

Vulcan-Hart Gas Steamer Performance Testing
Model VL2GSS (Pressure) and
Model VS3616G (Atmospheric)

Application of ASTM Standard
Test Method F 1484-99

FSTC Report 5011.00.85

Food Service Technology Center Manager: Don Fisher
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Prepared by:

Todd Bell
Fisher-Nickel Inc.

Contributors:

Scott Miner
Judy Nickel
David Zabrowski
Fisher-Nickel Inc.

Prepared for:

Peter Turnbull, Senior Project Manager
Customer Energy Management
Pacific Gas and Electric Company
123 Mission Street, P.O. Box 770000
San Francisco, California 94177

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Round Table Pizza

McDonald's Corporation apostrophe placement correct?

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Executive Summary

Vulcan-Hart Company's VL2GSS pressure steamer and VS3616G atmospheric steamer are two highly productive, gas powered, boiler-based steam cookers that deliver respectable cooking energy efficiency. Further, a near zero boiler recovery time, enables the units to deliver continuous, on-demand cooking energy.

The Food Service Technology Center (FSTC) tested the Vulcan VL2GSS pressure steamer and VS3616G atmospheric 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 efficiency, production capacity, water consumption and condensate temperature from product testing. The spectrum of test products included: 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 and compares the two steamers' cooking energy efficiency for different cooking scenarios. The production capacities are shown in Figure ES-2. The steamers' part-load production capacities are illustrated in Figures ES-3 and ES-4. The cooking energy consumption profiles are shown in Figures ES-5 and ES-6.

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.

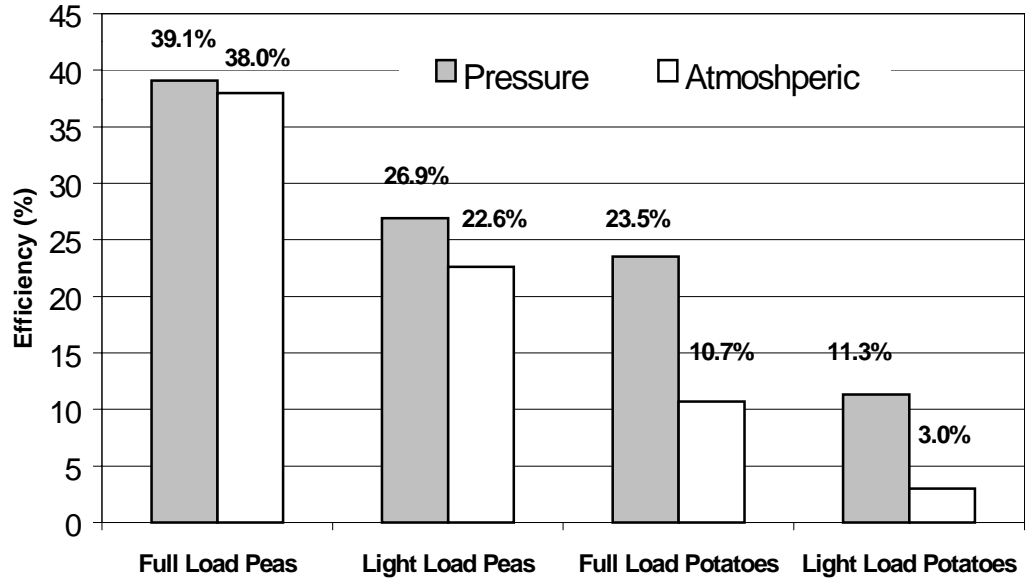
Executive Summary

Table ES-1. Performance Summary: Vulcan, Pressure and Atmospheric Steamers

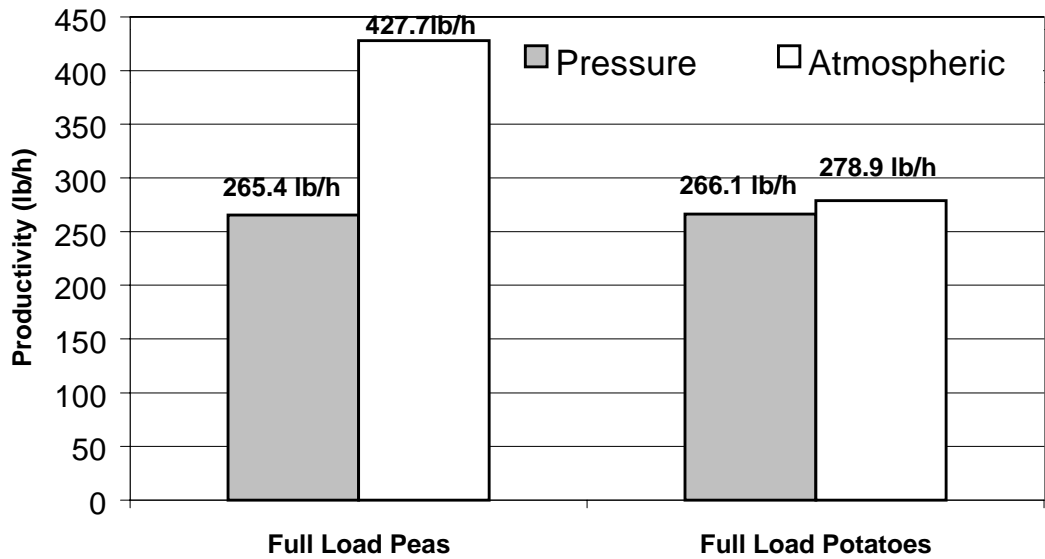
<i>Preheat and Idle</i>	<i>Pressure</i>	<i>Atmospheric</i>
Rated Energy Input Rate (Btu/h)	240,000	300,000
Measured Energy Input Rate (Btu/h)	235,000	305,000
Preheat Time (min)	12.7	11.1
Preheat Energy (Btu)	34,050	41,980
Idle Energy Rate (Btu/h)	11,270	16,020
 <i>Full-Load Frozen Green Peas (16 pans)</i>		
Cook Time (min)	29.0	18.0
Cooking Energy Efficiency (%)	39.1	38.0
Production Capacity (lb/h)	265.4	427.7
Water Consumption (gal/h)	8.9	71.6
Condensate Temperature (°F)	93.1	86.7
 <i>Light-Load Frozen Green Peas (2 pans)</i>		
Cook Time (min)	6.1	4.9
Cooking Energy Efficiency (%)	26.9	22.6
Water Consumption (gal/h)	8.9	106.4
Condensate Temperature (°F)	79.8	86.7
 <i>Full-Load Red Potatoes (16 pans)</i>		
Cook Time (min)	25.6	24.3
Cooking Energy Efficiency (%)	23.5	10.7
Production Capacity (lb/h)	266.1	278.9
Water Consumption (gal/hr)	5.2	120.9
Condensate Temperature (°F)	81.8	152.7
 <i>Light-Load Red Potatoes (2 pans)</i>		
Cook Time (min)	16.0	18.0
Cooking Energy Efficiency (%)	11.3	3.0
Water Consumption (gal/hr)	4.1	125.7
Condensate Temperature (°F)	85.7	182.9

Executive Summary

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



*Figure ES-2.
Steamer Production
Capacities.*



Executive Summary

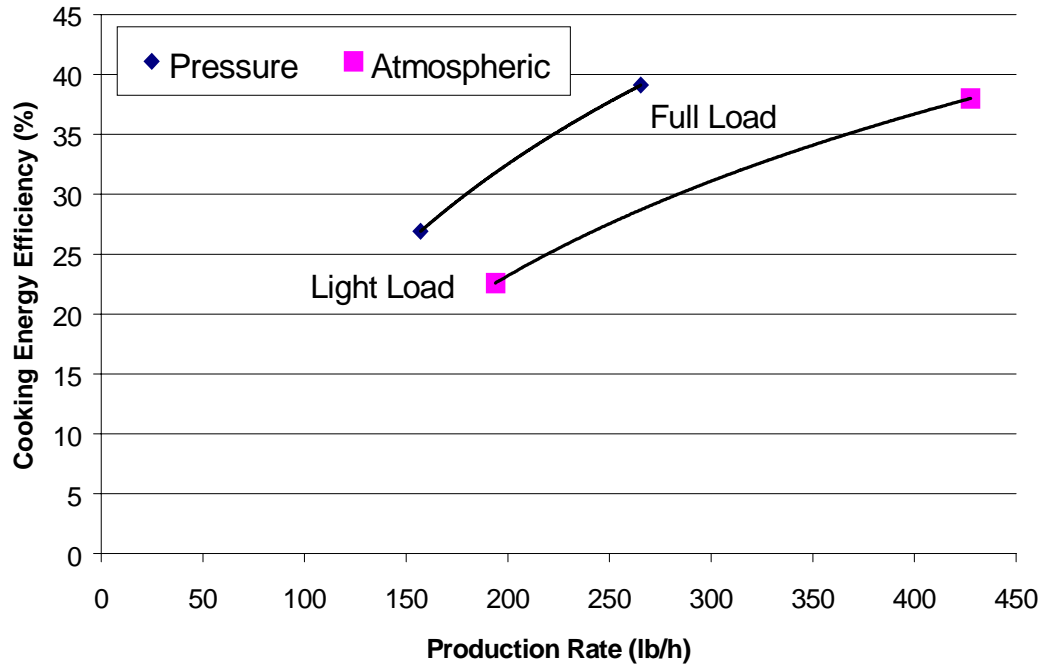


Figure ES-3.
Steamer Part-Load
Green Pea Cooking
Efficiency.

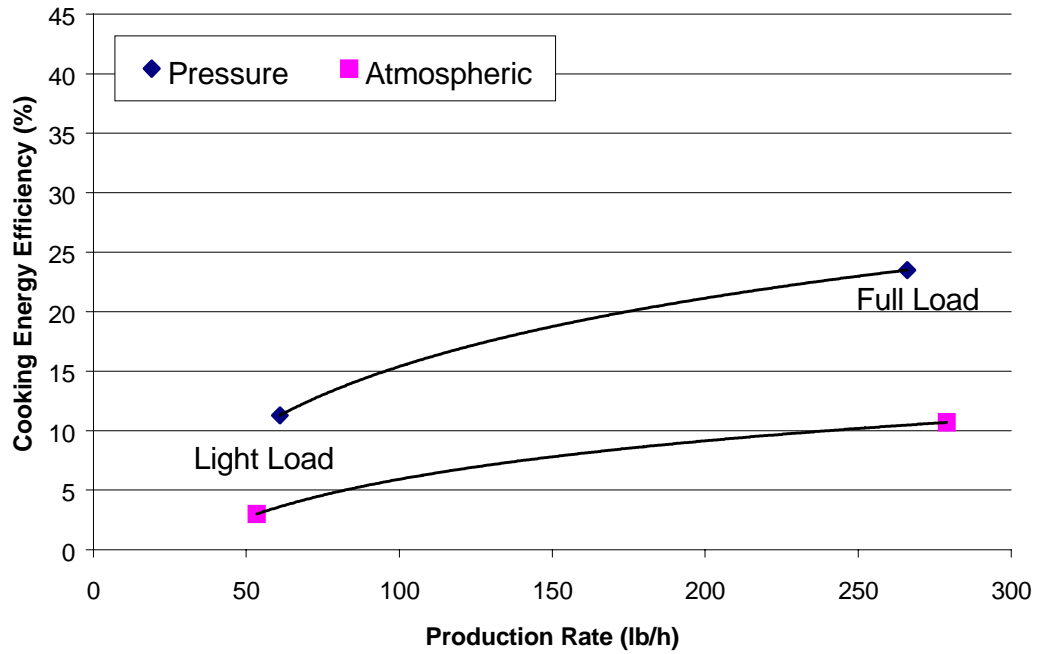


Figure ES-4.
Steamer Part-Load
Red Potato Cooking
Efficiency.

Executive Summary

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

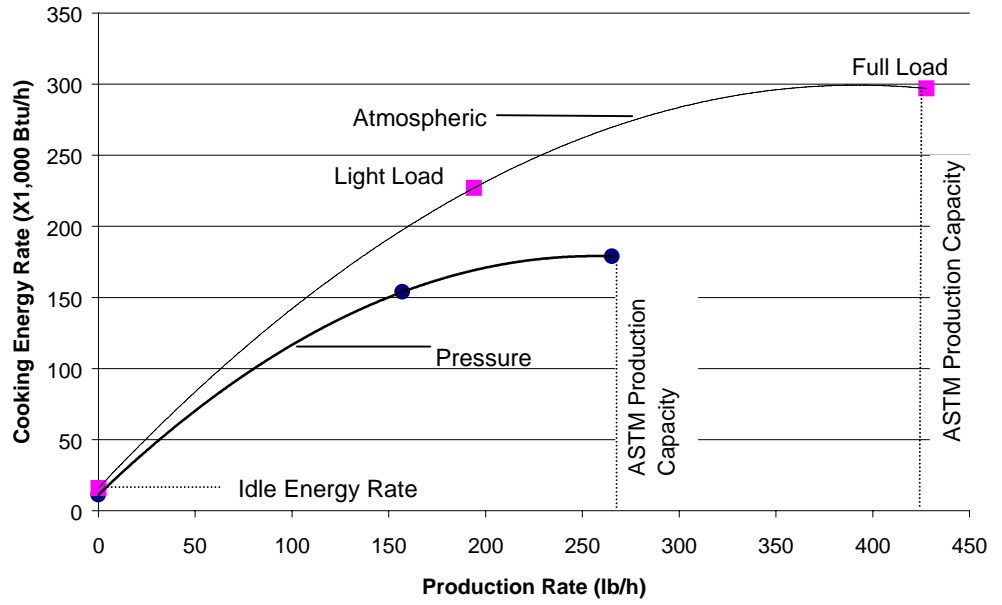
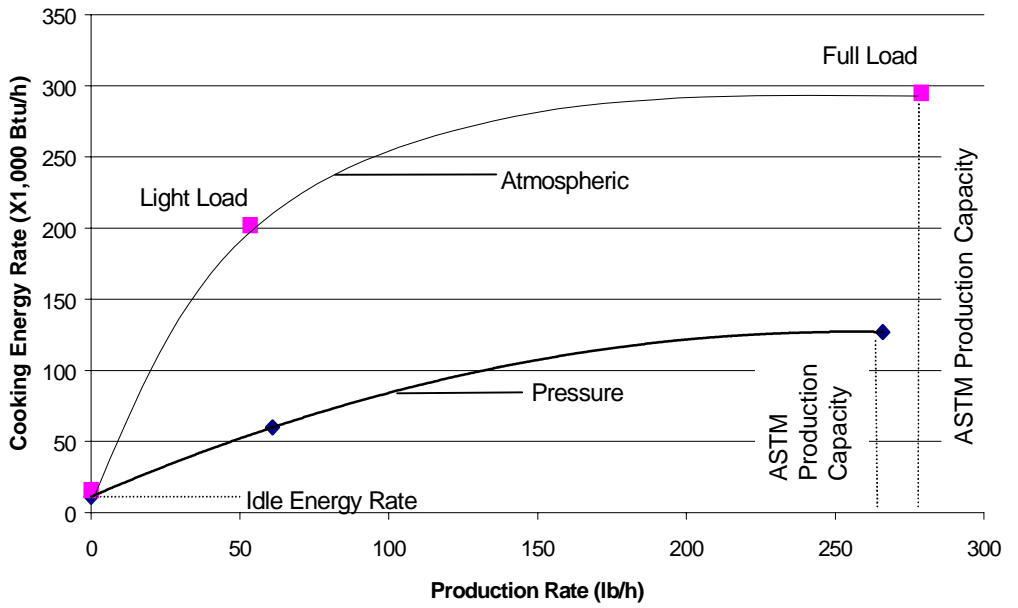


Figure ES-6.
Steamer Cooking Energy Consumption Profile, Red Potatoes.



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) and GRI, formerly the Gas Research Institute (GRI), 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 VL2GSS pressure steamer and VS3616G atmospheric steamer are both free standing, floor mounted steam cookers manufactured by Vulcan. Each steamer utilizes a gas powered, pressurized boiler to provide steam to its two cooking compartments.

The objective of this report is to examine the operation and performance of Vulcan's VL2GSS pressure steamer and VS3616G atmospheric steamer, under the controlled conditions of the ASTM Standard Test Method.

The scope of this testing is as follows:

Objectives

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 (16 pans), light-load frozen green peas (2 pans), full-load red potatoes (16 pans) and light-load red potatoes (2 pans).
5. Determine the production capacity, water consumption rate and condensate temperature for full- and light load testing scenario.

Appliance Description and Operation

Both units are stainless steel, free standing, floor mounted appliances with gas powered boiler bases. The VL2GSS steamer's dual cooking compartments can accommodate four 12" x 20" x 6" pans, six 12" x 20" x 4" pans, eight 12" x 20" 2-1/2" pans or six 18" x 26" x 1" (after removing the center support). The VS3616G steamer's dual cooking compartments can accommodate two 12" x 20" x 6" pans, four 12" x 20" x 4" pans, eight 12" x 20" 2-1/2" pans. Water hook up is also necessary to satisfy the boiler and condenser water feed requirements of both appliances. Automatic boiler blow-down following each shut down is standard on both models.

The VL2GSS pressure steamer, has a total power input of 240,000 Btu/h and pressurized cooking compartments. A standing pilot lights the units atmospheric burners. After the boiler has reached its full operating capacity, cooking can commence. An automated timer controls the steam supply to the cooking compartments. To begin a cooking cycle, the cooking cavity door is closed and secured shut, the timer is set to the desired cook time and the compartment control arm is pulled forward and locked in place, closing the drain and allowing steam to enter the compartment. The top half of the

compartment switch is pushed, starting the timer. When time expires the compartment control arm retracts automatically, shutting off the steam supply and exhausting steam from the cooking compartment. The door can then be opened and the product removed. During the testing process, the door was opened as soon as possible after the compartment control arm had been released. The boiler continues to idle independently until required to supply steam to the cooking cavity.

The VS3616G atmospheric steamer has a total power input of 300,000 Btu/h and atmospheric cooking compartments. The boiler ignition is started 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. 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.
Vulcan VL2GSS pressure steamer.*

Table 1-1. Appliance Specifications.

Manufacturer	Vulcan Company
Model	VL2GSS
Generic Appliance Type	2-compartment, pressure steamer
Rated Input	240,000 Btu/h
Technology	Boiler Base, Gas Powered, pressure steamer
Boiler Operating Pressure	8 psi
Controls	Boiler Power ON / OFF Switch. 60-Minute Electro-Mechanical Timers and Activation Switches for each Compartment. Compartment Control Arm to Control Steam to Cooking Compartments.
Construction	Exterior: Heavy Gauge Stainless Steel. Interior: Stainless Steel.
Compartment Capacity	16 (12" x 20" x 1") pans 8 (12" x 20" x 2 $\frac{1}{2}$ ") pans 6 (12" x 20" x 4") pans 4 (12" x 20" x 6") pans 6 (18" x 26" x 1") sheet pans
Dimensions	36" x 66 $\frac{3}{16}$ " x 29 $\frac{7}{8}$ " (W×H×D)

Introduction



*Figure 1-2.
Vulcan VS3616G atmospheric steamer*

Table 1-2. Appliance Specifications.

Manufacturer	Vulcan Company
Model	VS3616G
Generic Appliance Type	2-compartment, Atmospheric, Steamer.
Rated Input	300,000 Btu/h
Technology	Boiler Base, Gas Powered, atmospheric steamer
Boiler Operating Pressure	15 psi
Controls	Boiler Power ON / OFF Switch. 60-Minute Electro-Mechanical Timers to Control Steam to each Cooking Compartment.
Construction	Exterior: Heavy Gauge Stainless Steel. Interior: Stainless Steel.
Compartment Capacity	16 (12" x 20" x 1") pans 8 (12" x 20" x 2 $\frac{1}{2}$ ") pans 4 (12" x 20" x 4") pans 2 (12" x 20" x 6") sheet pans
Dimensions	36" x 66 $\frac{3}{16}$ " x 34" (W×H×D)

2 Methods

Setup and Instrumentation

The steamers were 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 two steamers are 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 ft^3 . 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 Vulcan VL2GSS and
VS3616G Steamers Instru-
mented for Testing.*

Methods

Revisions to the ASTM Test Method

The steam cooker test method, originally published as F 1484-93, has been 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 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. 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 ± 2 °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 (16 pans) determines the steamer's peak cooking energy efficiency and production capacity, while the light-load test (2 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 both Vulcan steamers: 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. Both units had a simple on/off power switch with which to actuate the filling of the boiler and the consequent lighting of the atmospheric burners. 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 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. Both units required 16 pans of green peas for a full load, while 2 pans, placed side by side in the center racks of the steamers' 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. The pans of peas were trans-

Methods

Red Potatoes Full- and Light- Load Efficiency Tests

ferred 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, both steamers required 16 pans of red potatoes for a full load and 2 pans for a light load, each pan containing 8.0 ± 0.2 lb.

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 steamers were operating within their specified parameters. The VL2GSS pressure steamer drew a maximum input rate of 235,000 Btu/h, 2.0% lower than the nameplate rating of 240,000 Btu/h, but within the 5% tolerance of the ASTM standard. The VS3616G atmospheric steamer, which has a nameplate rating of 300,000 Btu/h, consumed 305,000 Btu/h when its energy input was measured. Although 1.6% higher than its rated input rate, it was still within the 5% tolerance level stipulated in the ASTM.

Preheat and Idle Tests

Preheat Energy and Time

Both appliances were tested in identical fashion. A simple, main power switch begins the preheat process. The two units differ in their ignition technology however, as the VL2GSS pressure steamer utilizes a standing pilot to start its burners whereas the VS3616G atmospheric steamer relies upon an electronically controlled intermittent pilot. After the boiler cavity has filled with water, the boiler's atmospheric burners light. The pressure steamer required 12.7 minutes to reach its full operational capacity and consumed 34,100 Btu. The atmospheric steamer consumed 41,980 Btu and took 11.1 minutes to achieve a ready state of operation.

Idle Energy Rate

Following the preheat period, the steamers were 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 11,350 Btu/h for the VL2GSS pressure steamer and 16,020 Btu/h for the VS3616G atmospheric steamer.

Results

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.

	Pressure	Atmospheric
Rated Energy Input Rate (Btu/h)	240,000	300,000
Measured Energy Input Rate (Btu/h)	235,000	305,000
Preheat to Operational Capacity		
Time (min)	12.7	11.1
Energy (Btu)	34,050	41,980
Idle Energy Rate (Btu/h)	11,350	16,020

Cooking Tests

The steamers were tested with two test products under two loading scenarios: full-load green peas (16 pans), light-load green peas (2 pans), full-load red potatoes (16 pans), and light-load red potatoes (2 pans). For the light-load tests the two pans were placed side by side in the center racks of the top cooking cavity of each appliance. The energy consumption, elapsed cook time, water consumption, ambient temperature and product 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 (Cp) of 0.44 Btu/lb°F for frozen and 0.85 Btu/lb°F for thawed peas.³ The pressure steamer required 29.0 minutes to cook the full load of frozen green peas and had a cooking energy efficiency of 39.1% and production capacity of 265.4 lb/h. Water was consumed at a rate of 8.9 gal/hr. The atmospheric steamer cooked a full load of green peas in

Results

18.0 minutes with a cooking energy efficiency of 38.0% and a production capacity of 427.7 lb/h. Its water consumption was 71.6 gal/h.

During the 2 pan light-load tests, the VL2GSS pressure steamer required an average of 6.1 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 26.9% and 157.1lb/h, respectively. Water was consumed at a rate of 8.9 gal/h. The VS3616G atmospheric steamer cooked a light load of green peas in 4.9 minutes and had a cooking energy efficiency of 22.6% and a production capacity of 194.2 lb/h. Its water consumption was 106.36 gal/h.

Full- and Light-Load Potato Tests

The red potatoes contained 84% moisture by weight with the specific heat (Cp) of $0.87 \text{ Btu/lb}^\circ\text{F}$.³ The pressure steamer was able to cook a full load of potatoes in 25.6 minutes, and had a cooking energy efficiency of 23.5%.

The unit had a production capacity of 266.1 lb/h. Water consumption was measured at 5.2 gal/h. A full load of red potatoes cooked in the atmospheric steamer took 24.3 minutes. The cooking energy efficiency and production capacity were calculated to be 10.7% and 278.9 lb/h, respectively. Water consumption was 120.9 gal/h.

The pressure steamer required 16.0 minutes to cook 2 pans of red potatoes. The energy efficiency lowered to 11.3% and the water consumption fell to 5.2 gal/h. A 2-pan load of potatoes required 18.0 minutes to cook in the atmospheric steamer. The unit's cooking energy efficiency was 3.0% and the water consumption was calculated to be 120.9 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 weight ratio, promote condensation. The

Results

energy transfer from steam to frozen food is high, resulting in greater cooking energy efficiency and productivity. The contrast between the two food products and the resulting cooking energy efficiencies is most apparent in the VS3616G atmospheric steamer. The unit had a cooking energy efficiency of 38.0% when tasked with cooking a full load of green peas, but could only muster a cooking energy efficiency of 10.7% when cooking a full load of red potatoes. The same disparity between the two efficiencies held true for the light-load tests as well, with the unit able to achieve a respectable 22.6% cooking energy efficiency for a light load of peas, but only a 3.0% 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 VS3616G atmospheric steamer. Most of the heat energy is unused, as it has no food product to be transferred to. In this case, the steam that does not condense for lack of food product is simply expelled down the drain. The VL2GSS pressure steamer, on the other hand, has the advantage of having closed and pressurized compartments that prevent steam from escaping, resulting in a smaller variance between the full-load and light-load red potato test cooking energy efficiencies.

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 and compares the performances of the VL2GSS pressure steamer and the VS3616G atmospheric steamer. Figures 3-1 and 3-2 compare these results in a graphical format. Table 3-3 further summarizes each appliances' water consumption and condensate temperature data. Figures 3-3 and 3-4 illustrate the steamers' part-load energy efficiencies and Figures 3-5 and 3-6 show both of the units' cooking energy profiles.

Results

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

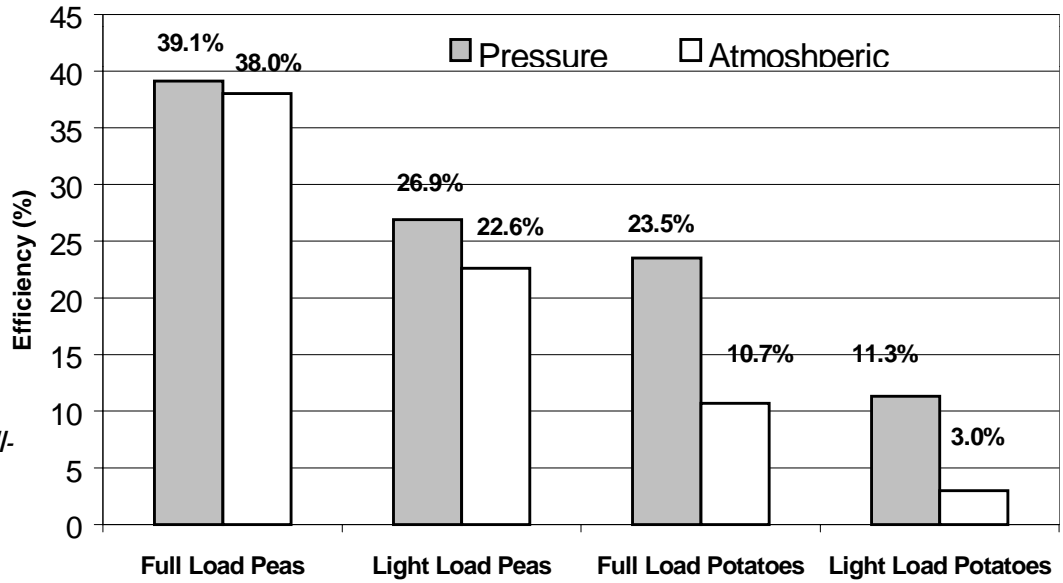
	Full Load		Light Load		Full Load		Light Load	
	Peas		Peas		Potatoes		Potatoes	
	Press.	Atmos.	Press.	Atmos.	Press.	Atmos.	Press.	Atmos.
Number of Pans	16	16	2	2	16	16	2	2
Cook Time (min)	29.0	18.0	6.1	4.9	25.6	24.3	16.0	18.0
Cooking Energy Rate (kBtu/h)	179	297	154	227	127	295	60	202
Energy Cooking Efficiency (%)	39.1	38.0	26.9	22.6	23.5	10.7	11.3	3.0
Production Rate (lb/h)	265.4	427.7	157.1	194.2	266.1	278.9	60.9	53.4
Energy Consumption (Btu/lb)	674	690	949	1114	464	1053	884	3779

Table 3-3. Water and Condensate Temperature Test Results

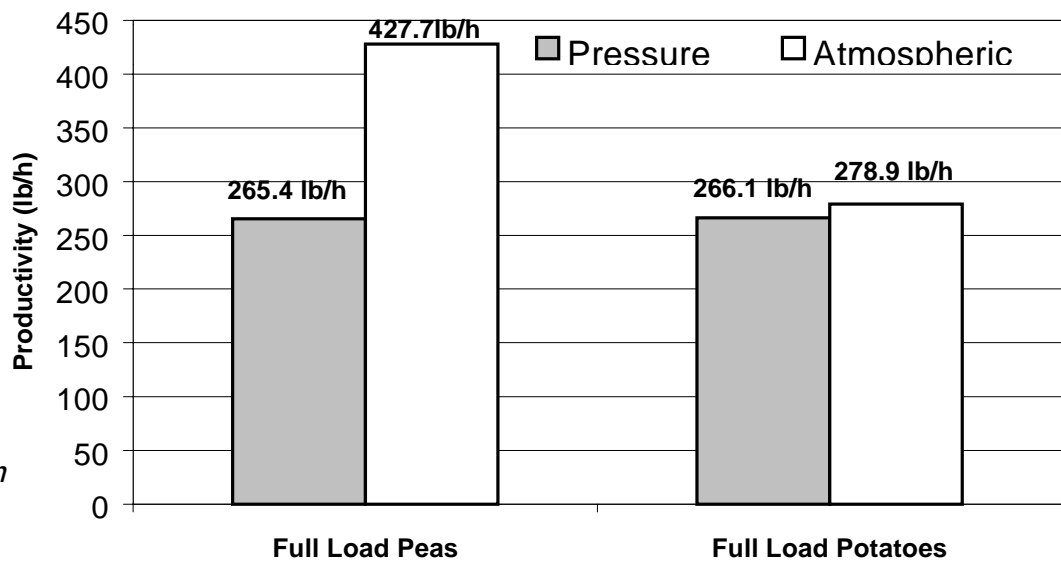
	Full Load		Light Load		Full Load		Light Load	
	Peas		Peas		Potatoes		Potatoes	
	Press.	Atmos.	Press.	Atmos.	Press.	Atmos.	Press.	Atmos.
Condensate Temperature (°F)	93.1	86.7	79.8	86.7	81.8	152.7	85.7	182.9
Water consumption (gal/h)	8.9	71.6	8.9	106.3	5.2	120.9	4.2	125.7

Results

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



*Figure 3-2.
Steamer Production
Capacities.*



Results

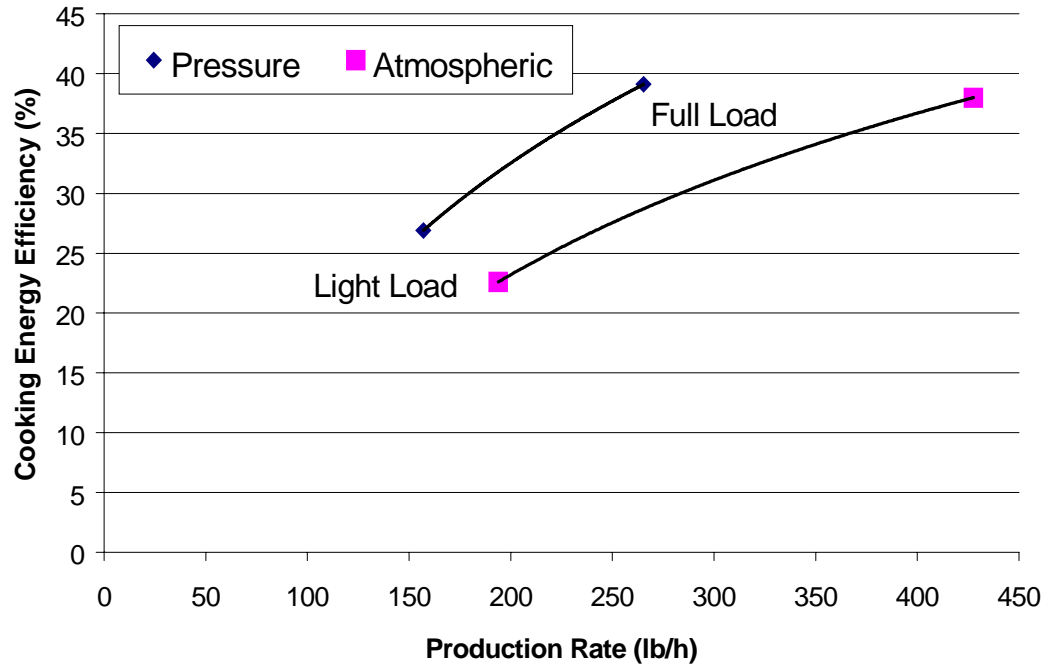


Figure 3-3.
Steamer Part-Load
Green Pea Cooking
Efficiency.

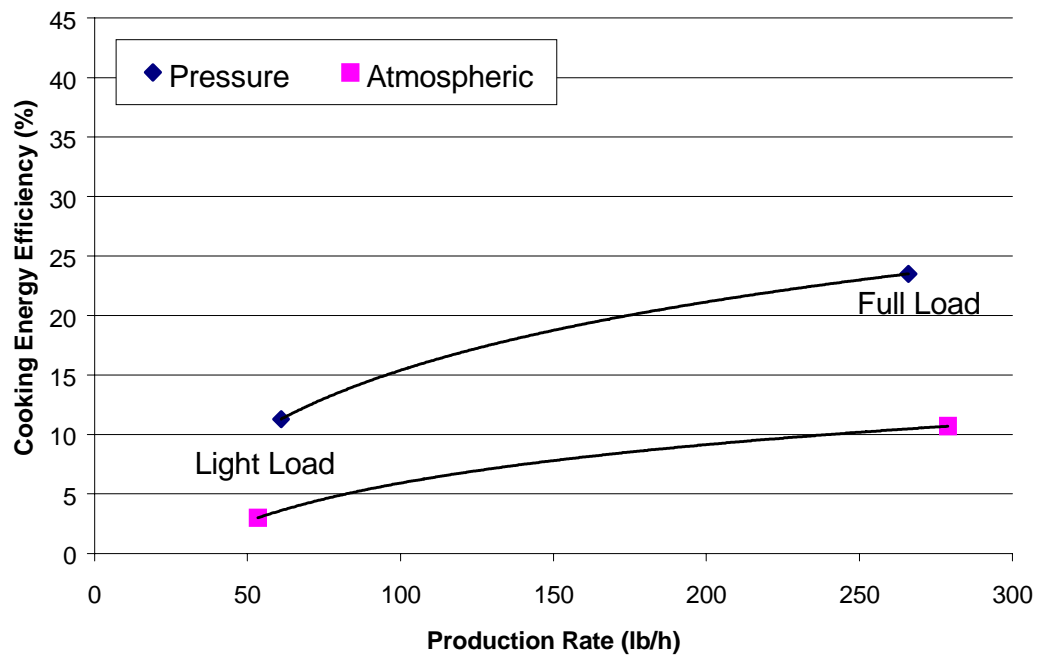


Figure 3-4.
Steamer Part-Load Red
Potato Cooking
Efficiency.

Results

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

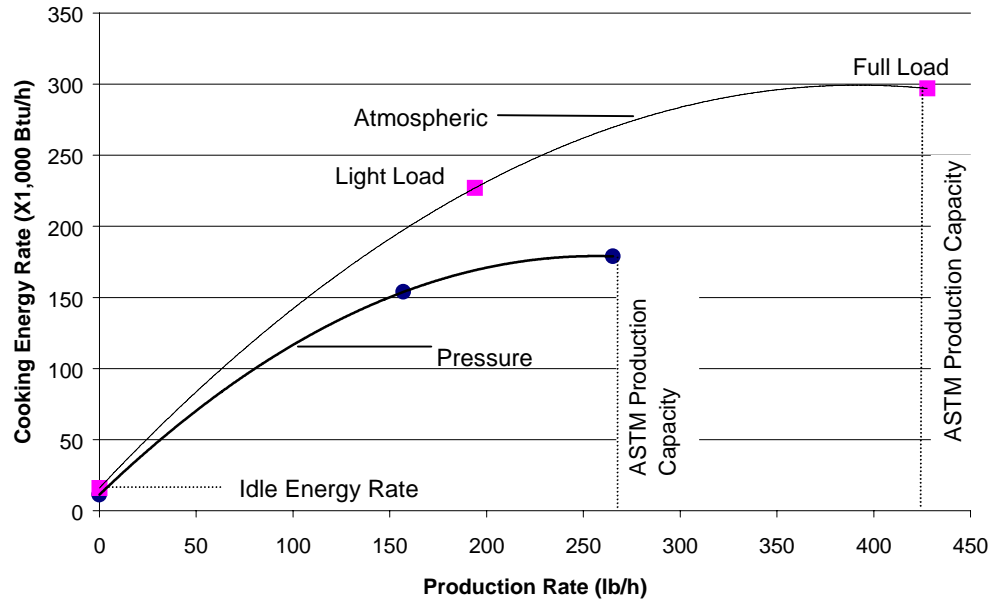
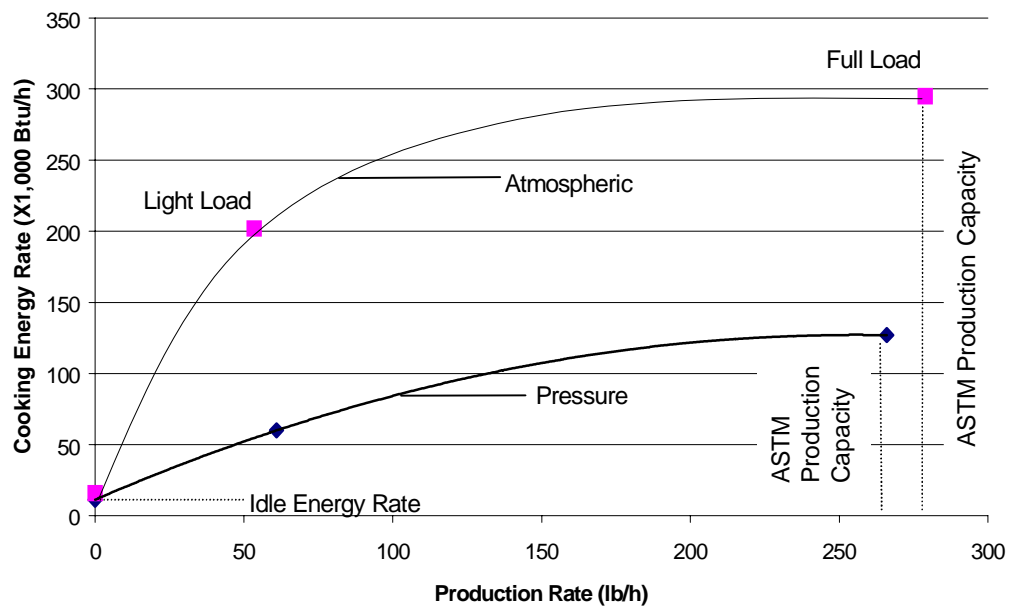


Figure 3-6.
Steamer Cooking Energy Consumption Profile, Red Potatoes.



4 Conclusions

The Vulcan VL2GSS pressure steamer and the VS3616G atmospheric steamer outperformed previously FSTC tested boiler-based steamers of relatively similar energy inputs, both in cooking energy efficiency and production capacity. Each unit had readily available, on demand, steam to deliver to its cooking compartments. As a result, cook times were very fast, especially when considering that a full load consists of 16 pans of food product. The light loads (2 pans), cooked quickly also. Of all the steamers tested to date at the FSTC, the VS3616G atmospheric steamer had the fastest cook time for a light-light load of green peas.^{3,4,5,6} The VL2GSS pressure steamer can make the same the claim with regards to the light-load potato test.^{3,4,5,6}

Comparing the two appliances brings to light several important differences in performance capabilities. The cooking energy efficiencies of both units, for full- and light-load green peas are very respectable for a gas powered appliance of any application and almost identical, roughly 40%. The similarities ended when looking at the cook time, production capacity and water consumption of each steamer. The VS3616G atmospheric steamer delivers a speedy 18.0 minute cook time for a full-load (16 pans) of green peas and 4.9 minutes for a light load (2 pans) of green peas. The pressure steamer on the other hand, takes a more leisurely 29.0 minutes for the same full load and 6.1 minutes for a light load. Thus, the difference between production capacity for full loads is quite pronounced, 427.7 lb/h for the atmospheric steamer, and 265.4 lb/h for the pressure steamer. The performance advantage shifts to the pressure steamer with regards to water consumption however, as it used a paltry 8.9 gal/h for a heavy and light load of green peas. In contrast, the opposing unit used 71.6 gal/h for a full load of green peas and 106.3 gal/h for a light load.

Conclusions

When the two units were challenged with cooking a “tough” food product such as red potatoes, the pressure steamer came out ahead. Both units had relatively the same cook times, 25.6 minutes for the pressurized model and 24.3 minutes for the atmospheric model and thus, nominally differing production capacities of 266.1 lb/h and 278.9 lb/h. The pressure steamer, however, used substantially less cooking energy to cook a full load of red potatoes, as is demonstrated by its cooking input rate of 127,090 Btu/h versus 295,080 Btu/h required by the atmospheric steamer. As a result, the cooking energy efficiency of the pressurized unit was markedly higher than that of the atmospheric unit, 23.5% versus 10.7%. Water consumption also distinguished the two models. Again the pressure steamer was the water miser, consuming a mere 5.2 gal/h for a full load and 4.2 gal/h for light. The VS3616G atmospheric steamer used 120.9 gal/h for a full load and 125.7 gal/h for a light load.

The VL2GSS pressure steamer can attribute much of its higher red potato cooking performance to its pressurized cooking compartments. The unit’s cooking compartments are effectively sealed during a cooking event, ensuring that much of the cooking energy stays where its supposed to; in the cooking compartment as opposed to escaping down the condensate drain. Furthermore, the pressurized compartment forces that cooking energy into the food product, which is a valuable asset when cooking “tough” food products like red potatoes. The VS3616G atmospheric steamer is hard pressed to keep up, as its compartments are continually venting steam and condensate down the drain. Water consumption is high in the VS3616G atmospheric steamer because it must continually draw water to cool the condensate.

Conclusions

Both units performed admirably and more importantly give operators many choices when looking to outfit a kitchen's line up. "Do I need cost cutting energy savings, higher energy efficiency and low water consumption?" or "am I looking for fast cook times for frozen product to maximize my production capacity?" Each steamer's attributes offer different advantages that must be weighed carefully. Ultimately, Vulcan has designed two solid work-horses to fill its stable of commercial cooking appliances, ready to satisfy the needs of various types of food service operations.

5 References

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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.

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.

Atmospheric Steam Cooker

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

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 VulcanVL2GSS pressure steamer and the VS3616G atmospheric steamer.

C Results Reporting Sheets

Manufacturer: Vulcan Company
Model: VL2GSS pressure steamer
Date: September 2000

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 - One 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

Description of operation characteristics: The boiler is turned on with a power on/off switch. After the boiler has reached its full operational capacity, cooking can commence. The compartment doors are closed and secured shut, then the compartment control arm is drawn forward and locked in place allowing steam to enter the cooking compartment. The timer is set to desired cook time and the top portion of the timer switch is pressed. When the cook time has expired, the steam supply is automatically stopped, the drain opened and steam vented from the cooking compartment. The door can then be opened and the food removed.

Results Reporting Sheets

Manufacturer: Vulcan Company
Model: VS3616G atmospheric steamer
Date: September 2000

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 - One 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

Description of operation characteristics: The boiler is turned on with a simple on/off switch. When the boiler has reached its full operational capacity, cooking can commence. 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.

Results Reporting Sheets

Section 10.7 Apparatus

The steamers were 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

	Pressure	Atmospheric
Measured	235,000 Btu/h	305,000 Btu/h
Rated	240,000 Btu/h	300,000 Btu/h
Percent Difference between Measured and Rated	2.0%	1.6%

Section 11.5 Boiler Preheat Energy Consumption and Duration

Energy Consumption	34,050 Btu	41,980 Btu
Duration	12.7 min	11.1 min

Section 11.6 Boiler Idle Energy Rate

Idle Energy Rate	11,346 Btu/h	16,020 Btu/h
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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:	Pressure	Atmospheric
Cooking Time	29.0 min	18.0 min
Cooking Energy Efficiency	39.1 ± 0.2 %	38.0 ±1.0%
Cooking Energy Rate	178,950 Btu/h	297,390 Btu/h
Production Capacity	265.4 ± 3.5 lb/h	427.7 ±5.7 lb/h
Water Consumption Rate	8.9 ± 0.1 gal/h	71.62 ±6.9 gal/h
Light Load:		
Cooking Time	6.1 min	4.9 min
Cooking Energy Efficiency	26.9 ± 1.2 %	22.6 ±1.3%
Cooking Energy Rate	153,830 Btu/h	226,940 Btu/h
Production Rate	157.1 ± 6.9 lb/h	194.2 ± 4.7 lb/h
Water Consumption Rate	8.9 ± 0.8 gal/h	106.4 ± 9.4 gal/h

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

Full Load:	Pressure	Atmospheric
Cooking Time	25.6 min	24.3 min
Cooking Energy Efficiency	23.5 ± 1.4%	10.7 ±0.2%
Cooking Energy Rate	127,090 Btu/h	295,080 Btu/h
Production Capacity	266.1 ± 8.4lb/h	278.9 ± 4.5lb/h
Water Consumption Rate	5.16 ± 0.4 gal/h	120.9 ± 2.5 gal/h

Results Reporting Sheets

Light Load:	Pressure	Atmospheric
Cooking Time	16.0 min	18.0 min
Cooking Energy Efficiency	11.3 ±0.3%	3.0 ±0.1%
Cooking Energy Rate	59,560 Btu/h	201,890 Btu/h
Production Capacity	60.9 ± 0.5lb/h	53.4± 0.3lb/h
Water Consumption Rate	4.1 ± 4.1 gal/h	125.7 ± 0.5 gal/h

D Cooking Energy Efficiency Data

Table D-1. Preheat and Idle Data (VL2GSS pressure steamer)

Measured Values	Replication 1	Replication 2	Replication 3
Preheat Time (min)	12.42	12.92	12.67
Preheat Energy (BTU)	33,277	35,060	33,833
Idle Time (min)	120.00	120.00	120.00
Idle Energy (BTU)	23,238	22,068	22,776

Calculated Values			
Preheat Energy Rate (BTU/h)	160,760	162,820	160,220
Idle Energy Rate (BTU/h)	11,620	11,030	11,390

Cooking Energy Efficiency Data

Table D-2. Full-Load Peas Data (VL2GSS pressure steamer)

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	16	16	16
Cook Time (min)	29.0	29.0	29.0
Initial Water Temperature (°F)	45.0	42.7	41.8
Final Water Temperature (°F)	102.0	99.0	100.0
Frozen Food Temperature (°F)	0.0	0.0	0.0
Weight of Empty Calorimeter (lb)	44.4	44.5	44.3
Weight of Full Calorimeter (lb)	155.0	154.8	154.5
Weight of Calorimeter Water (lb)	60.0	60.0	60.0
Weight of Cooked Food (lb)	50.6	50.3	50.2
Weight of Frozen Food (lb)	127.5	128.7	128.7
Weight of Stainless-Steel Pans (lb)	43.1	43.1	43.1
Moisture Content (%)	81	81	81
Condensate Temperature (°F)	93.5	94.6	91.2
Water Consumption (gal/h)	8.9	9.0	8.9
<hr/>			
Moisture Weight in Green Peas(lb)	103.3	104.2	104.2
Final Food Temperature (°F)	181.6	178.3	182.0
Cooking Energy (Btu)	86,141	86,308	87,023
Energy Consumed by Green Peas (Btu)	32,857	32,798	33,205
Energy Consumed by Pans (Btu)	860	844	862
Energy of Boiler Re-init (Btu)	0	0	0
Energy Consumed by the Steamer (Btu)	86,141	86,308	87,023
<hr/>			
Cooking Energy Rate (Btu/h)	178,220	178,570	180,050
Productivity (lb/h)	263.8	266.3	266.3
Energy Efficiency (%)	39.1	39.0	39.1

Cooking Energy Efficiency Data

Table D-3. Light-Load Peas Data (VL2GSS pressure steamer)

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	2	2	2
Cook Time (min)	6.0	6.17	6.17
Initial Water Temperature (°F)	45.7	41.0	44.0
Final Water Temperature (°F)	88.3	84.6	82.6
Frozen Food Temperature (°F)	0.0	0.0	0.0
Weight of Empty Calorimeter (lb)	44.5	44.7	44.3
Weight of Full Calorimeter (lb)	91.7	90.6	88.5
Weight of Calorimeter Water (lb)	30.3	30.0	30.3
Weight of Cooked Food (lb)	16.9	15.9	13.9
Weight of Frozen Food (lb)	16.0	16.0	16.0
Weight of Stainless-Steel Pans (lb)	4.8	4.8	5.6
Moisture Content (%)	81	81	81
Condensate Temperature (°F)	72.9	80.7	85.9
Water Consumption (gal/h)	8.6	9.0	9.2
Moisture Weight in Green Peas(lb)	13.0	13.0	13.0
Final Food Temperature (°F)	178.6	181.7	181.8
Cooking Energy (Btu)	15,270	14,905	15,398
Energy Consumed by Green Peas (Btu)	4,082	4,124	4,125
Energy Consumed by Pans (Btu)	95	96	112
Energy of Boiler Re-init (Btu)	477	480	481
Energy Consumed by the Steamer (Btu)	15,747	15,386	15,879
Cooking Energy Rate (Btu/h)	157,470	149,620	154,410
Productivity (lb/h)	160.0	155.7	155.7
Energy Efficiency (%)	26.5	27.4	26.7

Cooking Energy Efficiency Data

Table D-4. Full-Load Potatoes Data (VL2GSS pressure steamer)

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	16	16	16
Cook Time (min)	25.8	25.5	25.3
Temperature of Uncooked Potatoes (°F)	72.2	75.0	72.0
Temperature of Cooked Potatoes (°F)	195.4	195.7	195.0
Weight of Stainless-Steel Pans (lb)	42.9	42.9	42.9
Weight of Potatoes (lb)	112.9	113.6	113.5
Total Potato Count	778	762	754
Moisture Content (%)	81.1	81.1	81.1
Condensate Temperature (°F)	77.2	84.1	84.2
Water Consumption (gal/h)	5.0	5.2	5.3
Calculated Values			
Moisture Weight in Potatoes (lb)	94.9	95.5	94.3
Average Weight of Each Potatoes (lb)	0.15	0.15	0.15
Cooking Energy (Btu)	52,986	51,023	53,695
Energy Consumed by Potatoes (Btu)	12,148	11,970	12,187
Energy Consumed by Pans (Btu)	582	570	581
Energy of Boiler Re-init (Btu)	1,858	1,032	1,644
Energy Consumed by the Steamer (Btu)	54,844	52,055	55,339
Cooking Energy Rate (Btu/h)	127,540	122,480	131,240
Productivity (lb/h)	262.3	267.2	268.7
Energy Efficiency (%)	23.2	24.1	23.1

Cooking Energy Efficiency Data

Table D-5. Light-Load Potatoes Data (VL2GSS pressure steamer)

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	2	2	2
Cook Time (min)	16.0	16.0	16.0
Temperature of Uncooked Potatoes (°F)	74.8	75.0	72.0
Temperature of Cooked Potatoes (°F)	194.9	194.4	196.2
Weight of Stainless-Steel Pans (lb)	5.6	5.1	5.6
Weight of Potatoes (lb)	16.3	16.2	16.2
Total Potato Count	94	97	94
Moisture Content (%)	81.1	81.1	81.1
Condensate Temperature (°F)	82.6	77.0	97.6
Water Consumption (gal/h)	3.8	2.7	6.0
Calculated Values			
Moisture Weight in Potatoes (lb)	13.7	13.6	13.7
Average Weight of Each Potatoes (lb)	0.17	0.17	0.17
Cooking Energy (Btu)	14,445	13,959	14,694
Energy Consumed by Potatoes (Btu)	1,709	1,692	1,755
Energy Consumed by Pans (Btu)	74	67	76
Energy of Boiler Re-init (Btu)	1,445	1,444	1,659
Energy Consumed by the Steamer (Btu)	15,890	15,403	16,353
Cooking Energy Rate (Btu/h)	59,590	57,760	61,320
Productivity (lb/h)	61.1	60.9	60.7
Energy Efficiency (%)	11.2	11.4	11.1

Cooking Energy Efficiency Data

Table D-6. Preheat and Idle Data (VS3616G atmospheric steamer)

Measured Values	Replication 1	Replication 2	Replication 3
Preheat Time (min)	11.00	11.08	11.08
Preheat Energy (BTU)	42,300	42,300	41,328
Idle Time (min)	120.00	120.00	120.00
Idle Energy (BTU)	32,855	31,645	31,620

Calculated Values			
Preheat Energy Rate (BTU/h)	230,730	229,060	223,800
Idle Energy Rate (BTU/h)	16,430	15,820	15,810

Cooking Energy Efficiency Data

Table D-7. Full-Load Peas Data (VS3616G atmospheric steamer)

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	16	16	16
Cook Time (min)	18.0	18.0	18.0
Initial Water Temperature (°F)	39.5	38.6	48.4
Final Water Temperature (°F)	96.0	95.2	102.1
Frozen Food Temperature (°F)	0.0	0.0	0.0
Weight of Empty Calorimeter (lb)	44.4	44.5	44.3
Weight of Full Calorimeter (lb)	150.7	151.7	151.5
Weight of Calorimeter Water (lb)	59.8	60.2	59.8
Weight of Cooked Food (lb)	46.5	47.0	47.4
Weight of Frozen Food (lb)	127.5	128.7	128.7
Weight of Stainless-Steel Pans (lb)	43.1	43.1	43.1
Moisture Content (%)	81	81	81
Condensate Temperature (°F)	86.6	87.5	85.9
Water Consumption (gal/h)	74.1	68.6	72.1
<hr/>			
Moisture Weight in Green Peas(lb)	103.3	104.2	104.2
Final Food Temperature (°F)	181.6	180.6	181.9
Cooking Energy (Btu)	88,269	89,389	87,943
Energy Consumed by Green Peas (Btu)	32,853	33,047	33,197
Energy Consumed by Pans (Btu)	860	855	862
Energy of Boiler Re-init (Btu)	681	686	258
Energy Consumed by the Steamer (Btu)	88,950	90,074	88,626
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Cooking Energy Rate (Btu/h)	296,500	300,250	295,420
Productivity (lb/h)	425.0	429.0	429.0
Energy Efficiency (%)	37.9	37.6	38.4

Cooking Energy Efficiency Data

Table D-8. Light-Load Peas Data (VS3616G atmospheric steamer)

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	2	2	2
Cook Time (min)	4.9	5.0	4.9
Initial Water Temperature (°F)	45.8	43.8	40.5
Final Water Temperature (°F)	88.7	86.9	85.2
Frozen Food Temperature (°F)	0.0	0.0	0.0
Weight of Empty Calorimeter (lb)	44.5	44.2	44.5
Weight of Full Calorimeter (lb)	90.8	90.4	91.2
Weight of Calorimeter Water (lb)	30.0	30.0	30.0
Weight of Cooked Food (lb)	16.3	16.2	16.7
Weight of Frozen Food (lb)	16.0	16.0	16.0
Weight of Stainless-Steel Pans (lb)	5.2	5.2	5.2
Moisture Content (%)	81	82	83
Condensate Temperature (°F)	86.6	87.5	85.9
Water Consumption (gal/h)	102.0	109.1	107.9
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Moisture Weight in Green Peas(lb)	13.0	13.0	13.0
Final Food Temperature (°F)	181.6	181.3	180.0
Cooking Energy (Btu)	17,364	18,111	18,027
Energy Consumed by Green Peas (Btu)	4,122	4,119	4,101
Energy Consumed by Pans (Btu)	104	104	103
Energy of Boiler Re-init (Btu)	826	817	835
Energy Consumed by the Steamer (Btu)	18,190	18,928	18,862
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Cooking Energy Rate (Btu/h)	222,730	227,140	230,960
Productivity (lb/h)	195.3	192.0	195.3
Energy Efficiency (%)	23.2	22.3	22.3

Cooking Energy Efficiency Data

Table D-9. Full-Load Potatoes Data (VS3616G atmospheric steamer)

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	16	16	16
Cook Time (min)	24.5	24.0	24.5
Temperature of Uncooked Potatoes (°F)	70.8	70.4	72.7
Temperature of Cooked Potatoes (°F)	195.7	195.0	195.0
Weight of Stainless-Steel Pans (lb)	42.9	42.9	42.9
Weight of Potatoes (lb)	113.2	112.3	113.8
Total Potato Count	751.0	741.0	721.0
Moisture Content (%)	81.1	81.1	81.1
Condensate Temperature (°F)	148.7	149.9	159.4
Water Consumption (gal/h)	120.7	120.0	122.0
Calculated Values			
Moisture Weight in Potatoes (lb)	95.1	94.4	95.7
Average Weight of Each Potatoes (lb)	0.15	0.15	0.16
Cooking Energy (Btu)	121,231	118,601	117,531
Energy Consumed by Potatoes (Btu)	12,340	12,210	12,153
Energy Consumed by Pans (Btu)	590	588	578
Energy of Boiler Re-init (Btu)	546	545	531
Energy Consumed by the Steamer (Btu)	121,780	119,146	118,062
Cooking Energy Rate (Btu/h)	298,240	297,860	289,130
Productivity (lb/h)	277.1	280.7	278.7
Energy Efficiency (%)	10.6	10.7	10.8

Cooking Energy Efficiency Data

Table D-10. Light-Load Potatoes Data (VS3616G atmospheric steamer)

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	2	2	2
Cook Time (min)	18.0	18.0	18.0
Temperature of Uncooked Potatoes (°F)	72.0	72.0	72.0
Temperature of Cooked Potatoes (°F)	194.8	195.5	195.5
Weight of Stainless-Steel Pans (lb)	5.6	5.0	5.2
Weight of Potatoes (lb)	16.0	16.1	16.0
Total Potato Count	94.0	95.0	94.0
Moisture Content (%)	81.1	81.1	81.1
Condensate Temperature (°F)	182.0	183.1	183.5
Water Consumption (gal/h)	125.5	125.9	125.9
Calculated Values			
Moisture Weight in Potatoes (lb)	13.5	13.5	13.4
Average Weight of Each Potatoes (lb)	0.17	0.17	0.17
Cooking Energy (Btu)	61,634	60,513	59,552
Energy Consumed by Potatoes (Btu)	1,716	1,732	1,724
Energy Consumed by Pans (Btu)	76	68	71
Energy of Boiler Re-init (Btu)	0.0	0.0	0.0
Energy Consumed by the Steamer (Btu)	61,634	60,513	59,553
Cooking Energy Rate (Btu/h)	205,450	201,710	198,510
Productivity (lb/h)	53.4	53.6	53.3
Energy Efficiency (%)	2.9	3.0	3.0

