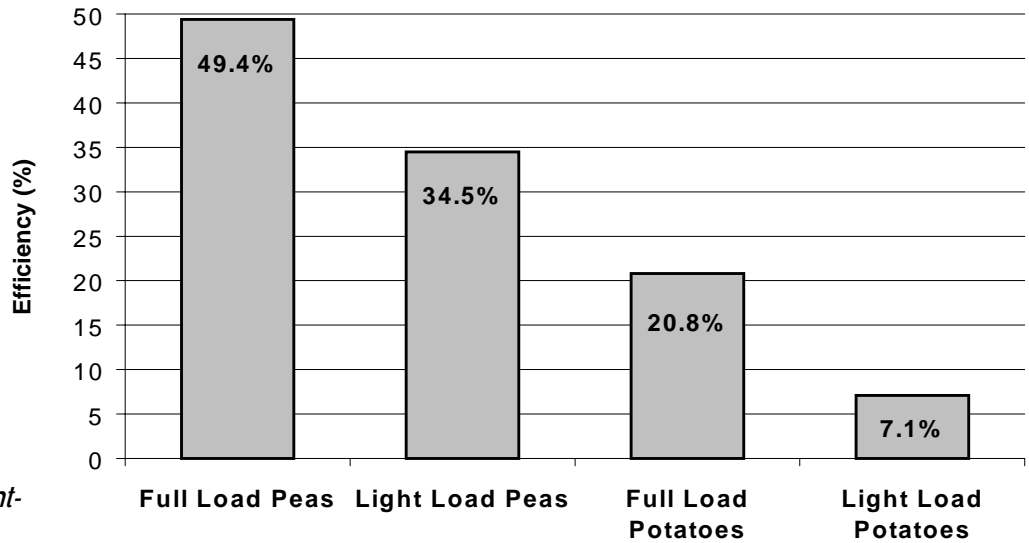


Figure 3-1.
Steamer Cooking
Energy Efficiency
Under Full- and Light-
Load Scenarios.

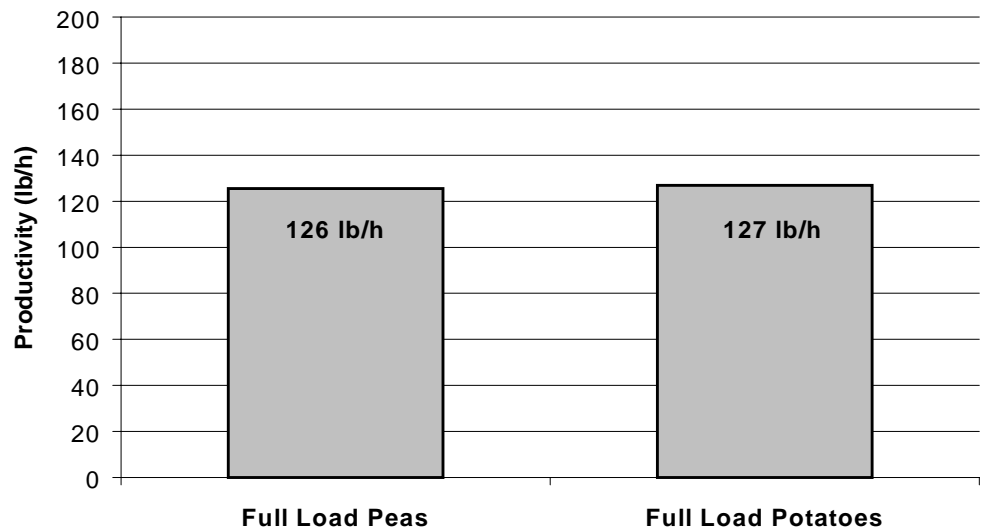


Figure 3-2.
Steamer Production
Capacity.

Results

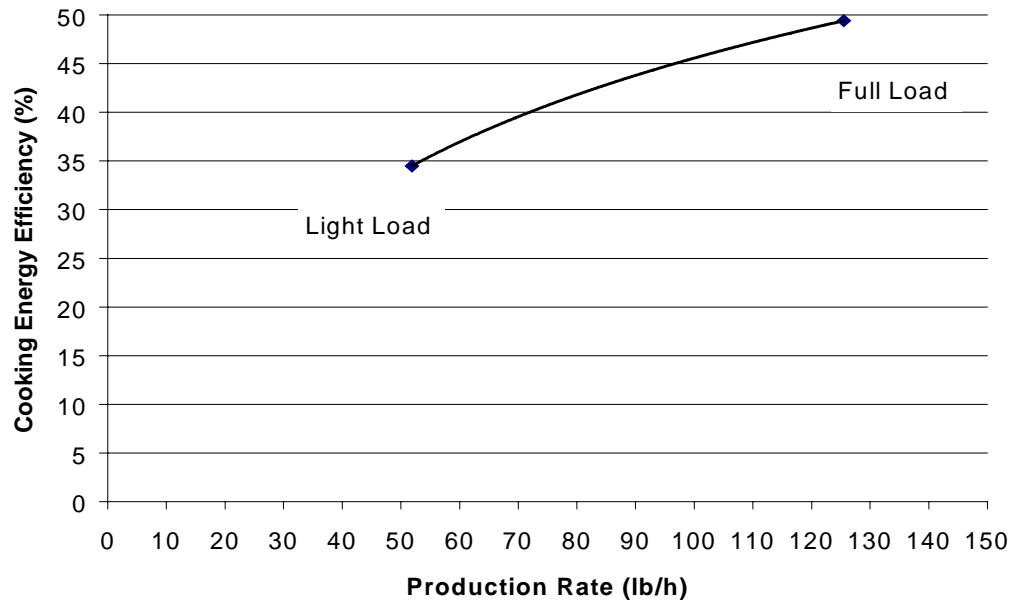


Figure 3-3.
Steamer Part-Load
Green Pea Cooking
Energy Efficiency.

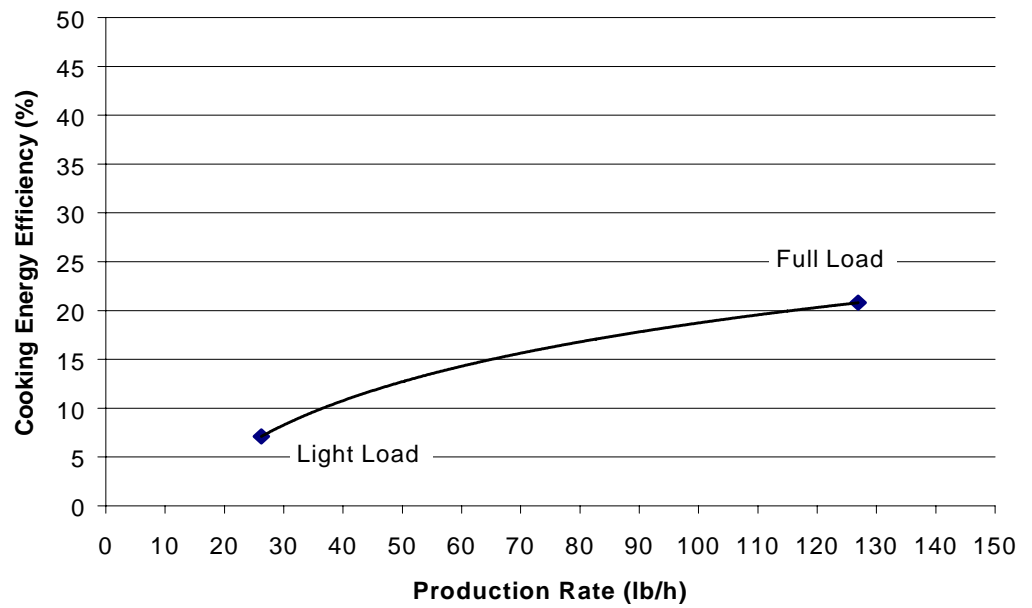


Figure 3-4.
Steamer Part-Load
Red Potato Cooking
Energy Efficiency.

Results

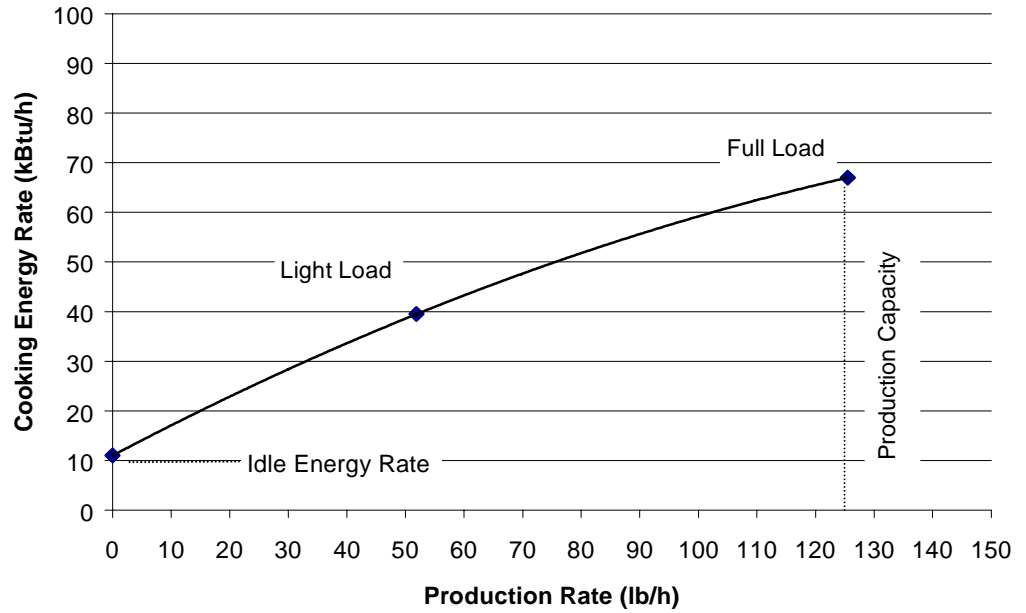


Figure 3-5.
Steamer Cooking
Energy Consumption
Profile, Green Peas.

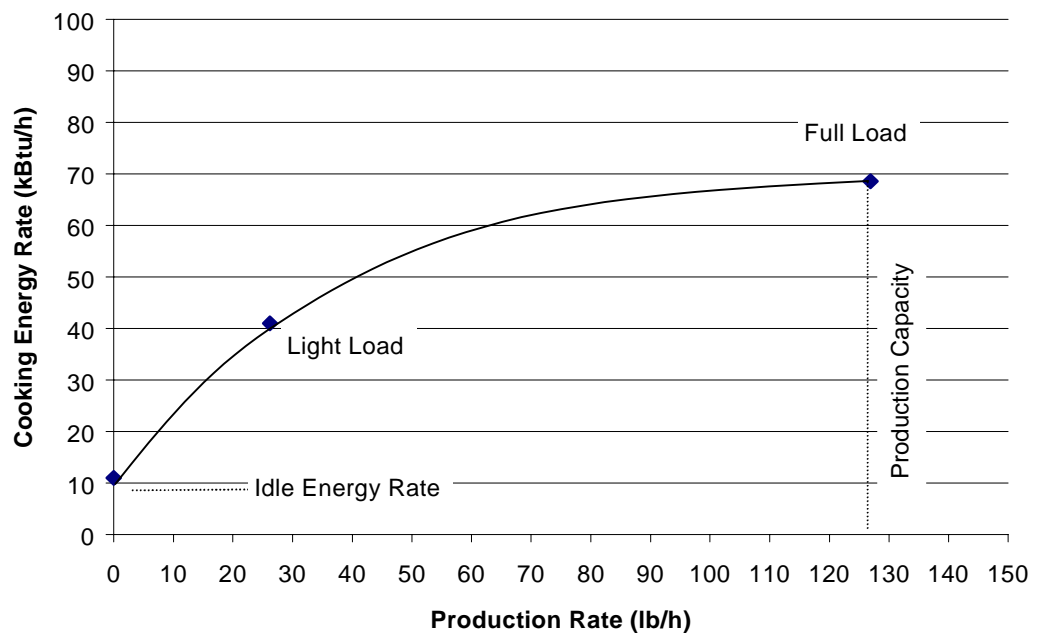


Figure 3-6.
Steamer Cooking
Energy Consumption
Profile, Red Potatoes.

4 Conclusion

The Vulcan VHX24G-3 atmospheric steamer exhibited the highest cooking energy efficiency of any gas steamer tested to date at the FSTC.^{3,5} In fact its 50% cooking energy efficiency is a 10% improvement over previously tested Vulcan steamers.⁵ The VHX24G-3's 21% cooking energy efficiency when cooking a full load of a "tough" food product like red potatoes is nearly double that of any other atmospheric steamer tested.^{3,5} Only the larger capacity Vulcan VL2GSS pressure steamer outperformed the VHX24G-3 when cooking a full load of red potatoes.⁵

The VHX24G-3 is fully operational in less than 10 minutes, with a recorded preheat time of 8.7 minutes. When compared to previously FSTC tested six pan capacity steamers, the VHX24G-3 has some of the fastest cook times recorded to date.^{6,7} A full-load of frozen green peas and red potatoes had a cooktime of approximately 23 minutes. These rapid cook times yielded production capacities of 126 lb/h for a full load of green peas and 127 lb/h for a full load of red potatoes. The cook time performance is comparable to other steamers tested in the laboratory, regardless of capacity, energy source or cooking technology.^{5,6,7,8,9,10}

The VHX24G-3 offers excellent cooking performance in a much smaller footprint than its much larger, FSTC tested brethren, the VL2GSS (Pressure) and VS3616G (Atmospheric) steamers.⁵ The VHX24G-3's boiler delivers a steady supply of steam with rapid recovery after each cooking event. An example of this quick recovery was the zero re-init (the energy required to return the boiler to its maximum pressure/temperature), recorded during the cooking of both loading scenarios of red potatoes.

Conclusion

With its low cooking energy rates the boiler can potentially supply steam energy to other steam powered appliances. This was demonstrated during both full-load cooking scenarios, where the cooking energy rate for a full-load of green peas and red potatoes was found to be 67,130 Btu/h and 68,580 Btu/h, respectively. These cooking tests utilized only 25% of the boiler's available capacity. In light of this, the VHX24G-3 can be said to have an oversized boiler for the steaming application for which it is tasked. End users should seek to take full advantage of the unit's steam generating capacity by using it to power another appliance such as a steam kettle. The base model VHX24G, with a rated input of 170,000 Btu/h, may be a better alternative for operators who only need a steam cooker.

The Vulcan VHX24G-3 atmospheric steamer offers operators, especially those with limited kitchen space, a gas-fired, boiler-based steamer that delivers high energy efficiency, on demand cooking energy and high productivity.

5 References

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A Glossary

Atmospheric Steam Cooker

Steam cooker wherein cooking compartment operates between 0 and 2.9 psig (ASTM F1217-92 Classification Type I).

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.

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.

Glossary

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 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 steam cooker can bring the specified food product to a specified "cooked" condition.

Production Rate

Rate (lb(kg)/h) at which 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 Specifications

Appendix B includes the product literature for the VHX24G-3 atmospheric steamer.

C Results Reporting Sheets

Manufacturer: Vulcan Company
Model: VHX24G-3 Atmospheric Steamer
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 operation characteristics: The boiler is turned on with a simple on/off switch. After the boiler has filled, the burner ignition button is pressed. When the boiler has reached its full operational capacity, cooking can commence. Prior to a cooking event, a manufacturer recommended pre-heat is performed whereby the timer is set to one minute, releasing steam into the cooking compartment. For an actual cooking event, the food product is placed in the cooking compartment, the timer is set to the desired cook time and the doors closed. Steam will enter the cooking compartment. The steam supply is terminated when the cook time expires or the door is opened.

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

Natural gas consumption was measured using a positive displacement-type gas meter that generated a pulse every 0.1 ft³. The gas meter was 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.

Section 11.4 Energy Input Rate

Measured	272,900 Btu/h
Rated	270,000 Btu/h
Percent Difference between Measured and Rated	1.1%

Section 11.5 Boiler Preheat Energy Consumption and Duration

Energy Consumption	27,070 Btu
Duration	8.7 min

Section 11.6 Boiler Idle Energy Rate

Idle Energy Rate	11,640 Btu/h
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Results Reporting Sheets

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

Full Load:

Cooking Time	23.0 min
Cooking Energy Efficiency	49.3 ± 0.4%
Cooking Energy Rate	67,130 Btu/h
Production Capacity	125.5 ± 0.0 lb/h
Water Consumption Rate	10.4 ± 2.7 gal/h

Light Load:

Cooking Time	9.3 min
Cooking Energy Efficiency	34.5 ± 3.2%
Cooking Energy Rate	39,500 Btu/h
Production Rate	51.6 ± 0.0 lb/h
Water Consumption Rate	13.7 ± 1.7 gal/h

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

Full Load:

Cooking Time	23.3 min
Cooking Energy Efficiency	20.8 ± 1.7%
Cooking Energy Rate	68,580 Btu/h
Production Capacity	126.9 ± 12.1 lb/h
Water Consumption Rate	31.4 ± 0.8 gal/h

Results Reporting Sheets

Light Load:

Cooking Time	18.6 min
Cooking Energy Efficiency	7.1 ± 0.6%
Cooking Energy Rate	41,000 Btu/h
Production Capacity	26.1 ± 1.5lb/h
Water Consumption Rate	35.3 ± 2.1 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)	8.75	8.75	8.58
Preheat Energy (Btu)	27,070	26,720	27,430
Idle Time (min)	120.0	120.0	120.0
Idle Energy (Btu)	22,550	23,760	23,560

Calculated Values			
Preheat Energy Rate (Btu/h)	185,620	183,220	191,820
Idle Energy Rate (Btu/h)	11,270	11,880	11,780

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)	23.0	23.0	23.0
Initial Water Temperature (°F)	48.0	45.2	41.8
Final Water Temperature (°F)	102.5	100.2	97.0
Frozen Food Temperature (°F)	-4.0	-4.0	-4.0
Weight of Empty Calorimeter (lb)	44.8	44.8	44.9
Weight of Full Calorimeter (lb)	153.5	153.5	153.0
Weight of Calorimeter Water (lb)	60.0	60.0	60.0
Weight of Cooked Food (lb)	48.8	48.6	48.1
Weight of Frozen Food (lb)	48.0	48.0	48.0
Weight of Stainless-Steel Pans (lb)	15.2	16.2	15.2
Moisture Content (%)	81	81	81
Condensate Temperature (°F)	86.6	87.5	85.9
Water Consumption (gal/h)	11.6	9.5	10.0
Calculated Values			
Moisture Weight in Green Peas(lb)	38.9	38.9	38.9
Final Food Temperature (°F)	181.6	180.2	178.1
Cooking Energy (Btu)	25,040	24,980	24,830
Energy Consumed by Green Peas (Btu)	12,450	12,400	12,300
Energy Consumed by Pans (Btu)	310	330	300
Energy of Boiler Re-init (Btu)	660	670	670
Energy Consumed by Fan/Controls (Btu)	117	114	116
Energy Consumed by the Steamer (Btu)	25,820	25,760	25,620
Cooking Energy Rate (Btu/h)	67,360	67,210	66,830
Productivity (lb/h)	125.2	125.2	125.2
Energy Efficiency (%)	49.3	49.3	49.1

Cooking Energy Efficiency Data

Table D-3. Light-Load Peas Data

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	1	1	1
Cook Time (min)	9.3	9.3	9.3
Initial Water Temperature (°F)	43.5	46.4	42.1
Final Water Temperature (°F)	77.8	79.7	77.1
Frozen Food Temperature (°F)	-4.0	-4.0	-4.0
Weight of Empty Calorimeter (lb)	44.5	44.5	44.6
Weight of Full Calorimeter (lb)	72.6	72.6	72.5
Weight of Calorimeter Water (lb)	20.0	20.1	20.0
Weight of Cooked Food (lb)	8.0	8.0	8.0
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)	119.5	125.6	120.0
Water Consumption (gal/h)	13.0	14.0	14.3
Calculated Values			
Moisture Weight in Green Peas(lb)	6.5	6.5	6.5
Final Food Temperature (°F)	178.7	178.5	180.9
Cooking Energy (Btu)	5,060	5,310	4,960
Energy Consumed by Green Peas (Btu)	2,060	2,050	2,070
Energy Consumed by Pans (Btu)	48	49	57
Energy of Boiler Re-init (Btu)	965	1,010	990
Energy Consumed by Fan/Controls (Btu)	33	34	31
Energy Consumed by the Steamer (Btu)	6,060	6,350	5,980
Cooking Energy Rate (Btu/h)	39,100	40,970	38,580
Productivity (lb/h)	51.6	51.6	51.6
Energy Efficiency (%)	34.8	33.1	35.6

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	23.75	23.33
Temperature of Uncooked Potatoes (°F)	72.0	70.0	75.0
Temperature of Cooked Potatoes (°F)	195.0	195.7	195.7
Weight of Stainless-Steel Pans (lb)	16.8	17.0	16.4
Weight of Potatoes (lb)	48.6	48.9	48.6
Total Potato Count	274	292	316
Moisture Content (%)	84	84	84
Condensate Temperature (°F)	151.5	146.8	147.0
Water Consumption (gal/h)	31.8	30.9	31.9
Calculated Values			
Moisture Weight in Potatoes (lb)	40.8	41.1	40.8
Average Weight of Each Potatoes (lb)	0.18	0.17	0.15
Cooking Energy (Btu)	26,000	27,760	24,790
Energy Consumed by Potatoes (Btu)	5,220	5,400	5,120
Energy Consumed by Pans (Btu)	227	234	218
Energy of Boiler Re-init (Btu)	0	0	0
Energy Consumed by Fan/Controls (Btu)	115	122	119
Energy Consumed by the Steamer (Btu)	26,120	27,880	24,910
Cooking Energy Rate (Btu/h)	71,240	70,440	64,060
Productivity (lb/h)	132.5	123.5	125.0
Energy Efficiency (%)	20.9	20.2	21.4

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)	18.50	19.08	18.25
Temperature of Uncooked Potatoes (°F)	71.9	72.8	72.6
Temperature of Cooked Potatoes (°F)	195.0	195.7	195.7
Weight of Stainless-Steel Pans (lb)	2.8	2.8	2.4
Weight of Potatoes (lb)	8.1	8.1	8.1
Total Potato Count	47	49	49
Moisture Content (%)	84	84	84
Condensate Temperature (°F)	122.0	123.8	124.0
Water Consumption (gal/h)	35.0	34.7	36.3
Calculated Values			
Moisture Weight in Potatoes (lb)	6.8	6.8	6.8
Average Weight of Each Potatoes (lb)	0.17	0.17	0.16
Cooking Energy (Btu)	12,190	12,930	12,650
Energy Consumed by Potatoes (Btu)	874	870	867
Energy Consumed by Pans (Btu)	38	38	33
Energy of Boiler Re-init (Btu)	0	0	0
Energy Consumed by Fan/Controls (Btu)	122	125	125
Energy Consumed by the Steamer (Btu)	12,310	13,060	12,780
Cooking Energy Rate (Btu/h)	39,920	41,070	42,000
Productivity (lb/h)	26.3	25.5	26.6
Energy Efficiency (%)	7.4	7.0	7.0

