

**Cleveland Range Inc., SteamCraft Ultra 3
Electric Steamer Performance Test**

Application of ASTM Standard
Test Method F 1484-99

FSTC Report 5011.00.84

**Food Service Technology Center
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Specific appreciation is extended to the Cleveland Range company for supplying the FSTC with the SteamCraft Ultra 3 steamer for controlled testing in the appliance laboratory.

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Executive Summary

The Food Service Technology Center (FSTC) tested the Cleveland, Steam-Craft Ultra 3 electric, pressureless steamer under the tightly controlled conditions of the American Society for Testing and Materials (ASTM) Standard Test Method for the Performance of Steam Cookers.¹ Steamer performance is characterized by preheat energy consumption and duration, idle energy rate, cooking energy rate and efficiency, production capacity, water consumption and condensate temperature from product testing. The spectrum of test products includes: full-load frozen green peas, light-load frozen green peas, full-load red potatoes and light-load red potatoes.

The SteamCraft Ultra 3 steamer is a multifunctional countertop, pressureless convection steamer. It utilizes a self-contained steam generator to provide steam for the single, 3-pan capacity cooking-compartment. Two jet nozzles convey steam to the cooking compartment. The appliance exhibited rapid cook times, as was demonstrated by the 16.2 minute required to cook full-load (3-pans) of frozen green peas. A partial load required 5.8 minutes. When tasked with cooking a frozen food product, the SteamCraft Ultra 3 also achieved respectable cooking energy efficiencies for both full- and light-load scenarios, 81.5% and 74.2%, respectively.

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

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

Executive Summary

Beyond the Cleveland steamer's cooking performance is the unit's continuous state of readiness. Leaving the unit in the zeroed out "Timed" mode keeps the steam generator at full operational capacity. Despite this continuous state of readiness the unit exhibited a low idle energy rate of 0.3 kW.

Executive Summary

Table ES-1. Performance Summary, Cleveland SteamCraft Ultra 3.

Preheat and Idle

Rated Energy Input Rate (kW)	8.3
Measured Energy Input Rate (kW)	8.6
Preheat Time (min)	12.3
Preheat Energy (kWh)	1.5
Idle Energy Rate (kW)	0.3

Full-Load Frozen Green Peas (3 pans)

Cook Time (min)	16.2
Cooking Energy Rate (kW)	8.5
Cooking Energy Efficiency (%)	81.5
Production Capacity (lb/h)	89
Water Consumption (gal/h)	40

Light-Load Frozen Green Peas (1 pan)

Cook Time (min)	5.8
Cooking Energy Rate (kW)	8.5
Cooking Energy Efficiency (%)	74.2
Water Consumption (gal/h)	41

Full-Load Red Potatoes (3 pans)

Cook Time (min)	22.7
Cooking Energy Rate (kW)	8.4
Cooking Energy Efficiency (%)	24.7
Production Capacity (lb/h)	64
Water Consumption (gal/h)	40

Light-Load Red Potatoes (1 pan)

Cook Time (min)	19.3
Cooking Energy Rate (kW)	8.2
Cooking Energy Efficiency (%)	9.7
Water Consumption (gal/h)	41

Executive Summary

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

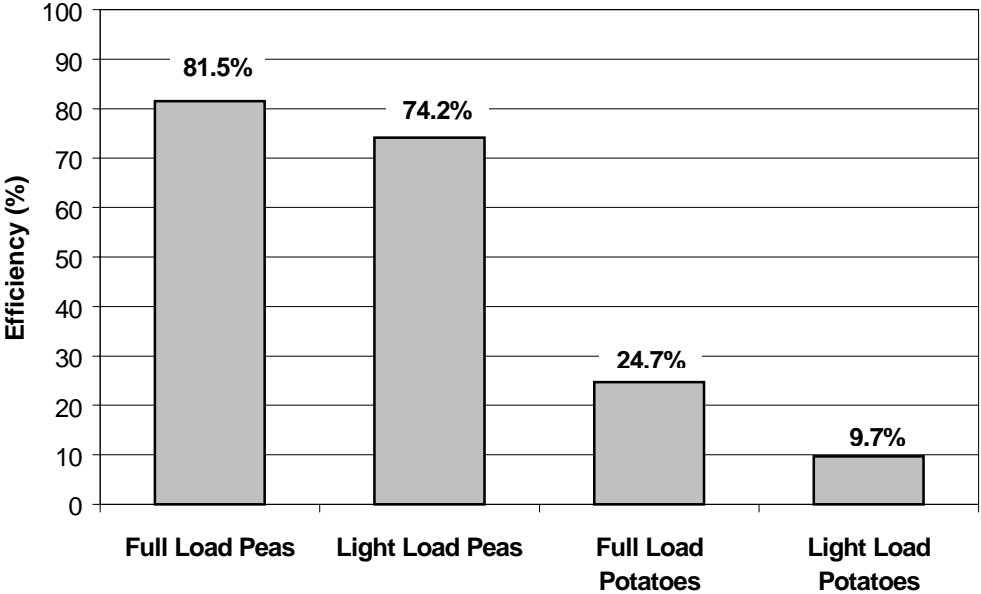
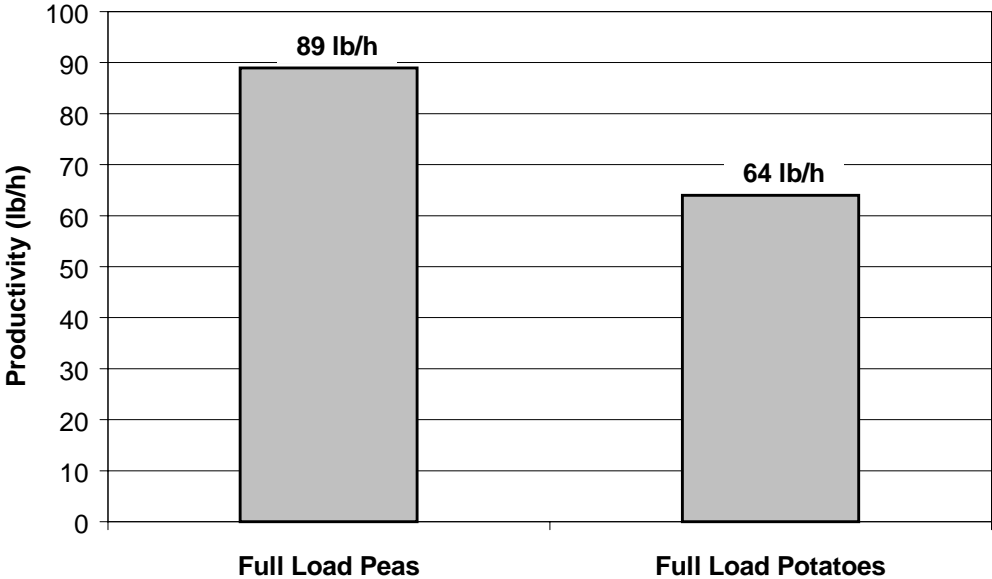


Figure ES-2.
Steamer Production
Capacity.



1 Introduction

Background

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

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

The Cleveland SteamCraft Ultra 3 is a single-compartment, countertop pressureless convection steamer with an electric steam generator. The SteamCraft Ultra 3 steamer was tested according to the ASTM procedure, and this report documents the results. The glossary in Appendix A provides a quick reference to the terms used in this report.

Introduction

Objectives

The objective of this report is to examine the operation and performance of the Cleveland SteamCraft Ultra 3 steamer, under the controlled conditions of the ASTM Standard Test Method. The scope of this testing is as follows:

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

Appliance Description and Operation

The Cleveland SteamCraft Ultra 3 is a single-compartment, countertop pressureless convection steamer with a steam generator (Figure 1-1). The appliance employs a steam generator equipped with a single 8.3 kW heating element and 3.5 gallon water reservoir to provide steam to its single cooking compartment. Steam is conveyed to the cooking compartment via two high velocity jet nozzles that are designed to evenly distribute the steam within the cooking compartment. Water hook-up and condensate drain lines are required. The cooking chamber accommodates six 12" x 20" x 1", three 12" x 20" x 2½" or two 12" x 20" x 4" perforated steamer pans. The SteamCraft Ultra 3 has two cooking modes of operation, "Timed" and "Manual". The "Timed" cooking mode not only controls steam entering the cooking compartment, but compensates for preheating the compartment as well. The "Manual" mode of operation allows user to start and stop steaming operation.

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

Introduction



Table 1-1. Appliance Specifications.

Manufacturer	Cleveland Range, a Welbilt Company
Model	SteamCraft Ultra 3
Generic Appliance Type	1-compartment, pressureless, electric, steamer.
Rated Input	8.3 kW
Technology	Electric Steam Generator.
Controls	Main Power ON / OFF Switch. 60-Minute Electro-Mechanical Timer and Switch for Timed or Manual Operation (optional Electronic Timer as shown).
Construction	Exterior: 14 Gauge Stainless Steel. Interior: 14 Gauge Stainless Steel.
Compartment Capacity	3 (12" x 20" x 2.5") pans 12 (12" x 20" x 1") pans 2 (12" x 20" x 4") pans
Dimensions	21" x 22.25" x 32.13" (W×H×D)

Figure 1-1.
The Cleveland SteamCraft Ultra 3 Steamer.

2 Methods

Setup and Instrumentation

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

Power and energy were measured with a watt/watt-hour transducer that generated an analog signal for instantaneous power and a pulse for every 10 Wh. The transducer and thermocouples were connected to a computerized data acquisition unit that recorded data every 5 seconds. A voltage regulator, connected to the steamer, maintained a constant voltage for all tests. Figure 2-1 shows the SteamCraft Ultra 3 instrumented with the data acquisition system.



*Figure 2-1.
The Cleveland SteamCraft
Ultra 3 Instrumented
for Testing.*

Methods

Measured Energy Input, Preheat and Idle Rate

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

Green Peas Full- and Light-Load Efficiency Tests

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

Since probing proves difficult and erroneous in measuring temperature of the small-sized green peas, a water-bath calorimeter was utilized to measure the final bulk temperature of the cooked green peas. Pea doneness is specified as $180 \pm 2^\circ\text{F}$.

Methods

Red Potatoes Full- and Light- Load Efficiency Tests

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

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

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



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

3 Results

Manufacturer's Rated Input and Maximum Energy Input Rate

Measured energy input rate and the manufacturer's nameplate value were compared prior to any testing to ensure that the steamer was operating within its specified parameters. The SteamCraft Ultra 3 drew a maximum input rate of 8.6 kW, 3.6% higher than the nameplate rate of 8.3 kW, but within the 5% tolerance of the ASTM standard.

Preheat and Idle Tests

Preheat Energy and Time

The preheat was executed in the "Timed" mode of operation, whereby water automatically filled the steam generator reservoir during the initial 1.5 minutes of being turned on, with the boiler preheat following immediately afterwards. Total time elapsed, from when the unit was turned on, until the steam generator elements cycled off was 12.3 minutes. The steamer consumed 1.5 kWh.

Idle Energy Rate

Leaving the steamer in its "Timed" mode of operation, the steam generator was allowed to stabilize for one-half hour following the initial preheat. Energy consumption was monitored for 120 minutes thereafter. The unit exhibited an idle energy rate of 0.3 kW.

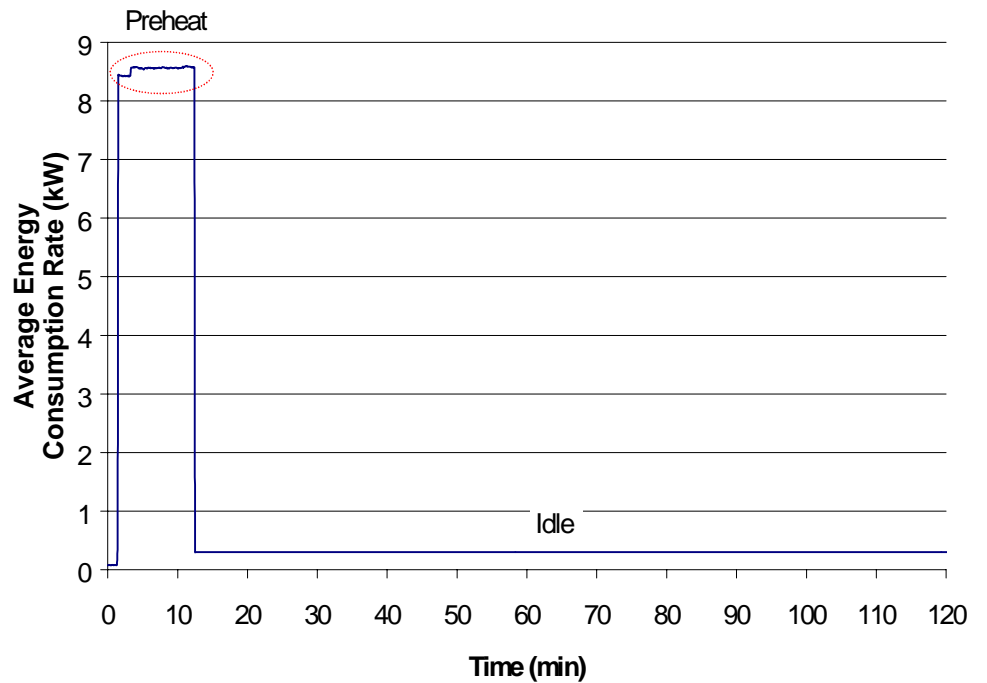
Results

Test Results

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

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

Rated Energy Input Rate (kW)	8.3
Measured Energy Input Rate (kW)	8.6
Preheat to Operational Capacity Time (min)	12.3
Energy (kWh)	1.5
Idle Energy Rate (kW)	0.3



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

Results

Cooking Tests

The steamer was tested with two test products under two loading scenarios: full-load green peas (3 pans), light-load green peas (1 pan), full-load red potatoes (3 pans), and light-load red potatoes (1 pan). The energy consumption, elapsed cook time, water consumption and ambient temperature were monitored for the duration of each test at five-second intervals. All cooking scenarios were conducted in the unit's "Manual" mode of operation.

Full- and Light-Load Green Peas Test

Moisture content of the frozen green peas was 81% by weight corresponding to specific heats (C_p) of 0.44 Btu/lb°F for frozen and 0.84 Btu/lb°F for thawed peas.⁴ The SteamCraft Ultra 3 required 16.2 minutes to cook the full load of frozen green peas and had a cooking energy efficiency of 81.5% and a production capacity of 89 lb/h.

The light-load test required an average of 5.8 minutes when cooking a single pan of frozen green peas. Cooking energy efficiency and productivity were determined to be 74.2% and 83 lb/h.

Full- and Light-Load Potatoes Test

The red potatoes contained 84% moisture by weight with the specific heat (C_p) of 0.87 Btu/lb°F.⁴ A full load of potatoes averaged 22.7 minutes to reach a bulk cooked temperature of $195 \pm 2^\circ\text{F}$. The cooking energy efficiency and production capacity was 24.7% and 64 lb/h, respectively.

The single pan of red potatoes required 19.3 minutes to achieve an average bulk temperature of $195 \pm 2^\circ\text{F}$. The light-load potato test exhibited a somewhat lower cooking energy efficiency of 9.7% and productivity to 25 lb/h.

Results

Result Discussion

The rate at which steam condenses on food depends on the surface temperature and area of the food. Therefore, frozen green peas (at 0°F) and red potatoes (at room temperature) represent two extremities in steam cooking.

Frozen green peas, having large surface area to volume ratio, promote condensation. The energy transfer from steam to frozen food is high, resulting in greater cooking energy efficiency and productivity. Potatoes are “tough” to cook due to low surface to volume ratio and the slower rate of condensation.

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

Results

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

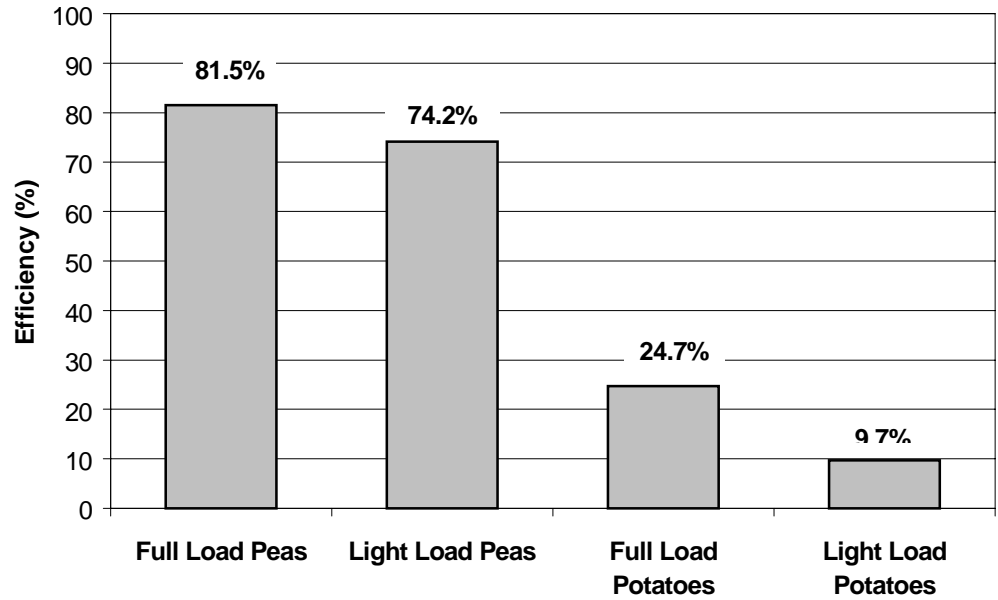
	Full-Load Peas	Light-Load Peas
Number of Pans	3	1
Cook Time (min)	16.2	5.8
Cooking Energy Rate (kW)	8.5	8.5
Cooking Energy Efficiency (%)	81.5	74.2
Production Rate (lb/h)	89	83
Energy Consumption (Btu/lb)	330	357
Water Consumption (gal/h)	40	41
Condensate Temperature (°F)	78.0	105.0

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

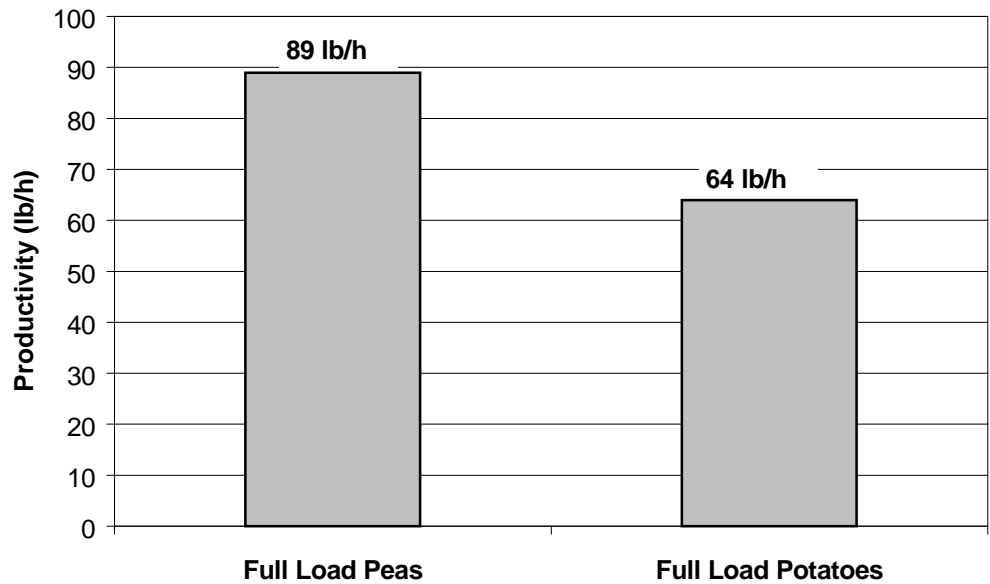
	Full-Load Potatoes	Light-Load Potatoes
Number of Pans	3	1
Cook Time (min)	22.7	19.3
Cooking Energy Rate (kW)	8.4	8.2
Cooking Energy Efficiency (%)	24.7	9.7
Production Rate (lb/h)	64	25
Energy Consumption (Btu/lb)	450	1120
Water Consumption (gal/h)	40	41
Condensate Temperature (°F)	184.4	189.5

Results

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



*Figure 3-3.
Steamer Production
Capacities.*



Results

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

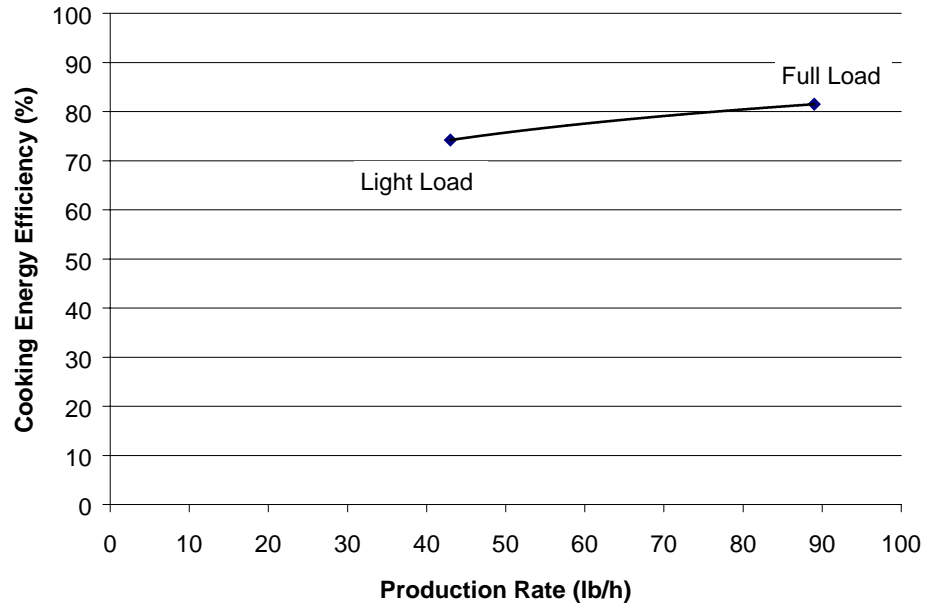
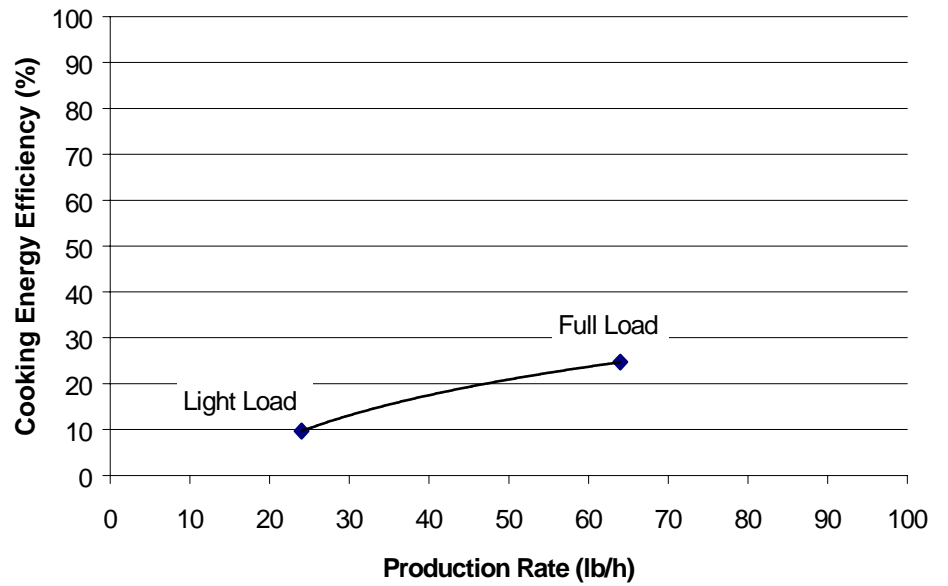


Figure 3-5.
*Steamer Part-Load
Red Potato Cooking
Energy Efficiency.*



4 Conclusions

The Cleveland SteamCraft Ultra 3 electric, pressureless steamer provides on demand steam cooking energy for high productivity. The unit is one of the fastest cooking three pan steamers tested to date at the FSTC.^{7,8,11} Most notable was the 16.2 minutes cook time for a full-load of frozen green peas and 5.8 minute cooktime for light. The single-pan frozen green pea cook time is the fastest of any electric steamer that has been currently tested in the laboratory setting.^{5,6,7,9,11,12,13,14} These rapid cook times suggest that the steamer's jet nozzle design effectively delivers steam cooking energy to the food product. The appliance also maintained high cooking energy efficiencies when tasked with cooking frozen food product, 81.5% for full-load and 74.2% for the single pan cooking scenario.

The SteamCraft Ultra 3's steam generator required little energy in maintaining a ready state of operation. During idle tests the steamer exhibited a low idle energy rate of 0.3 kW. The cooking compartment can be quickly preheated in about one minute prior to a cooking event in the "Manual" mode of operation. In the "Timed" mode of operation the timer automatically compensates for preheating of the compartment. The relatively short preheat time of 12.3 minutes from a cold start makes turning the appliance off a viable option when steam cooking is not required for extended periods.

Users of the Cleveland SteamCraft Ultra 3 will need to consider the steamer's water and sewer costs as well as maintenance costs associated with cleaning the unit's steam generator. Typical water usage for any given cooking

Conclusions

scenario was at least 40 gal/hr. This is due in large part to the unit's need to cool the released condensate before it enters the kitchen's sewer inlet as well as replenishing the steam generator's water reservoir during the cooking process. The steamer is equipped with warning light that indicates when deliming is required. Automatic blow-down of the generator occurs each time the unit is turned off, essentially assuring a minimum of preventative maintenance. As the steamer has a plumbed water connection, however, ensuring that the steam generator has an adequate water supply is not an issue. Other steaming technologies, specifically connectionless steamers, require periodic refilling during the course of daily operation.

For restaurant operators seeking high production capacities in a small footprint, the Cleveland SteamCraft Ultra 3 is a potential candidate. The steamer's continuous state of readiness guarantees ample steam energy during peak hours of operation. Left to idle, the steamer has minimal impact on utility costs with its low idle energy rate.

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A Glossary

Boiler

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

Boiler Idle Energy Rate

Idle Energy Rate

Idle Rate

Idle Energy Consumption Rate

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

Boiler Preheat

Preheat

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

Boiler Preheat Duration

Preheat Time

Preheat Period

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

Boiler Preheat Energy

Preheat Energy Consumption

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

Boiler Preheat Energy Rate

Preheat Energy Rate

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

Condensate

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

Condensate Temperature

The temperature at which the condensate enters the floor drain.

Cooking Energy Efficiency

Energy Efficiency

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

Cooking Energy Rate

Cooking Energy Consumption Rate

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

Cook Time

Cooking Period

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

Energy Input Rate

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

Glossary

Frozen Green Peas Load

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

High-Pressure Steam Cooker

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

Idle Energy Consumption

Idle Energy Use

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

Ice Load

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

Low-Pressure Steam Cooker

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

Maximum Energy Input Rate

Measured Energy Input

Measured Peak Energy Input Rate

Peak Rate of Energy Input

Peak rate at which an appliance consumes energy.

Potato Load

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

Production Capacity

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

Production Rate

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

Rated Energy Input Rate

Input Rating (ANSI definition)

Nameplate Energy Input Rate

Rated Input

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

Steam Cooker

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

Water Consumption

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

B Appliance Specification Sheet

Appendix B includes the product literature for the Cleveland Model SteamCraft Ultra 3 steamer.

C Results Reporting Sheets

Manufacturer: Cleveland
Model: SteamCraft Ultra 3
Date: November 2001

Section 11.1 Test Steam Cooker

ASTM F 1216 Classification (check one for each classification)

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

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

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

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

Results Reporting Sheets

Description of operational characteristics: The steamer controls are set to the “timed” operation mode and the “On/Off” switch is turned to the “On” position. Water automatically fills the steamer generator reservoir and the heater elements are activated. When steam generation has been achieved, the steam is then injected into the steamer cavity via two jet nozzles. Depending upon the users demands, the unit can be operated in either the “Manual” mode of operation, by which steam is continuously produced, or in the “Timed” mode of operation, which controls steam generation.

Section 10.7 Apparatus

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

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

Section 11.4 Energy Input Rate

Measured	8.3 kW
Rated	8.6 kW
Percent Difference between Measured and Rated	3.6%

Section 11.5 Appliance Preheat Energy Consumption and Duration

Energy Consumption	1.5 kWh
Duration	12.3 min

Section 11.6 Appliance Idle Energy Rate

Idle Energy Rate	0.3 kW
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Results Reporting Sheets

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

Full Load:

Cooking Time	16.2 min
Cooking Energy Efficiency	81.5 ± 0.9 %
Cooking Energy Rate	8.5 ± 0.1 kW
Production Capacity	89.4 ± 3.1 lb/h
Water Consumption Rate	40.2 ± 0.7 gal/h

Light Load

Cooking Time	5.8 min
Cooking Energy Efficiency	74.2 ± 1.5 %
Cooking Energy Rate	8.6 ± 0.3 kW
Production Rate	82.5 ± 2.6 lb/h
Water Consumption Rate	40.7 ± 1.4 gal/h

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

Full Load:

Cooking Time	22.7 min
Cooking Energy Efficiency	24.7 ± 1.0 %
Cooking Energy Rate	8.4 ± 0.4 kW
Production Capacity	63.6 ± 4.0 lb/h
Water Consumption Rate	39.9 ± 0.8 gal/h

Results Reporting Sheets

Light Load:

Cooking Time	19.3 min
Cooking Energy Efficiency	$9.7 \pm 0.5 \%$
Cooking Energy Rate	$8.2 \pm 0.13 \text{ kW}$
Production Rate	$25.0 \pm 0.7 \text{ lb/h}$
Water Consumption Rate	$41.2 \pm 0.1 \text{ gal/h}$

D Cooking Energy Efficiency Data

Table D-1. Preheat and Idle Data

Measured Values	Replication 1	Replication 2	Replication 3
Preheat Time (min)	12.4	12.4	12.1
Preheat Energy (kWh)	1.56	1.52	1.52
Idle Time (min)	120	120	120
Idle Energy (kWh)	0.6	0.7	0.6
Calculated Values			
Preheat Energy Rate (kW)	7.54	7.34	7.55
Idle Energy Rate (kW)	0.33	0.34	0.33

Cooking Energy Efficiency Data

Table D-2. Full-Load Peas Data

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	3	3	3
Cook Time (min)	16.0	16.3	16.3
Initial Water Temperature (°F)	42.3	40.7	43.6
Final Water Temperature (°F)	76.8	76.5	78.5
Frozen Food Temperature (°F)	-4.00	-4.00	-4.00
Weight of Empty Calorimeter (lb)	44.4	44.2	44.3
Weight of Full Calorimeter (lb)	128.4	128.3	128.4
Weight of Calorimeter Water (lb)	60.0	60.0	60.1
Weight of Cooked Food (lb)	24.0	24.1	24.1
Weight of Frozen Food (lb)	24.2	24.0	24.0
Weight of Stainless-Steel Pans (lb)	7.60	7.60	8.00
Moisture Content (%)	81	81	81
Condensate Temperature (°F)	78.5	77.4	78.1
Water Consumption (gal/h)	40.5	40.1	39.9
Calculated Values			
Moisture Weight in Green Peas (lb)	19.6	19.4	19.4
Final Food Temperature (°F)	178.4	181.7	180.8
Cooking Energy (kWh)	2.28	2.30	2.30
Energy Consumed by Green Peas (Btu)	6218.9	6230.5	6210.8
Energy Consumed by Pans (Btu)	153.1	155.5	162.8
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	7781.6	7849.9	7849.9
Cooking Energy Rate (kW)	8.6	8.5	8.5
Productivity (lb/h)	90.8	88.6	88.6
Energy Efficiency (%)	81.9	81.4	81.2

Cooking Energy Efficiency Data

Table D-3. Light-Load Peas Data

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	1	1	1
Cook Time (min)	5.9	5.7	5.8
Initial Water Temperature (°F)	43.1	45.7	42.1
Final Water Temperature (°F)	69.7	70.2	68.5
Frozen Food Temperature (°F)	-4.00	-4.00	-4.00
Weight of Empty Calorimeter (lb)	44.2	44.3	44.2
Weight of Full Calorimeter (lb)	82.6	82.3	82.6
Weight of Calorimeter Water (lb)	30.0	30.0	30.0
Weight of Cooked Food (lb)	8.40	8.00	8.40
Weight of Frozen Food (lb)	8.00	8.00	8.00
Weight of Stainless-Steel Pans (lb)	2.80	2.80	2.80
Moisture Content (%)	81	81	81
Condensate Temperature (°F)	103.8	102.3	108.8
Water Consumption (gal/h)	40.8	40.0	40.2
Calculated Values			
Moisture Weight in Green Peas(lb)	6.50	6.50	6.50
Final Food Temperature (°F)	181.9	178.4	180.2
Cooking Energy (kWh)	0.84	0.84	0.84
Energy Consumed by Green Peas (Btu)	2088.5	2056.2	2065.9
Energy Consumed by Pans (Btu)	57.4	56.4	57.1
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	2866.9	2866.9	2866.9
Cooking Energy Rate (kW)	8.5	8.8	8.6
Productivity (lb/h)	81.6	83.6	82.3
Energy Efficiency (%)	74.9	73.7	74.1

Cooking Energy Efficiency Data

Table D-4. Full-Load Potatoes Data

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	3	3	3
Cook Time (min)	22.9	22.1	23.1
Temperature of Uncooked Potatoes (°F)	74.9	72.4	70.2
Temperature of Cooked Potatoes (°F)	195.8	195.5	195.4
Weight of Stainless-Steel Pans (lb)	7.90	7.80	7.60
Weight of Potatoes (lb)	24.1	24.1	24.0
Total Potato Count	148	150	149
Moisture Content (%)	84	84	84
Condensate Temperature (°F)	186.0	184.3	183.1
Water Consumption (gal/h)	39.6	40.0	40.2
Calculated Values			
Moisture Weight in Potatoes (lb)	20.3	20.2	20.1
Average Weight of Each Potatoes (lb)	0.16	0.16	0.16
Cooking Energy (kWh)	3.16	3.14	3.28
Energy Consumed by Potatoes (Btu)	2546.7	2586.2	2618.0
Energy Consumed by Pans (Btu)	105.2	106.0	104.7
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	10785.0	10716.8	11194.6
Cooking Energy Rate (kW)	8.3	8.5	8.5
Productivity (lb/h)	63.2	65.4	62.3
Energy Efficiency (%)	24.6	25.1	24.3

Cooking Energy Efficiency Data

Table D-5. Light-Load Potatoes Data

Measured Values	Replication 1	Replication 2	Replication 3
Number of Pan(s)	1	1	1
Cook Time (min)	19.2	19.2	19.6
Temperature of Uncooked Potatoes (°F)	74.7	74.0	75.5
Temperature of Cooked Potatoes (°F)	195.1	194.2	194.2
Weight of Stainless-Steel Pans (lb)	2.40	2.80	2.80
Weight of Potatoes (lb)	8.0	8.0	8.0
Total Potato Count	50	50	50
Moisture Content (%)	84	84	74.
Condensate Temperature (°F)	187.4	190.8	190.2
Water Consumption (gal/h)	41.2	41.2	41.3
Calculated Values			
Moisture Weight in Potatoes (lb)	6.70	6.80	6.80
Average Weight of Each Potatoes (lb)	0.16	0.16	0.16
Cooking Energy (kWh)	2.61	2.62	2.70
Energy Consumed by Potatoes (Btu)	842.0	844.8	835.0
Energy Consumed by Pans (Btu)	31.8	36.9	36.7
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	8907.9	8942.1	9215.1
Cooking Energy Rate (kW)	8.2	8.2	8.3
Productivity (lb/h)	25.1	25.2	24.7
Energy Efficiency (%)	9.80	9.90	9.50

