

**Vulcan-Hart, VSX 10GC
Gas Steamer Performance Test**

Application of ASTM Standard
Test Method F 1484-04

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Executive Summary

The Food Service Technology Center (FSTC) tested the Vulcan, VSX 10GC steam-generator based gas steamer under the controlled conditions of the American Society for Testing and Materials (ASTM) *Standard Test Method for the Performance of Steam Cookers*.¹ Steamer performance is characterized by preheat duration and energy consumption, idle energy rate, cooking energy rate and efficiency, production capacity, water consumption, and condensate temperature from product testing. The steamer's cooking uniformity was determined by heating ice loads and examining their temperature profiles. Cooking tests were conducted with grade A frozen green peas and grade B red potatoes in accordance with ASTM test materials specifications for weight, size, and water content.¹ Researchers also monitored the water consumption rate during testing, since the VSX 10GC is equipped with water connections for automatic refilling of the steam generators and for condensate cooling.

The VSX 10GC performed very well during the standard tests as evidenced by its high production capacities of 197 lb/h for frozen green peas and 230 lb/h for red potatoes. Not only is the VSX 10GC able to cook large quantities of food very quickly, but it also steams the entire compartment with excellent uniformity.

Cooking-energy efficiency is a measure of how much of the energy that an appliance consumes is actually delivered to the food product during the cooking process. Cooking-energy efficiency is therefore defined by the following relationship:

¹ American Society for Testing and Materials, 2004. Standard Test Method for the Performance of Steam Cookers. ASTM Designation F1484-04, in the Annual Book of ASTM Standards, West Conshohocken, PA.

Executive Summary

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

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

Table ES-1. Summary of VSX 10GC Steamer Performance.

Rated Energy Input Rate (Btu/h)	90,000
Measured Energy Input Rate (Btu/h)	88,990
Preheat Time (min)	10.7
Preheat Energy (Btu)	10,330
Idle Energy Rate (Btu/h)	4,460
Frozen Green Peas	
Light-Load Cooking-Energy Efficiency (%)	49.9 ± 2.5
Light-Load Water Consumption Rate (gal/h)	48.1
Heavy-Load Cooking-Energy Efficiency (%)	58.7 ± 0.8
Heavy-Load Water Consumption Rate (gal/h)	91.7
Production Capacity (lb/h)	196.8 ± 4.7
Red Potatoes	
Light-Load Cooking-Energy Efficiency (%)	12.5 ± 0.4
Light-Load Water Consumption Rate (gal/h)	48.0
Heavy-Load Cooking-Energy Efficiency (%)	29.2 ± 2.6
Heavy Load Water Consumption Rate (gal/h)	90.8
Production Capacity (lb/h)	230.4 ± 7.8
Ice-Loads	
Cook Time – Top (min)	31.0
Maximum Temperature Difference – Top (°F)	19.2
Cook Time – Bottom (min)	32.0
Maximum Temperature Difference – Bottom (°F)	16.6

1 Introduction

Background

Steaming provides a fast-cooking option for preparing large quantities of food, while retaining vital nutrients in the cooked product. Steamers are versatile appliances that can be used to prepare almost any food that does not require a crust. Delicate vegetables, such as asparagus and broccoli, are cooked without damage; frozen foods are defrosted and cooked in one step; and hard-to-cook meats, such as beef ribs, can be par-cooked quickly with less weight loss than oven roasting.

Dedicated to the advancement of the food service industry, the Food Service Technology Center (FSTC) has focused on the development of standard test methods for commercial food service equipment since 1987. The primary component of the FSTC is a 10,000 square-foot appliance laboratory equipped with energy monitoring and data acquisition hardware, 60 linear feet of canopy exhaust hoods integrated with utility distribution systems, appliance setup and storage areas, and a state-of-the-art demonstration and training facility.

The test methods, approved and ratified by the American Society for Testing and Materials (ASTM), allow benchmarking of equipment so that users can make informed comparisons among available equipment choices. By collaborating with the Electric Power Research Institute (EPRI) and the Gas Technology Institute (GTI) through matching funding agreements, the test methods have remained unbiased to fuel choice. End-use customers and commercial appliance manufacturers consider the FSTC to be the national leader in commercial food service equipment testing and standards, sparking alliances with several major chain customers to date.

Since the development of the ASTM test method for steam cookers in 1993,¹ the FSTC has tested a wide range of gas and electric steamers.²⁻²⁰

Introduction

The VSX 10GC features two 45,000 Btu/h high output steam generators, two 5-pan capacity compartments, and steam ports mounted on both sides of the interior for uniform steaming.

The glossary in Appendix A is provided so that the reader has a quick reference to the terms used in this report.

Objectives

The objective of this report is to examine the operation and performance of the Vulcan, VSX 10GC 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 time and energy required to preheat the steamer to an operating condition.
3. Characterize the idle energy use of the steamer while maintaining a ready-to-cook state.
4. Determine the cooking-energy efficiency under four scenarios: heavy-load frozen green peas (10 pans), light-load frozen green peas (two pans), heavy-load red potatoes (10 pans) and light-load red potatoes (two pans).
5. Determine the production capacity, cooking energy rate and cook time for each loading scenario.
6. Characterize cooking uniformity by steaming ice loads.
7. Determine the water consumption during various test scenarios.

Appliance Description

The Vulcan VSX 10GC is a 10-pan capacity, double compartment, gas, steam generator based steamer (Figure 1-1). The steamer is powered by two 45,000 Btu/h burners located beneath each steam generator. Steam is quickly produced within these generators and forced into the compartment from natural steam pressure via ports located on both sides of each compartment. Each cooking chamber can accommodate 5 standard full-size, 2½-inch deep

Introduction

hotel pans. The VSX 10GC has a single cooking mode: timed. The timed mode allows operators to set a pre-determined cooktime of up to 60 minutes. When the cook time has expired, the unit automatically switches to a standby mode. In this standby mode (0 minutes on timer), steam is discontinued to the compartments and the unit maintains a predetermined water temperature within each generator. The steamer will cycle the burners on and off as necessary to maintain the generators at a near boiling state until a time is chosen on the timer dial. During this standby period, the doors may be opened or left closed.

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



Figure 1-1.
The Vulcan VSX 10GC
steamer.

Table 1-1. Appliance Specifications.

Manufacturer	Vulcan-Hart
Model	VSX 10GC
Generic Appliance Type	Steam generator based, 2 compartment, gas, atmospheric, steamer with water connections.
Rated Input	90,000 Btu/h
Technology	Steam-generator based steamer.
Construction	Stainless-steel walls.
Interior	316 stainless-steel
Exterior	304 Stainless-steel
Controls	Main ON/OFF buttons. 60-minute mechanical timer with continuous steam.
Compartment Capacity	5 (12" x 20" x 2 1/2") pans
Dimensions	24" x 37" x 75 5/8" (wxdxh)

2 Methods

Setup and Instrumentation

The steamer was installed in accordance with the manufacturer's instructions and in accordance with Section 9 of the ASTM test method¹: 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 $75 \pm 5^\circ\text{F}$.

Natural gas consumption was measured using a positive displacement-type gas meter that generated a pulse every 0.1 ft^3 . The meter and thermocouples were connected to a computerized data acquisition unit that recorded data every 5 seconds. The higher-heating value of the gas was determined with a water bath calorimeter and all gas measurements were corrected to standard conditions. Figure 2-1 shows the VSX 10GC instrumented with the data acquisition system.



*Figure 2-1.
The VSX 10GC instrumented for testing.*

Methods

Non-Cooking Tests

The energy input rate was determined by measuring the energy consumed by the steamer during a complete preheat cycle. The maximum power draw during this period was reported as the measured energy input rate. Preheat tests recorded the time and energy required for the steamer to reach operating temperature from a cold start when turned on for the first time in a day. An hour after the preheat cycle, idle energy consumption was monitored over a 2-hour period and conducted with the timer set to zero minutes.

Frozen Green Pea Efficiency Tests



Figure 2-2.
Frozen green pea load.

Individually flash-frozen, grade A green peas (Figure 2-2) represented one of two food products for steamer performance testing. Standard full-size (12" x 20" x 2½"), perforated stainless-steel hotel pans were used for cooking the green peas. The VSX 10GC required 10 pans of green peas for a full load, while a single pan placed on the center rack of each compartment cavity comprised a light load. Each pan contained 8.0 ± 0.01 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 testing. The pans of peas were transferred into an insulated box and transported to the testing location where the plastic bags were removed, and the pans of green peas were loaded into the steamer according to the loading time prescribed in section 10.7.6 of the ASTM test method.¹

Since probing proves to be difficult and erroneous in measuring the temperature of small-sized green peas, a water-bath calorimeter was utilized to determine the final bulk temperature of the cooked green peas. The time required to cook the frozen peas to a bulk temperature of $180 \pm 2^\circ\text{F}$ was determined through an iterative process. Once the cooking parameters were established, the test was replicated a minimum of three times to minimize the uncertainty in the test results.

Methods

Red Potato Efficiency Tests



*Figure 2-3.
Red potato load.*

Freshly packed, size B, red potatoes (Figure 2-3) served as the second food product for steamer performance testing. The VSX 10GC required 10 pans of red potatoes for a full load and two pans for a light load. Each pan contained 8.0 ± 0.2 pounds of red 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 then cooked to $195 \pm 2^\circ\text{F}$ using a predetermined cook time. The final temperature was determined by probing a minimum of 3 potatoes per pan during testing and then randomly probing potatoes (using a hand-held, digital thermocouple meter) within 3 minutes after cooking was terminated. Again, the test was replicated a minimum of three times to minimize the uncertainty in the test results.

Ice-Load Cooking Uniformity Test



*Figure 2-4.
Ice load.*

This test required 10 full-size solid steam pans of ice. Each pan contained 8.0 ± 0.2 pounds of ice, which had been stabilized in a freezer at $0 \pm 5^\circ\text{F}$ for approximately 12 hours. Each pan was instrumented with a thermocouple positioned at the geometric center of the ice. This was used to monitor ice load temperature during the test. When the first pan reached a final temperature of 170°F , the time was noted. The ice loads remained in the steamer and steaming did not cease until the last pan of ice reached 170°F , where the cook time was declared and the uniformity was determined. Three replications of this test were performed.

The ASTM results reporting sheets appear in Appendix C.

3 Results

Energy Input Rate

Researchers compared the manufacturer's nameplate value for energy input rate with that measured in the lab prior to any testing to ensure that the steamer was operating within its specified parameters. The VSX 10GC drew a maximum energy input rate of 88,990 Btu/h.

Preheat and Idle Tests

Preheat Energy and Time

The two generators were automatically filled with approximately 5.6 gallons of water at $70 \pm 5^\circ\text{F}$. The steamer was started in an arbitrary timed setting by turning the timer dial beyond 15 minutes. Figure 3-1 illustrates the preheat and idle characteristics of the VSX 10GC and shows the temperature of both compartments.

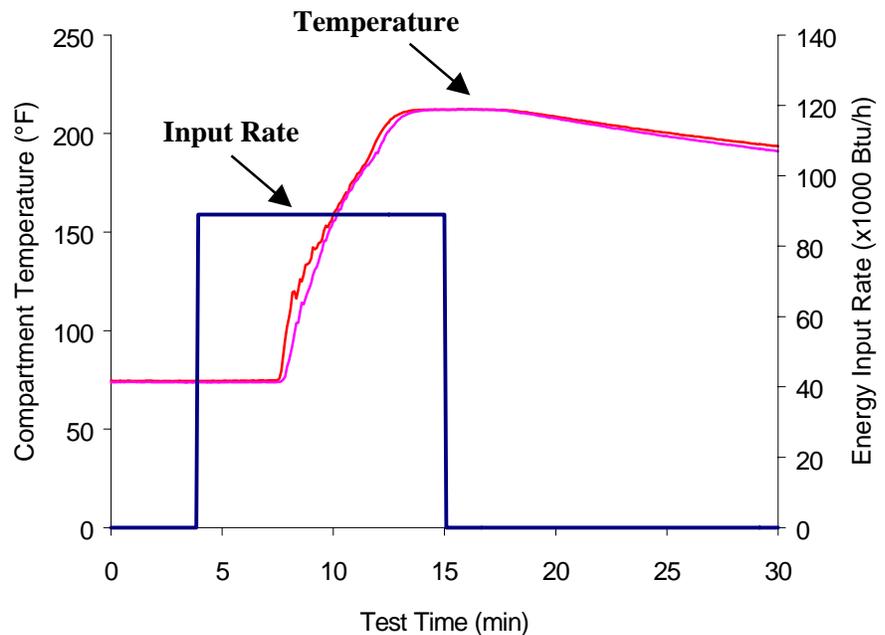


Figure 3-1.
Preheat characteristics.

Results

Idle Energy Rate

Following the preheat period, the steamer timer was set to zero minutes and allowed to stabilize for one hour. The steamer was then monitored over a 2-hour period and the idle energy rate was determined to be 4,460 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)	90,000
Measured Energy Input Rate (Btu/h)	88,990
Preheat to Operational Capacity:	
Time (min)	10.7
Energy (Btu)	10,330
Idle Energy Rate (Btu/h)	4,460

Cooking Tests

The steamer was tested using two different food products (green peas and red potatoes) under two loading scenarios—heavy (10 pans) and light (two pans in top compartment). All cooking scenarios were conducted with the unit continuously steaming in a timed setting.

The Vulcan VSX 10GC steamer uses two separate steam generators to supply steam to both compartments. There are water connections for supply/auto-fill water into these generators and condensate cooling water for cooling condensed steam that is sent down the drain. The steamer is automatically filled at the beginning of each day and whenever the water in the generators is

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below a predetermined level. At the end of each day, by selecting the off mode, the steamer will automatically drain and blowdown each generator.

Frozen Green Pea Tests

Moisture content of the frozen green peas was 81% by weight, corresponding to specific heats (C_p) of 0.44 Btu/lb°F for frozen and 0.84 Btu/lb°F for thawed peas.¹ The VSX 10GC required 24.4 minutes to cook a full load (10 pans) of frozen green peas and had a cooking-energy efficiency of 58.7% and a production capacity of 196.8 lb/h.

The light-load test required an average of 11.4 minutes when cooking two pans of frozen green peas. Cooking energy efficiency and productivity during the light-load tests were determined to be 49.9% and 84.4 lb/h, respectively.

Red Potato Tests

The red potatoes contained 84% moisture by weight with their specific heat (C_p) of 0.87 Btu/lb°F.¹ A full load (10 pans) of potatoes averaged 21.2 minutes to reach an average bulk cooked temperature of $195 \pm 2^\circ\text{F}$. The cooking-energy efficiency and production capacity was 29.2% and 230.4 lb/h, respectively.

The light-load potato test resulted in a cooking-energy efficiency of 12.5% and a productivity of 49.6 lb/h. Furthermore, the two pans of red potatoes required 19.4 minutes to achieve an average bulk temperature of $195 \pm 2^\circ\text{F}$.

Results Discussion

The rate at which steam condenses on food depends on the surface temperature and area of the food. Therefore, frozen green peas (at 0°F) and red potatoes (at room temperature) represent two extremes in steam cooking. Frozen green peas, having a large surface area to volume ratio, promote condensation. The energy transfer from steam to frozen food is high, resulting

Results

in greater cooking-energy efficiency and productivity. Potatoes are “tough” to cook, due to low surface to volume ratio and the slower rate of condensation.

Appendix D lists the physical properties of the test food product and measured values of each test run. Using the detailed equations provided in section 11 of the Steamer ASTM Standard Test Method 1484-04, the cooking energy efficiencies are calculated. Tables 3-2 through 3-3 summarize the VSX 10GC’s cooking performance.

Table 3-2. Frozen Green Pea Cooking Test Results.

	Heavy-Load	Light-Load
Number of Pans	10	2
Cook Time (min)	24.4	11.4
Cooking Energy Rate (Btu/h)	88,070	44,730
Cooking-Energy Efficiency (%)	58.7	49.9
Production Rate (lb/h)	196.8	84.4
Energy Consumption (Btu/lb)	447.4	530.1
Steamer Water Consumption (gal/h)	91.7	48.1
Condensate Temperature (°F)	77.2	83.9

Table 3-3. Red Potato Cooking Test Results.

	Heavy-Load	Light-Load
Number of Pans	10	2
Cook Time (min)	21.2	19.4
Cooking Energy Rate (Btu/h)	88,380	44,460
Cooking-Energy Efficiency (%)	29.2	12.5
Production Rate (lb/h)	230.4	49.6
Energy Consumption (Btu/lb)	389.7	896.3
Steamer Water Consumption (gal/h)	90.8	48.0
Condensate Temperature (°F)	100.4	118.5

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Figure 3-2 illustrates the relationship between cooking-energy efficiency and production rate for this steamer, when cooking two different types of food product. The upper line represents the part-load efficiency curve for the steamer when cooking frozen vegetables, while the lower curve represents the steamer's part-load efficiency while cooking more stubborn food products. Steamer production rate is a function of the cook time. Appendix D contains a synopsis of test data for each replicate of the cooking tests.

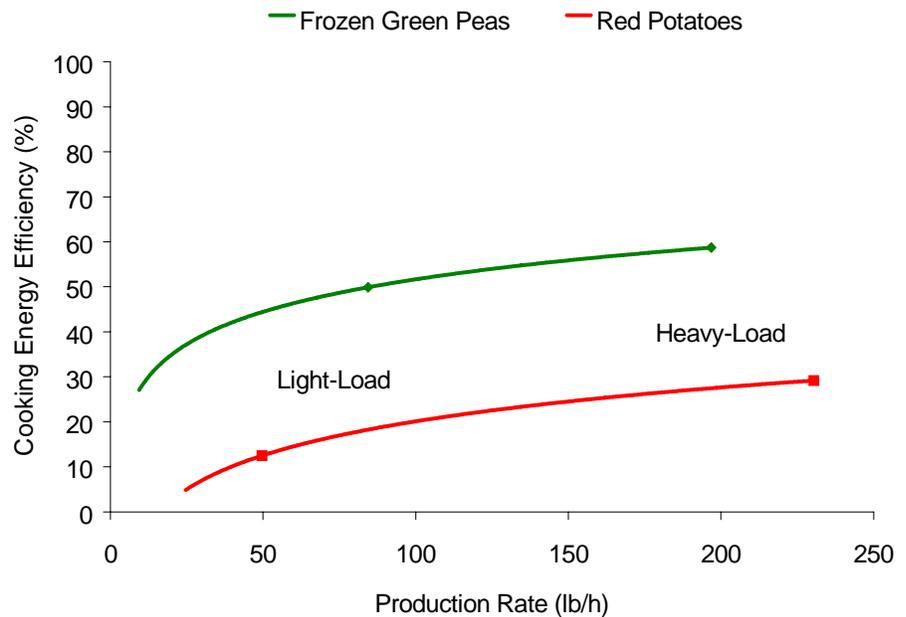


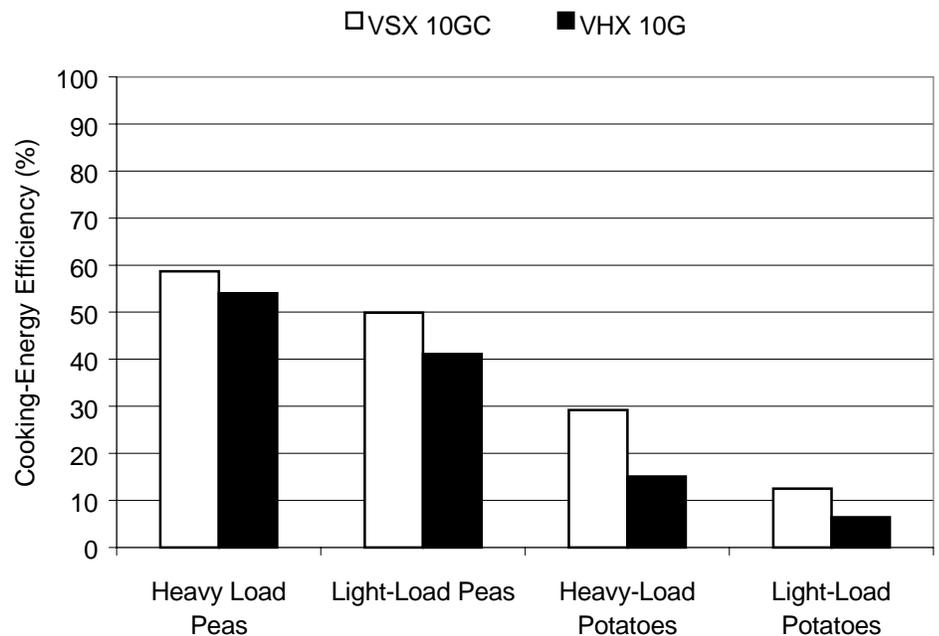
Figure 3-2.
Steamer part-load cooking-energy efficiency.

Note: Light-load = two pans/load; Heavy-load = 10 pans/load.

Figure 3-3 illustrates the VSX 10GC steamer's average cooking-energy efficiency for different types of food product at different test scenarios. Heavy loads tend to exhibit higher efficiencies due to better use of the available compartment space, as opposed to light load single pan tests, where most of the space in the steamer compartment is empty. Data gathered from the ASTM tests on its larger sibling, the VHX 10G, is included in the chart.²⁰ The VHX 10G is almost identical to the VSX 10GC except it is rated at

Results

190,000 Btu/h. During the frozen vegetable tests, the cooking-energy efficiency was very close for both; but during the red potato tests, the VSX 10GC was able to steam the food product almost two times more efficiently than the VHX 10G. While the VSX 10GC holds a slight advantage in cooking-energy efficiency, the higher input rate of the VHX 10G allows for shorter cook times resulting in high production rates, especially for frozen foods, as shown in Figure 3-4. However, for tougher to cook food products such as potatoes, the VSX 10GC yielded comparable production rates. This is due to the VSX 10GC's higher cooking-energy efficiency – with half the input rate, but twice the cooking efficiency for potatoes, cook times and production rates were similar.



*Figure 3-3.
Comparison of steamer
cooking-energy efficien-
cies.*

Note: Light-load = two pans/load; Heavy-load = 10 pans/load.

Figures 3-2 and 3-3 reinforce the fact that frozen green peas have higher cooking-energy efficiencies than red potatoes due to their higher surface-to-volume ratio. This allows the peas to cook faster and, given that the steamer

Results

has a continuous input rate for each generator, cooking the same weight of peas as potatoes in a shorter amount of time will yield higher efficiencies.

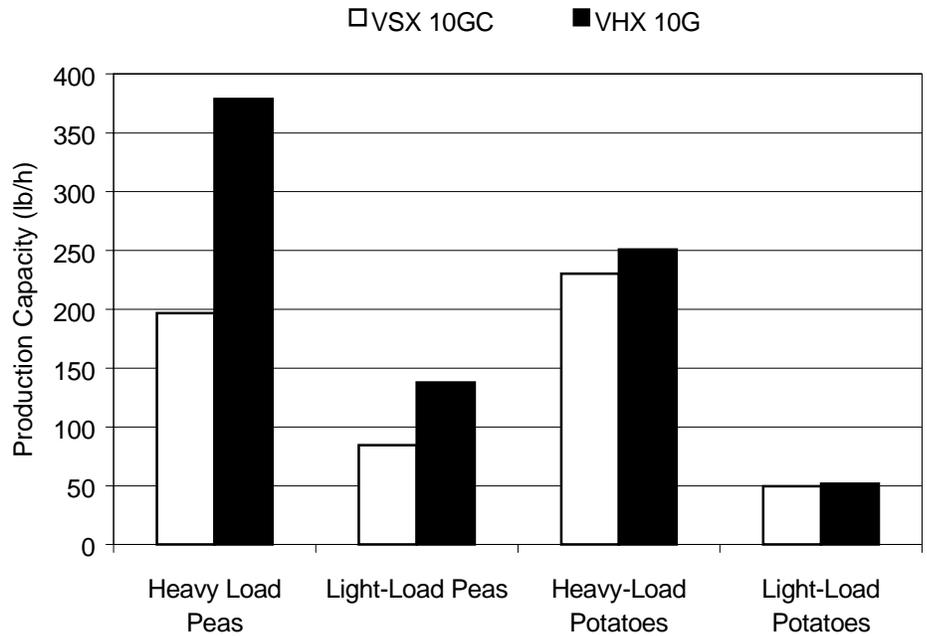


Figure 3-4. Comparison of steamer production capacities.

Note: Light-load = two pans/load; Heavy-load = 10 pans/load.

Figure 3-5 represents the cooking energy input rate for two different food products at the two test load scenarios. The green line represents the steamer’s energy consumption rate when cooking frozen vegetables, while the red curve represents the steamer’s energy consumption rate while cooking more stubborn food products. This graph can be used as a tool to estimate the average energy consumption for the steamer in a real-world operation, based on the type of usage. Average energy consumption rates at 15, 30, and 60 pounds per hour of frozen vegetables are 11,230 Btu/h, 19,550 Btu/h, and 34,045 Btu/h, respectively. For an operation cooking an average of 15 pounds of frozen vegetables per hour over the course of the day (e.g., 150 pounds of

Results

food over a ten hour day), the average energy consumption rate for this steamer would be 11,230 Btu/h.

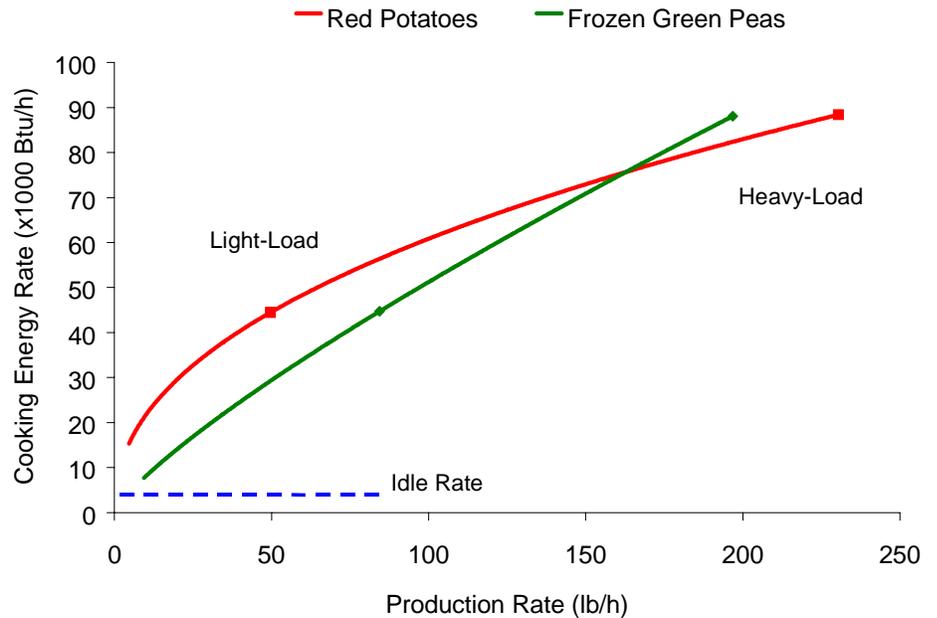


Figure 3-5.
Steamer cooking energy consumption profile.

Note: Light-load = two pans/load; Heavy-load = 10 pans/load.

Ice-Load Uniformity Test

The ice-load uniformity test was designed to emulate frozen vegetables, while allowing researchers to accurately monitor simulated food temperature during the cooking event. For each test, 5 pans (full-load) of ice were used to determine the steaming uniformity within each compartment. The last pan reached 170°F in a little over 30 minutes for each compartment. At this time, the maximum temperature difference between the hottest and coldest pan was found to be 19.2 °F and 16.6 °F for compartment 1 and 2, respectively. On average, the last pan to reach the 170°F endpoint required an additional 2.5-4.0 minutes beyond the cook time for the fastest pan. Tables 3-4 and 3-5 summarize the results of the ice-load uniformity tests and Figures 3-6 and 3-7 show the individual pan temperatures during a single ice-load test.

Results

Table 3-4. Ice-Load Uniformity Test Results Compartment 1: Top.

Number of Pans	5
Cook Time (min)	31.0
Initial Ice-Load Temperature (°F)	2.1
Final Ice-Load Temperatures (°F):	
Pan 1 (Top)	173.1
Pan 2	170.7
Pan 3	183.1
Pan 4	177.3
Pan 5	189.9
Maximum Temperature Difference (°F)	19.2
Maximum Time Delay* (min)	3.9

* Time for the last pan to reach 170°F after the first pan had reached 170°F.

Table 3-5. Ice-Load Uniformity Test Results Compartment 2: Bottom.

Number of Pans	5
Cook Time (min)	32.0
Initial Ice-Load Temperature (°F)	0.7
Final Ice-Load Temperatures (°F):	
Pan 1 (Top)	184.1
Pan 2	182.8
Pan 3	186.2
Pan 4	170.7
Pan 5	185.8
Maximum Temperature Difference (°F)	16.6
Maximum Time Delay* (min)	2.5

* Time for the last pan to reach 170°F after the first pan had reached 170°F.

Results

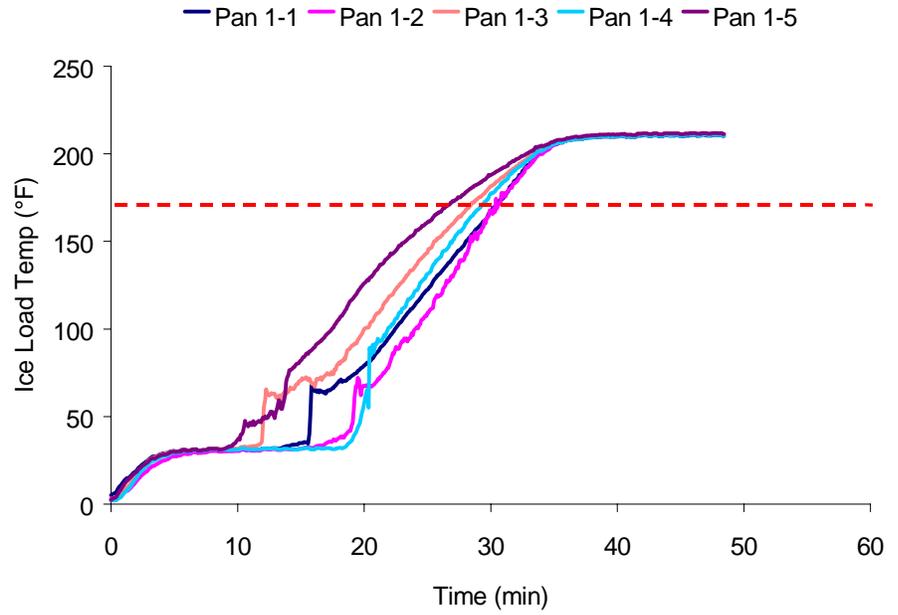


Figure 3-6.
Ice-load temperature
profile: Compartment 1.

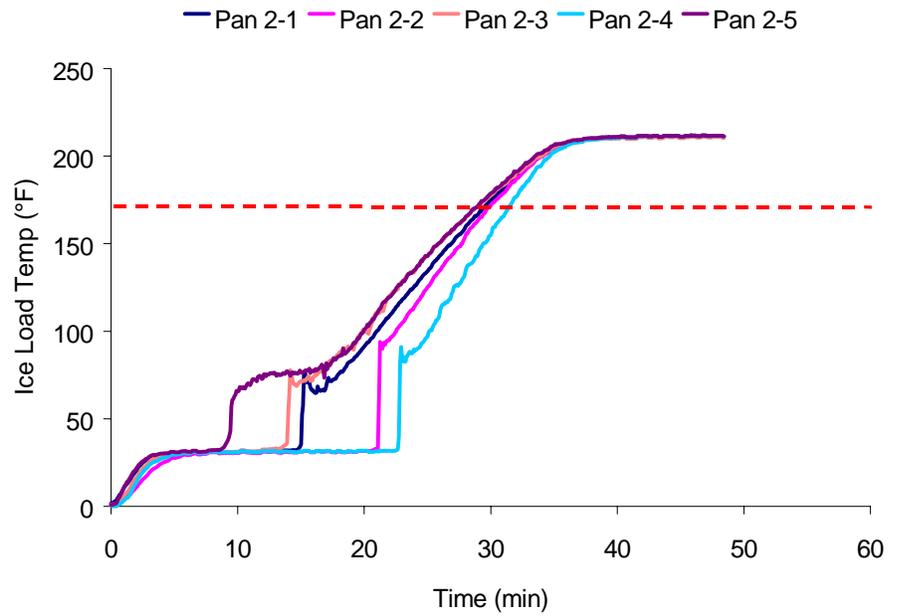


Figure 3-7.
Ice-load temperature
profile: Compartment 2.

4 Conclusions

The Vulcan VSX 10GC is a highly productive and steam generator-based steamer. Aided by twin 45,000 Btu/h high efficiency steam generators, the steamer produced 196.8 lb/h of frozen vegetables and 230.4 lb/h of potatoes, with cook times for 80 pounds of food under 25 minutes for both frozen peas and red potatoes. During heavy-load frozen vegetable tests, the VSX 10GC was able to transfer its steam energy to the food product quite efficiently while minimizing heat loss.

While cooking tests revealed the steamer's ability to perform with short cook times, the VSX 10GC also exhibited a low idle rate of 4,460 Btu/h. This is a credit to the design of the steamer, both in its controls and its ability to minimize heat loss that allows it to maintain a steady, standby temperature within the cooking compartment. The steamer cycles the burners intermittently to maintain generator water temperature, while at the same time preventing steam from reaching the compartment, producing the low idle rates.

The Vulcan VSX 10GC is a highly productive steamer that is versatile enough to satisfy all steaming demands. Throughout all of the rigorous ASTM tests, the VSX 10GC was a good performer and even surpassed its sibling, the VHX 10G, in many categories.²⁰ In addition, the VSX 10GC also provides features such as timed cooking, automatic generator fill and condensate cooling connections, and a 10 pan cooking capacity. The Vulcan VSX 10GC is an ideal candidate for busy operations where large quantities of steamed food and short cook times are required.

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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 Preheat

Preheat

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

Condensate

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

Condensate Temperature (°F)

The temperature at which the condensate enters the floor drain.

Cooking Energy (kWh or kBtu)

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

Cooking Energy Consumption Rate (kW or kBtu/h)

The average rate of energy consumption during the cooking period.

Cooking-Energy Efficiency (%)

The quantity of energy input to the food products; expressed as a percentage of the quantity of energy input to the appliance during the heavy-, medium-, and light-load tests.

Duty Cycle (%)

Load Factor

The average energy consumption rate (based on a specified operating period for the appliance) expressed as a percentage of the measured energy input rate.

$$\text{Duty Cycle} = \frac{\text{Average Energy Consumption Rate}}{\text{Measured Energy Input Rate}} \times 100$$

Energy Input Rate (kW or kBtu/h)

Energy Consumption Rate

Energy Rate

The peak rate at which an appliance will consume energy, typically reflected during pre-heat.

Frozen Green Peas Load

12 x 20 x 2½ in. hotel pan filled with 8.0 ± 0.01 lb of frozen, grade A, green peas subsequently frozen to 0±5°F. One of two food products 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).

Heating Value (Btu/ft³)

Heating Content

The quantity of heat (energy) generated by the combustion of fuel. For natural gas, this quantity varies depending on the constituents of the gas.

Ice Load

12 x 20 x 2½ in. hotel pan filled with 8.0 ± 0.2 lb of water and subsequently frozen to 0±5°F. This is used to simulate a food product load in the ice load cooking uniformity test.

Idle Energy Rate (kW or Btu/h)

Idle Energy Input Rate
Idle Rate

The rate of appliance energy consumption while it is “holding” or maintaining a stabilized operating condition or temperature.

Idle Temperature (°F, Setting)

The temperature of the cooking cavity/surface (selected by the appliance operator or specified for a controlled test) that is maintained by the appliance under an idle condition.

Idle Duty Cycle (%)

Idle Energy Factor

The idle energy consumption rate expressed as a percentage of the measured energy input rate.

$$\text{Idle Duty Cycle} = \frac{\text{Idle Energy Consumption Rate}}{\text{Measured Energy Input Rate}} \times 100$$

Low-Pressure Steam Cooker

Steam cooker wherein the cooking compartment operates between 3 and 9.9 psig.

Measured Input Rate (kW or Btu/h)

Measured Energy Input Rate
Measured Peak Energy Input Rate

The maximum or peak rate at which an appliance consumes energy, typically reflected during appliance preheat (i.e., the period of operation when all burners or elements are “on”).

Pilot Energy Rate (kBtu/h)

Pilot Energy Consumption Rate

The rate of energy consumption by the standing or constant pilot while the appliance is not being operated (i.e., when the thermostats or control knobs have been turned off by the food service operator).

Potato Load

12 x 20 x 2½ in. hotel pan filled with 8.0 ± 0.2 lb of fresh, whole, US No. 1, size B, red potatoes. One of two food products used to determine cooking-energy efficiency and production capacity.

Preheat Energy (kWh or Btu)

Preheat Energy Consumption

The total amount of energy consumed by an appliance during the preheat period.

Preheat Rate (°F/min)

The rate at which the cooking surface heats during a preheat.

Glossary

Preheat Time (minute)

Preheat Period

The time required for an appliance to heat from the ambient room temperature ($75 \pm 5^{\circ}\text{F}$) to a specified (and calibrated) operating temperature or thermostat set point.

Production Capacity (lb/h)

The maximum production rate of an appliance while cooking a specified food product in accordance with the heavy-load cooking test.

Production Rate (lb/h)

Productivity

The average rate at which an appliance brings a specified food product to a specified “cooked” condition.

Rated Energy Input Rate

(kW, W or Btu/h, Btu/h)

Input Rating (ANSI definition)

Nameplate Energy Input Rate

Rated Input

The maximum or peak rate at which an appliance consumes energy as rated by the manufacturer and specified on the nameplate.

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.

Test Method

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

Typical Day

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

Water Consumption (gal/h)

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 Vulcan VSX 10GC, steamer.

VSX7 & VSX10 SERIES

GAS CONVECTION STEAMER ON CABINET BASE



SPECIFICATIONS:

Two compartment gas convection steamer on cabinet base, Vulcan-Hart Model No. (VSX7GC) (VSX10GC). 304 series stainless steel exterior. Two stainless steel cooking compartments with coved interior corners. Two high output 45,000 BTU/hr. stainless steel steam generators, 90,000 BTU/hr. total input. Separate manual controls for each compartment. Heavy duty "slammable" doors and door latch mechanisms. Stainless steel cabinet base with door for storage. 6" adjustable stainless steel legs with flanged rear feet. $\frac{3}{4}$ " rear gas connection and gas pressure regulator. Requires 120/60/1 power supply, 2.0 amps maximum draw. 6 foot power cord with 3 prong plug. Split water line connection. Two drain connections.

Exterior dimensions: 24"w x 37"d x (76 $\frac{1}{4}$ ") (76 $\frac{1}{8}$ ")h on 6" legs.

CSA design certified. NSF listed.

SPECIFY TYPE OF GAS WHEN ORDERING.

SPECIFY ALTITUDE WHEN ABOVE 2,000 FT.

- VSX7GC** 7 pan capacity
- VSX10GC** 10 pan capacity

STANDARD FEATURES

- 304 series stainless steel exterior.
- Two stainless steel cooking compartments with coved interior corners.
- Two high output 45,000 BTU/hr. stainless steel steam generators, 90,000 BTU/hr. total input.
- Separate manual controls for each compartment.
- Heavy duty "slammable" doors and door latch mechanisms.
- Stainless steel cabinet base with door for storage.
- 6" adjustable stainless steel legs with flanged rear feet.
- $\frac{3}{4}$ " rear gas connection and gas pressure regulator.
- Requires 120/60/1 power supply, 2.0 amps maximum draw. 6 foot power cord with 3 prong plug.
- Split water line connection. Two drain connections.
- Water filter system, SPS620V. Includes second year extended limited water associated parts and labor warranty.
- One year limited parts and labor warranty.

OPTIONS

- Second year extended limited parts and labor warranty contract.

ACCESSORIES

- 12" x 20" stainless steel pans:
 - 1" deep (solid)(perforated) Qty.____.
 - 2 $\frac{1}{2}$ " deep (solid)(perforated) Qty.____.
 - 4" deep (solid)(perforated) Qty.____.
- Stainless steel pan cover. Qty.____.
- Removable sliding self. Qty.____.
- 12" x 20" pan guides for cabinet base (VSX7 only).



VSX7 & VSX10 SERIES

GAS CONVECTION STEAMER ON CABINET BASE

SERVICE CONNECTIONS:



Unless otherwise specified, Field Wire Electrical Connection to be 120/60/1 with grounding wire. Furnish with 6 foot cord with 3 prong plug. Maximum amps 2.0.



DRAIN: 1" (25 mm) IPS O.D. piped to open floor drain. No solid connection. 24" length before open air gap opening (no bends or elbows).



GAS CONNECTION: 3/4" (19 mm) O.D. supply line required.



GENERATOR WATER: 3/8" (10 mm) O.D. tubing at 25- 50 PSI (170-345 kPa).



CONDENSING WATER: 3/8" (10 mm) O.D. tubing at 25-50 PSI (170-345 kPa).

WATER QUALITY STATEMENT:

The fact that a water supply is potable is no guarantee that it is suitable for steam generation. Your water supply must be within these general guidelines:

SUPPLY PRESSURE	20 - 60 psig
HARDNESS*	less than 3 grains
SILICA	less than 13 ppm
TOTAL CHLORIDE	less than 4.0 ppm
pH RANGE	7-8
UN-DISSOLVED SOLIDS	less than 5 microns

* 17.1 ppm = 1 grain of hardness

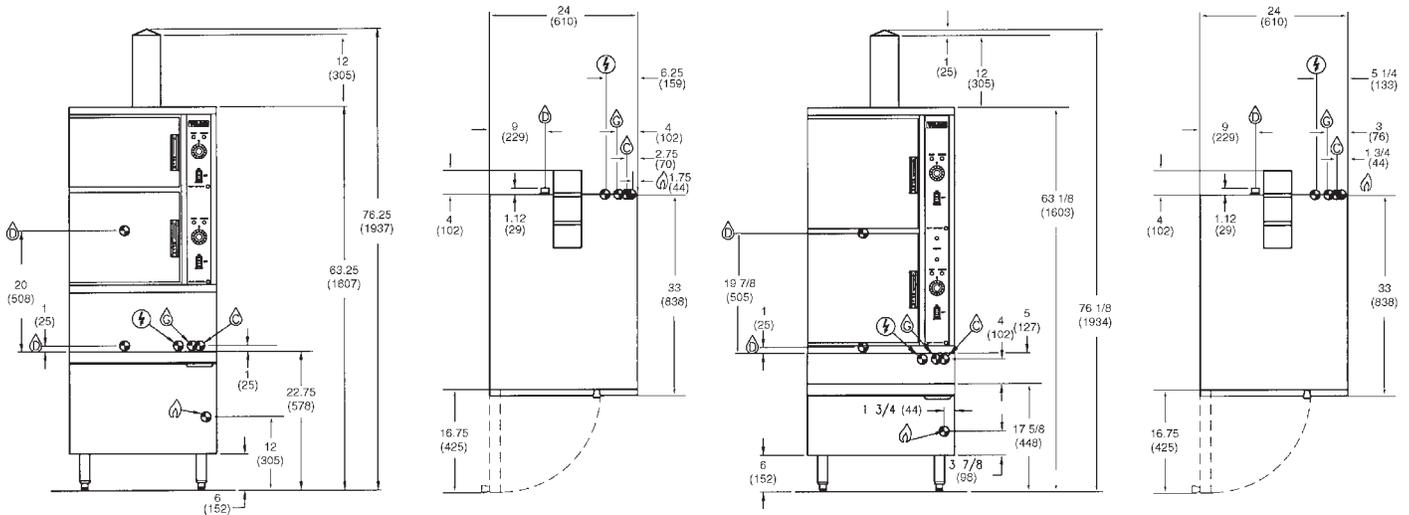
Other factors affecting steam generation are iron content, amount of chloridation and dissolved gases. Water supplies vary from state to state and from locations within a state. Therefore it is necessary that the local water treatment specialist be consulted before the installation of any steam generating equipment.

IMPORTANT:

1. A pressure regulator sized for this unit is included. Natural gas 7" W.C., propane gas 11" W.C.
 2. Gas line connecting to unit must be 3/4" or larger. If flexible connectors are used, the inside diameter must be at least the same as the 3/4" iron pipe.
 3. An adequate ventilation system is required for commercial cooking equipment. Information may be obtained by writing to the National Fire Protection Association, Batterymarch Park, Quincy, MA 02289. When writing, refer to NFPA No. 96.
 4. These units are manufactured for installation in accordance with ANSZ223.1A (latest edition), National Fuel Gas Code. Copies may be obtained from the American Gas Association, 1515 Wilson Blvd., Arlington, VA 22209.
- | | | |
|---------------|-------------|-----------------|
| 5. Clearance: | Combustible | Non-Combustible |
| Rear | 6" | 6" |
| Left Side | 3" | 3" |
| Right side | 8" | 8" |

NOTE:

- Dimensions which locate the above connections have a tolerance of + or -3" (+ or -75 mm).
- Installation of backflow preventers, vacuum breakers and other specific code requirements is the responsibility of the owner and installer. It is the responsibility of the owner and installer to comply with local codes.
- Plastic drains are not recommended due to inherent limited temperatures of the plastic. Boiler purge temperatures may exceed 180°F. The installer may be required to provide means to reduce boiler purge water temperature to be that of the condensate temperature of 140°F or less.
- This appliance is manufactured for commercial installation only and is not intended for home use.



VSX7GC
Front & Top View

VSX10GC
Front & Top View

NOTE: In line with its policy to continually improve its products, Vulcan-Hart Company reserves the right to change materials and specifications without notice.

C Results Reporting Sheets

Manufacturer: Vulcan
Model: VSX 10GC
Date: September 2004

Test Steam Cooker

ASTM F 1216 Classification (check one for each classification)

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

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

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

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

Results Reporting Sheets

Description of operational characteristics: The steamer is equipped with automatic water supply provisions for steam generator filling and condensate cooling water. The steamer automatically fills the generators whenever the steamer is switched to the “on” mode and maintains a constant water level. There is a single on/off switch for each compartment and individual timer controls as well. When each timer is set to a nonzero value, the steam generators will go into a continuous cooking mode – each generator will continuously send steam to their respective compartments.

Apparatus

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

The steamer was instrumented with a positive displacement residential type gas meter, with a resolution of 0.01 ft³, for all tests. A computerized data acquisition system recorded test information at 5-seconds intervals for all performance tests. All test apparatus were installed in accordance with Section 9 of the ASTM test method.

Energy Input Rate

Higher-heating value	1,019 Btu/ft ³
Measured	88,990 Btu/h
Rated	90,000 Btu/h
Percent Difference between Measured and Rated	1.1%

Results Reporting Sheets

Appliance Preheat Energy Consumption and Duration

Higher-heating value	1,019 Btu/ft ³
Energy Consumption	10,330 Btu
Duration	10.7 min

Appliance Idle Energy Rate

Higher-heating value	1,019 Btu/ft ³
Idle Energy Rate	4,460 Btu/h

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

Heavy-Load:

Higher-heating value	1,019 Btu/ft ³
Cooking Time	24.4 min
Cooking-Energy Efficiency	58.7 ± 0.8 %
Cooking Energy Rate	88,070 ± 2,270 Btu/h
Production Capacity	196.8 ± 4.7 lb/h
Water Consumption Rate	91.7 gal/h
Average Condensate Temperature	77.2 °F

Light-Load:

Higher-heating value	1,019 Btu/ft ³
Cooking Time	11.4 min
Cooking-Energy Efficiency	49.9 ± 2.5 %
Cooking Energy Rate	44,730 ± 740 Btu/h
Production Rate	84.4 ± 5.3 lb/h
Water Consumption Rate	48.1 gal/h
Average Condensate Temperature	83.9 °F

Results Reporting Sheets

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

Heavy-Load:

Higher-heating value	1,019 Btu/ft ³
Cooking Time	21.2 min
Cooking-Energy Efficiency	29.2 ± 2.6 %
Cooking Energy Rate	88,380 ± 1,900 Btu/h
Production Capacity	230.4 ± 7.8 lb/h
Water Consumption Rate	90.8 gal/h
Average Condensate Temperature	100.4 °F

Light-Load:

Higher-heating value	1,019 Btu/ft ³
Cooking Time	19.4 min
Cooking-Energy Efficiency	12.5 ± 0.4 %
Cooking Energy Rate	44,460 ± 615 Btu/h
Production Capacity	49.6 ± 1.7 lb/h
Water Consumption Rate	48.0 gal/h
Average Condensate Temperature	118.5 °F

Results Reporting Sheets

Ice-Loads Cooking Time, Temperature Uniformity

Compartment 1: Top

Higher-heating value		1,019 Btu/ft ³
Cooking Time		31.0 min
Initial Average Temperature		2.1 °F
Average Ice Load Temperatures	Pan 1	173.1 °F
	Pan 2	170.7 °F
	Pan 3	183.1 °F
	Pan 4	177.3 °F
	Pan 5	189.9 °F
Maximum Temperature Difference		19.2 °F
Maximum Time Delay (first pan to last pan to 170°F)		3.9 min

Compartment 2: Bottom

Higher-heating value		1,019 Btu/ft ³
Cooking Time		32.0 min
Initial Average Temperature		0.7 °F
Average Ice Load Temperatures	Pan 1	184.1 °F
	Pan 2	182.8 °F
	Pan 3	186.2 °F
	Pan 4	170.7 °F
	Pan 5	185.8 °F
Maximum Temperature Difference		16.6 °F
Maximum Time Delay (first pan to last pan to 170°F)		2.5 min

D Cooking-Energy Efficiency Data

Table D-1. Specific Heat and Latent Heat.

Specific Heat (Btu/lb, °F)	
Ice	0.50
Solids	0.20
Frozen Green Peas	0.84
Red Potatoes	0.87
Latent Heat (Btu/lb)	
Fusion, Water	144
Vaporization, Water	970

Cooking-Energy Efficiency Data

Table D-2. Heavy-Load Peas Data

	Replication 1	Replication 2	Replication 3
Measured Values			
Number of Pans	10	10	10
Cook Time (min)	24.1	24.4	24.6
Initial Water Temperature (°F)	37.0	38.6	37.3
Final Water Temperature (°F)	94.0	95.7	95.0
Frozen Food Temperature (°F)	0	0	0
Weight of Empty Calorimeter (lb)	5.96	5.96	5.96
Weight of Full Calorimeter (lb)	113.6	114.7	114.5
Weight of Calorimeter Water (lb)	60	60	60
Weight of Cooked Food (lb)	79.4	81.2	80.9
Weight of Frozen Food (lb)	80	80	80
Weight of Stainless-Steel Pans (lb)	25.7	25.7	24.7
Moisture Content (%)	81	81	81
Condensate Temperature (°F)	77.2	77.2	77.2
Water Consumption (gal/h)	91.7	91.7	91.7
Calculated Values			
Moisture Weight in Green Peas (lb)	64.8	64.8	64.8
Final Food Temperature (°F)	179.4	179.4	179.9
Cooking Energy (Btu)	35,580	36,110	35,695
Energy Consumed by Green Peas (Btu)	20,294	20,514	20,509
Energy to Food (Btu/lb)	253.7	256.4	256.4
Energy Consumed by Pans (Btu)	506.3	506.0	48,774
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	35,580	36,110	35,695
Energy to Steamer (Btu/lb of food cooked)	444.8	4451.4	446.2
Cooking Energy Rate (Btu/h)	88,445	88,732	87,026
Productivity (lb/h)	198.8	196.6	195.0
Energy Efficiency (%)	58.7	58.4	59.1

Cooking-Energy Efficiency Data

Table D-3. Light-Load Peas Data

	Replication 1	Replication 2	Replication 3
Measured Values			
Number of Pans	2	2	2
Cook Time (min)	11.1	11.4	11.7
Initial Water Temperature (°F)	39.1	45.1	39.7
Final Water Temperature (°F)	95.6	99.1	96.5
Frozen Food Temperature (°F)	0.0	0.0	0.0
Weight of Empty Calorimeter (lb)	5.96	5.96	5.96
Weight of Full Calorimeter (lb)	42.3	42.3	42.3
Weight of Calorimeter Water (lb)	20.0	20.0	20.0
Weight of Cooked Food (lb)	16.4	16.4	16.4
Weight of Frozen Food (lb)	16.0	16.0	16.0
Weight of Stainless-Steel Pans (lb)	5.6	5.6	5.6
Moisture Content (%)	81	81	81
Condensate Temperature (°F)	83.9	83.9	83.9
Water Consumption (gal/h)	48.1	48.1	48.1
Calculated Values			
Moisture Weight in Green Peas (lb)	13.0	13.0	13.0
Final Food Temperature (°F)	177.7	177.7	179.0
Cooking Energy (Btu)	8,310	8,450	8,690
Energy Consumed by Green Peas (Btu)	4,096.6	4,094.8	4130.5
Energy to Food (Btu/lb)	256.0	255.9	258.2
Energy Consumed by Pans (Btu)	109.4	109.6	110.2
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	8,310	8,450	8,690
Energy to Steamer (Btu/lb of food cooked)	519.4	528.1	543.1
Cooking Energy Rate (Btu/h)	45,002	44,412	44,773
Productivity (lb/h)	86.6	84.1	82.4
Energy Efficiency (%)	50.8	50.0	48.8

Cooking-Energy Efficiency Data

Table D-4. Heavy-Load Potatoes Data

	Replication 1	Replication 2	Replication 3
Measured Values			
Number of Pans	10	10	10
Cook Time (min)	20.9	20.9	21.7
Temperature of Uncooked Potatoes (°F)	70.5	70.0	72.4
Temperature of Cooked Potatoes (°F)	195.0	194.6	194.0
Weight of Stainless-Steel Pans (lb)	25.7	25.7	25.7
Weight of Potatoes (lb)	80.7	81.2	81.9
Total Potato Count	500	500	500
Moisture Content (%)	84	84	84
Condensate Temperature (°F)	100.4	100.4	100.4
Water Consumption (gal/h)	90.8	90.8	90.8
Calculated Values			
Moisture Weight in Potatoes (lb)	67.8	68.2	68.8
Average Weight of Each Potato (lb)	0.16	0.16	0.16
Cooking Energy (Btu)	30,851.0	30,510.0	32,116.0
Energy Consumed by Potatoes (Btu)	8,734.2	8,819.8	8,654.0
Energy to Food (Btu/lb)	108.3	108.6	105.6
Energy Consumed by Pans (Btu)	390.0	385.8	385.8
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	90,851.0	30,510.0	32,166.0
Energy to Steamer (Btu/lb of food cooked)	382.5	375.8	392.0
Cooking Energy Rate (Btu/h)	88,526.3	87,547.8	89,060.8
Productivity (lb/h)	231.4	232.9	226.9
Energy Efficiency (%)	29.5	30.1	28.0

Cooking-Energy Efficiency Data

Table D-5. Light-Load Potatoes Data

	Replication 1	Replication 2	Replication 3
Measured Values			
Number of Pans	2	2	2
Cook Time (min)	19.5	19.5	19.1
Temperature of Uncooked Potatoes (°F)	70.0	73.8	71.7
Temperature of Cooked Potatoes (°F)	195.1	195.6	194.6
Weight of Stainless-Steel Pans (lb)	5.6	4.8	5.2
Weight of Potatoes (lb)	16.0	16.0	16.0
Total Potato Count	100	100	100
Moisture Content (%)	84	84	84
Condensate Temperature (°F)	118.5	118.5	118.5
Water Consumption (gal/h)	48.0	48.0	48.0
Calculated Values			
Moisture Weight in Potatoes (lb)	13.4	13.5	13.5
Average Weight of Each Potato (lb)	0.16	0.16	0.16
Cooking Energy (Btu)	14,410.0	14,400.0	14,210.0
Energy Consumed by Potatoes (Btu)	1,739.9	1,703.1	1,712.4
Energy to Food (Btu/lb)	108.8	106.3	107.5
Energy Consumed by Pans (Btu)	84.5	72.2	78.0
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	14,410.0	14,400.0	14,210.0
Energy to Steamer (Btu/lb of food cooked)	900.7	898.6	887.3
Cooking Energy Rate (Btu/h)	44,309.3	44,317.3	44,742.5
Productivity (lb/h)	49.2	49.3	50.4
Energy Efficiency (%)	12.6	12.3	12.6

Cooking-Energy Efficiency Data

Table D-6. Frozen Green Pea Cooking-Energy Efficiency and Production Capacity Statistics.

	Cooking-Energy Efficiency		Production Capacity
	Heavy Load	Light Load	
Replicate #1	58.7	50.8	198.8
Replicate #2	58.4	50.0	196.6
Replicate #3	59.1	48.8	195.0
Average	58.7	49.9	196.8
Standard Deviation	0.3	1.0	1.9
Absolute Uncertainty	0.8	2.5	4.7
Percent Uncertainty	1.3	5.0	2.4

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

	Cooking-Energy Efficiency		Production Capacity
	Heavy Load	Light Load	
Replicate #1	29.5	12.6	231.4
Replicate #2	30.1	12.3	232.9
Replicate #3	28.0	12.6	226.9
Average	29.2	12.5	230.4
Standard Deviation	1.1	0.2	3.2
Absolute Uncertainty	2.7	0.4	7.8
Percent Uncertainty	9.0	3.4	3.4