AccuTemp, Model S62083D1701020
Electric Steamer Performance Test

Application of ASTM Standard
Test Method F 1484-05

FSTC Report # 5011.05.09—2nd edition

Food Service Technology Center

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Specific appreciation is extended to AccuTemp, Inc. for supplying the FSTC with a Model S62083D1701020 boilerless steamer for controlled testing in the appliance laboratory.

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Contents

List of Figures and Tables

Figures

Tables

Executive Summary

The Food Service Technology Center (FSTC) tested the AccuTemp, Model S62083D1701020 boilerless electric 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. 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] The steamer's cooking uniformity was determined by heating ice loads and examining their temperature profiles. Since the S62083D1701020 was not configured with an automatic water fill option or condensate drain, condensate temperature was not monitored for these tests.

The AccuTemp, Model S62083D1701020 performed favorably compared to other boilerless steamers, exhibiting excellent heavy-load (6 pan) cooking-energy efficiencies for frozen green peas (95.0%) and red potatoes (73.1%). The S62083D1701020 also demonstrated quick cook times, achieving heavy-load production capacities of 190.4 lb/h for frozen green peas and 135.3 lb/h for red potatoes.

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, 2005. Standard Test Method for the Performance of Steam Cookers. ASTM Designation F1484-05, in the Annual Book of ASTM Standards, West Conshohocken, PA.

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

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

Table ES-1. Summary of the S62083D1701020 Steamer Performance.

Rated Energy Input Rate (kW)	17.0
Measured Energy Input Rate (kW)	16.1
Preheat Time (min)	6.3
Preheat Energy (kWh)	1.7
Idle Energy Rate (kW)	0.16
Frozen Green Peas	
Light-Load Cooking-Energy Efficiency (%)	64.1 ± 3.3
Heavy-Load Cooking-Energy Efficiency (%)	95.0 ± 2.5
Production Capacity (lb/h)	190.4 ± 17.0
Red Potatoes	
Light-Load Cooking-Energy Efficiency (%)	31.2 ± 1.3
Heavy-Load Cooking-Energy Efficiency (%)	73.1 ± 1.8
Production Capacity (lb/h)	135.3 ± 1.0
Ice Loads	
Cook Time (min)	19.2
Maximum Temperature Difference (°F)	35.3
Maximum Time Delay (min)	6.8

Higher than normal water consumption was a result of the manufacturer requesting that the water reservoir be emptied and refilled with three gallons of fresh water after each food cooking trial. Steaming high starch food over an open reservoir can cause foaming, which may lead to longer cook times. Changing the water between cooking loads minimizes this effect. This resulted in water consumption rates from 6 gal/hr to 11 gal/hr, depending on the particular cooking scenario. Had this step been omitted, water

consumption would have been less than 3.0 gal/hr. Other steam cooking technologies, such as boiler-based or steam generator-type steamers, typically consume between 20 and 60 gal/h while cooking.

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 such that users can make meaningful comparisons among available equipment choices. Since the development of the ASTM test method for steamers in 1994[1,2], the FSTC has tested a wide range of gas and electric steamers. [3-26] 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.

The AccuTemp S62083D1701020 steamer features a vacuum pump on the side that creates a negative-pressure environment for the food to cook in, a cooking compartment that is simple and easy to clean, and a three gallon reservoir.

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 AccuTemp, Model S62083D1701020 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 (6 pans), light-load frozen green peas (single-pan), heavy-load red potatoes (6 pans) and light-load red potatoes (single-pan).
5. Determine the production capacity, cooking energy rate and cook time for each loading scenario.
6. Characterize cooking uniformity by steaming ice loads.

Appliance Description

The AccuTemp, Model S62083D1701020 is a 6-pan capacity, single compartment, electric, boilerless steamer (Figure 1-1). The steamer is powered by a 17.0 kW heating element placed beneath the cooking compartment's water reservoir. Steam is generated within the cooking compartment without a separate boiler – water is added and drained manually at the beginning and end of the day. The cooking chamber can accommodate six standard full-size, 2½-inch deep hotel pans. The S62083D1701020 has three cooking modes: timed, cook and fast cook. The timed mode allows operators to set a predetermined cook time of up to 90 minutes. When the cook time has expired, the unit automatically switches to a hold mode. This

hold feature allows the operator to maintain an idle state at a thermostat-set temperature inside the cooking compartment. In the cook mode, the user selects a cooking temperature with the thermostat dial and the heating elements are cycled automatically by microprocessor controls to maintain this internal compartment temperature. On the fast cook setting, the steamer always maintains maximum steaming temperature within the cooking compartment. A vacuum pump located within the steamer assists in steam generation by producing a vacuum inside the compartment during cooking.

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 AccuTemp S6 steamer.

Table 1-1. Appliance Specifications.

Manufacturer	AccuTemp
Model	Model S62083D1701020
Generic Appliance Type	Boilerless, 1-compartment, electric, atmospheric, connectionless steamer.
Rated Input	17.0 kW
Technology	Boilerless steamer with vacuum pump.
Construction	Stainless-steel walls.
Interior	14 Ga. stainless-steel
Exterior	Stainless-steel
Controls	Main ON/OFF buttons. 90 minute electromechanical timer with continuous steam or hold setting. Thermostat ranging from 100 °F to 200 °F.
Compartment Capacity	6 (12" x 20" x 2½") pans
Dimensions	23¼" x 25" x 30" (w×d×h)

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 method[1]: 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 ± 5°F.

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 steady voltage for all tests. Figure 2-1 shows the S62083D1701020 instrumented with the data acquisition system.

Figure 2-1.
The S62083D1701020 instrumented for testing.

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 is completed, the steamer was placed in the "hold" mode and idle energy consumption was monitored over a 2-hour period.

Frozen Green Pea Efficiency Tests

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 S62083D1701020 required 6 pans of green peas for a full load, while a single pan placed on the center rack of the steamer 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 ± 5°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 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.[1]

Figure 2-2.
Frozen green pea load.

Since probing proves to be difficult and erroneous for 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 ± 5°F was determined through an iterative process. Once the cook time was established, the test was replicated a minimum of three times to minimize the uncertainty in the test results.

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 S62083D1701020 required 6 pans of red potatoes for a full load and a single pan for a light load. Each pan contained exactly 50 red potatoes weighing 8.0 ± 0.2 pounds.

The red potatoes were loaded into perforated pans prior to the test and stabilized to a room temperature of 75 ± 5°F. The potatoes were then cooked to 195 ± 2°F. The final temperature was determined by probing a minimum of 3 potatoes per pan (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.

The ice load test required 3 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 ± 5°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, when the temperatures and final cook time were recorded. 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. Researchers determined that the S62083D1701020 drew a maximum energy input rate of 16.1 kW.

Preheat and Idle Tests

Preheat Energy and Time

The cavity was manually filled with three gallons of water at 70 ± 5°F. The steamer was started in its “fast cook” mode of operation indicated by continual steaming cycles until the timer expired after 15 minutes, as instructed by the user manual. Figure 3-1 illustrates the preheat and idle characteristics of the S62083D1701020.

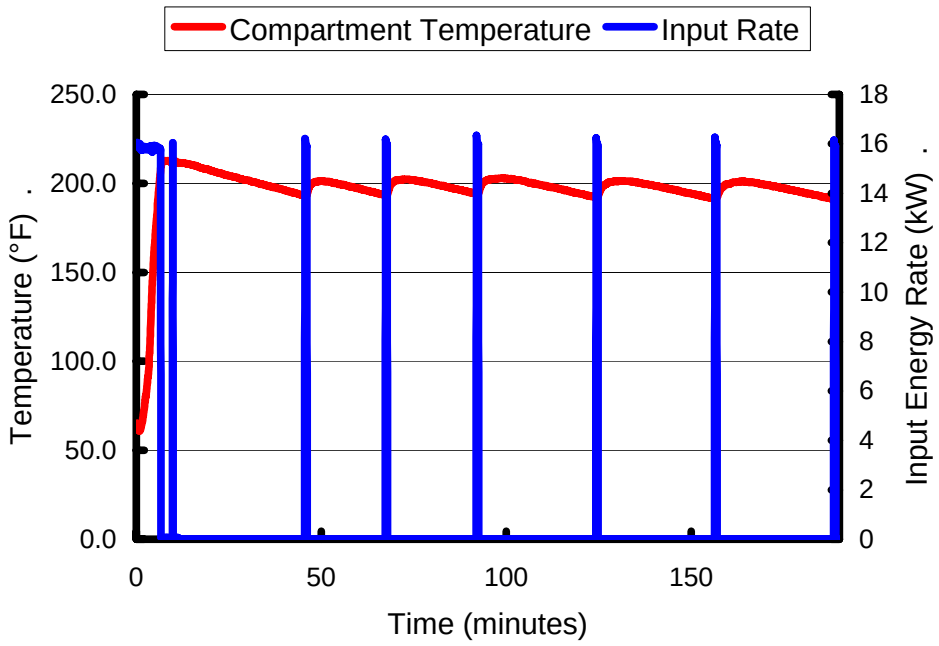

Figure 3-1.
Preheat and idle characteristics.

Results

Idle Energy Rate

Following the preheat period, the steamer was left in the "hold" mode and allowed to stabilize for one hour. Then, the steamer was monitored over a 2-hour period and the idle energy rate was determined to be 0.16 kW.

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 (kW)	17.0
Measured Energy Input Rate (kW)	16.1
Preheat to Operational Capacity:	
Time (min)	6.3
Energy (kWh)	1.7
Idle Energy Rate (kW)	0.16

Cooking Tests

The steamer was tested using two different food products (green peas and red potatoes) under two loading scenarios—heavy (6 pans) and light (single pan). All cooking scenarios were conducted in the unit's "fast cook" mode.

The AccuTemp S62083D1701020 does not employ a separate boiler, water connection or drain. Three gallons of water were poured into the reservoir at the bottom of the cooking compartment before testing began. The steamer was emptied at the end of each cooking test replication, as directed by the manufacturer's instructions. Typical water usage for each cooking scenario varied between 6 gallons per hour and 11 gallons per hour.

Frozen Green Pea Tests

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 0.84 Btu/lb°F for thawed peas.[1] The S62083D1701020 required 15.1 minutes to cook a full load of frozen green peas and had a cooking-energy efficiency of 95.0% and a production capacity of 190.4 lb/h.

The light-load test required an average of 10.5 minutes when cooking a single pan of frozen green peas. Cooking-energy efficiency and productivity during the light-load tests were determined to be 64.1% and 45.7 lb/h, respectively.

Red Potato Tests

The red potatoes contained 84% moisture by weight with the specific heat (Cp) of 0.87 Btu/lb°F.[1] A full load of potatoes averaged 21.3 minutes to reach an average bulk cooked temperature of 195 ± 2°F. The cooking-energy efficiency and production capacity was 73.1% and 135.3 lb/h, respectively.

The single pan of red potatoes required 18.3 minutes to achieve an average bulk temperature of 195 ± 2°F. The light-load potato test resulted in a cooking-energy efficiency of 31.2% and a productivity of 26.3 lb/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 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 in greater cooking-energy efficiency and productivity. Potatoes are “tough” to cook, due to a low surface to volume ratio and the slower rate of condensation.

Results

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 F1484-05, the cooking energy efficiencies are calculated. Tables 3-2 through 3-3 summarize the S62083D1701020's cooking performance.

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

	Heavy-Load	Light-Load
Number of Pans	6	1
Cook Time (min)	15.1	10.5
Cooking Energy Rate (kW)	15.5	5.4
Cooking-Energy Efficiency (%)	95.0 ± 2.5	64.1 ± 3.3
Production Rate (lb/h)	190.4 ± 17.0	45.7
Energy Consumption (Btu/lb)	278	404

Table 3-3. Red Potato Cooking Test Results.

	Heavy-Load	Light-Load
Number of Pans	6	1
Cook Time (min)	21.3	18.3
Cooking Energy Rate (kW)	6.0	2.8
Cooking-Energy Efficiency (%)	73.1 ± 1.8	31.2 ± 1.3
Production Rate (lb/h)	135.3 ± 1.0	26.3 ± 0.1
Energy Consumption (Btu/lb)	152	361

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 and 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 table of the test data for each replicate of the cooking tests.

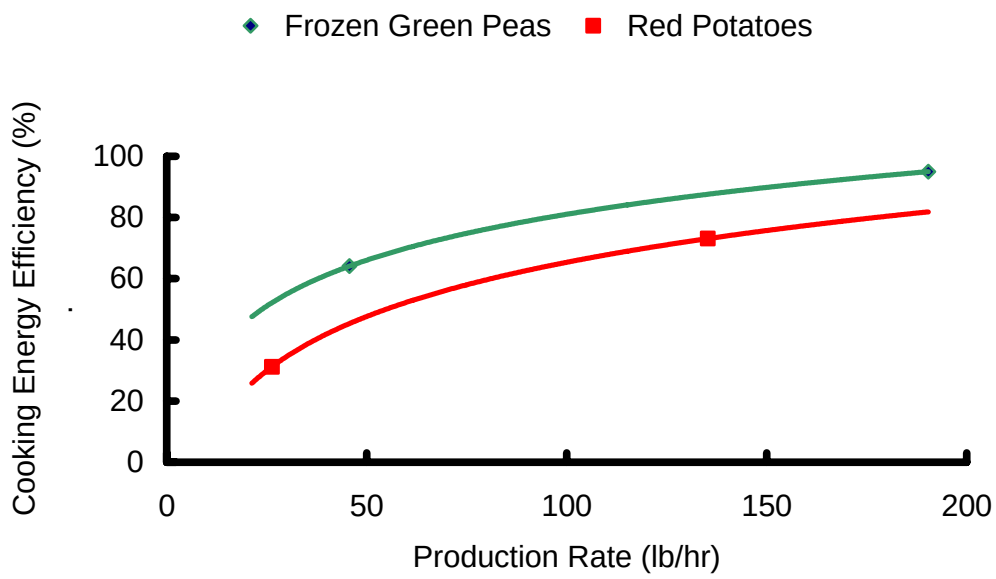

Figure 3-2.
Steamer part-load cooking-energy efficiency.

Note: Light-load = single pan/load; Heavy-load = 6 pans/load.

Figure 3-2 illustrates the relationship between the steamer's average cooking-energy efficiency and the production rate 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. Furthermore, Figure 3-3 shows that the frozen green peas have higher cooking-energy efficiencies than the red potatoes due to their higher surface-to-volume ratio.

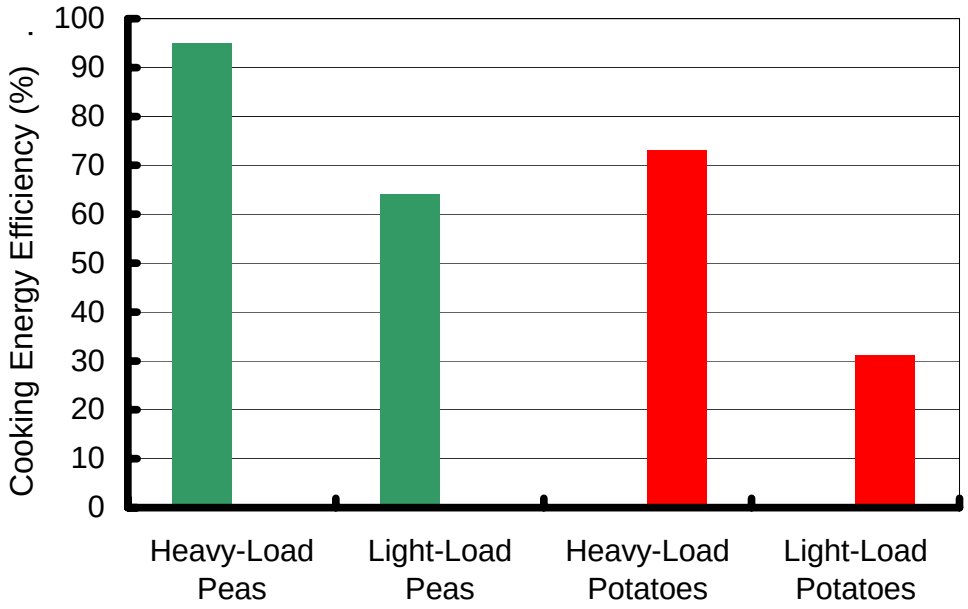

Figure 3-3. Comparison of steamer cooking-energy efficiencies.

Note: Light-load = single pan/load; Heavy-load = 6 pans/load.

Figure 3-4 represents the cooking energy rate for two different food products at the two test load scenarios. The upper line represents the steamer's energy consumption rate when cooking frozen vegetables, while the lower curve represents the steamer's energy consumption rate while cooking more stubborn food products. All thermostatically controlled electric steamers with the ability to cycle its elements will exhibit similar cooking energy rate profiles for frozen vs. fresh food products; these steamers will operate at higher average energy rates for frozen foods than for fresh products. This graph can be used as a tool to estimate the daily energy consumption and probable demand 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 2.6 kW, 3.6 kW, and 5.7 kW, 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 food over a ten hour day), the probable demand contribution from this steamer would be 2.6 kW.

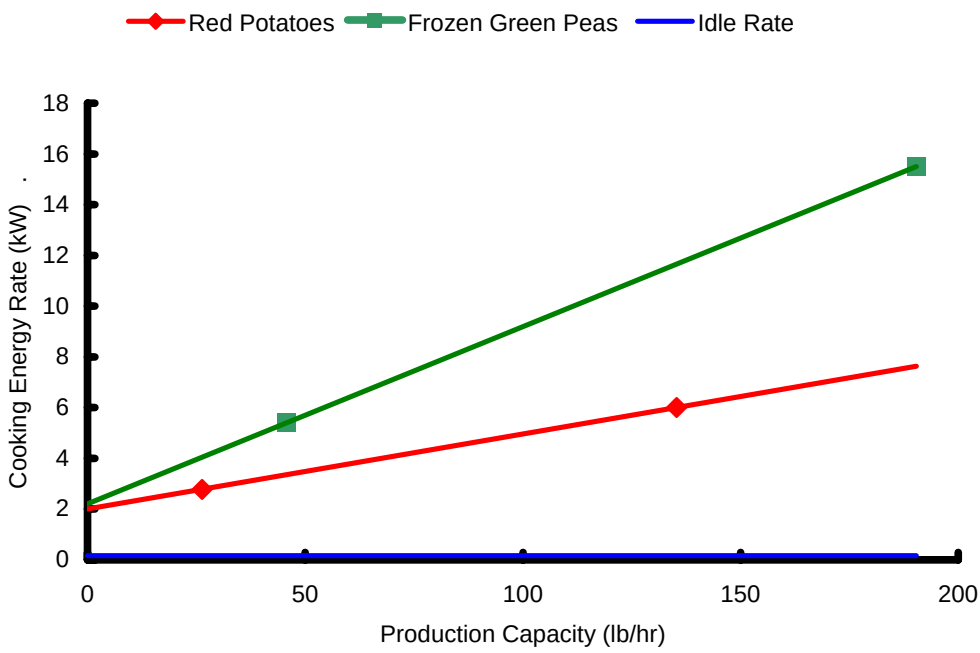

Figure 3-4.
Steamer cooking energy consumption profile.

Note: Light-load = single pan/load; Heavy-load = 6 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, 6 pans (full-load) of ice were used to determine the steaming uniformity within the compartment. The last pan reached 170°F in 19.2 minutes. At this time, the maximum temperature difference between the hottest and coldest pan was found to be 35.3°F. On average, the last pan to reach the 170°F endpoint required an additional 6.8 minutes beyond the cook time of the fastest pan. Table 3-4 summarizes the average results of the ice-load uniformity tests and Figure 3-5 shows the individual pan temperatures during a single ice-load test. Note that the final temperatures are averages of at least three replications and reflect the variations in results from each test.

Table 3-4. Ice-Load Uniformity Test Results.

Number of Pans	6
Cook Time (min)	19.2
Initial Ice-Load Temperature (°F)	1.9
Final Ice-Load Temperatures (°F):	
Pan 1 (Top)	172.9
Pan 2	172.9
Pan 3	202.8
Pan 4	206.9
Pan 5	208.2
Pan 6 (Bottom)	202.6
Maximum Temperature Difference (°F)	35.3
Maximum Time Delay* (min)	6.8

* Time required for ice load in last pan to reach 170°F after first pan reaches the endpoint.

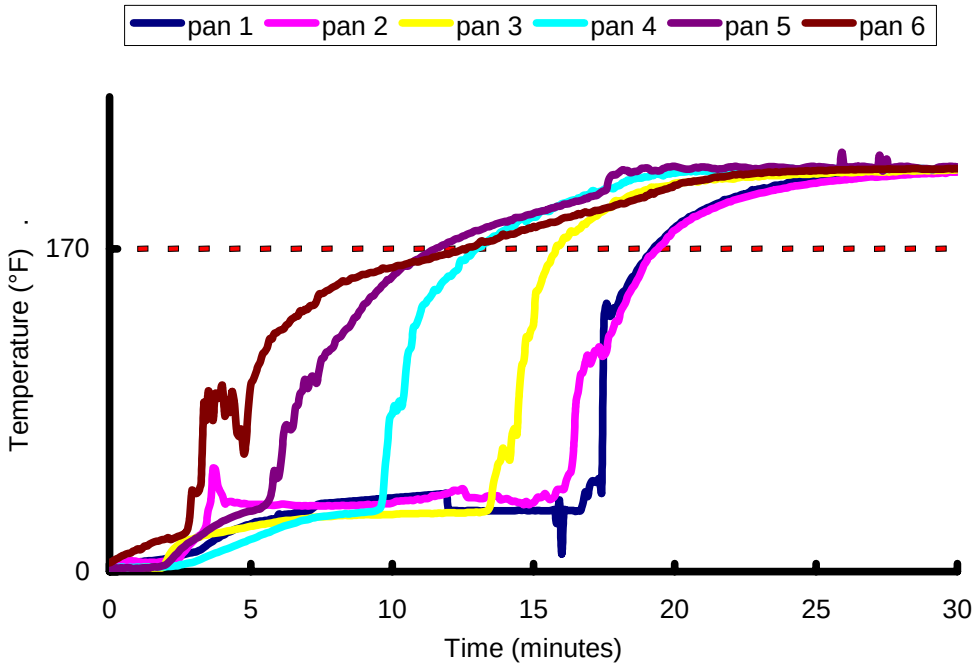

Figure 3-5.
Ice-load temperature profile.

4 Conclusions

The AccuTemp S62083D1700120 exhibited excellent cooking performance. With respective production capacities of 190.4 lb/hr and 135.3 lb/hr for frozen green peas and fresh red potatoes, AccuTemp's latest steamer has truly eclipsed the performance of its predecessor, the D12. With heavy-load cooking efficiencies all above 50%, and an idle energy input rate of just 0.16 kW, this steamer really shines as an energy saver.

With 17 kW of cooking power on tap, it took the S62083D1700210 only 6.3 minutes to reach full cooking temperature. This prodigious power was noticeable while cooking heavy loads of frozen green peas. Cook times were a scant 15.1 minutes for this scenario.

As illustrated by the ice load test, cooking uniformity was strong compared to other six pan steamers in the S62083D1700210's class. The time between the first and last pans reaching 170 °F was only 6.8 minutes. Other steamers in its class exhibited delays in the range of 12 minutes between the fastest and slowest pans.

Excessive foaming can occur when heavy loads of high starch content foods are cooked. To minimize foaming, the water reservoir was emptied and filled with fresh water after each cooking iteration. This step resulted in somewhat higher water consumption rates for a connectionless steamer. The S62083D1700210 used 6 gal/hr to 11 gal/hr of water, depending on the cooking scenario. If the water was not changed between cooking events, water consumption would be less than 3 gal/hr.

In addition to its good performance during the rigorous laboratory testing, the S62083D17001020 also provides features such as timed cooking, thermostat controlled steaming, and a hold mode. The AccuTemp S62083D17001020 is a good candidate for facilities looking to reduce operating costs without

sacrificing cooking performance. With its low energy consumption and high production rates, this 6-pan steamer is a fine choice for a wide variety of high-volume applications.

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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- 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 preheat.

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.

High-Pressure Steam Cooker

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

Heating Value (Btu/ft^3)
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.

Glossary

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.

Preheat Time (minute)
Preheat Period

The time required for an appliance to heat from the ambient room temperature (75 ± 5°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 AccuTemp, Model S62083D1701020 steamer.

Manufacturer	AccuTemp
Model	Model S62083D1701020
Generic Appliance Type	Boilerless, 1-compartment, electric, atmospheric, connectionless steamer.
Rated Input	17.0 kW
Technology	Boilerless steamer with vacuum pump.
Construction	Stainless-steel walls.
Interior	14 Ga. stainless-steel
Exterior	Stainless-steel
Controls	Main ON/OFF buttons. 90 minute electromechanical timer with continuous steam or hold setting. Thermostat ranging from 100 °F to 200 °F.
Compartment Capacity	6 (12" x 20" x 2½") pans
Dimensions	23¼" x 25" x 30" (w×d×h)

C Results Reporting Sheets

Manufacturer: AccuTemp
Model: S62083D1701020
Date: May 2005

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

Description of operational characteristics: The steamer has no water or drain connections. Approximately 3.0 gallons of water are manually poured in the bottom of the cooking compartment prior to operation, then manually drained at the end of the day. Users can choose to operate the steamer in a timed mode or in a continuous steaming mode. There is also a hold feature that allows the operator to hold the compartment temperature anywhere between 100°F to 200°F using a thermostat for an indefinite period of time. All cooking tests were conducted in the unit's continuous mode.

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 ± 5°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 5-second intervals for the entire test method application. All test apparatus were installed in accordance with Section 9 of the ASTM test method.

Energy Input Rate

Test Voltage	208 V
Measured	16.1 kW
Rated	17.0 kW
Percent Difference between Measured and Rated	5.3%

Appliance Preheat Energy Consumption and Duration

Test Voltage	208 V
Energy Consumption	1.7 kWh
Duration	6.3 min

Appliance Idle Energy Rate

Test Voltage	208 V
Idle Energy Rate	0.16 kW

<u>Frozen Green Peas</u> Cooking Time, Energy Efficiency, Energy Rate, Production Capacity, and Water Consumption Rate

Heavy-Load:

Test Voltage	208 V
Cooking Time	15.1 min
Cooking-Energy Efficiency	95.0 ± 2.5%
Cooking Energy Rate	15.5 ± 1.1 kW
Production Capacity	190.4 ± 17.0 lb/h
Water Consumption Rate	8 gal/h

Light-Load:

Test Voltage	208 V
Cooking Time	10.5 min
Cooking-Energy Efficiency	64.1 ± 3.3 %
Cooking Energy Rate	5.4 ± 0.3 kW
Production Rate	45.7 lb/h
Water Consumption Rate	11 gal/h

<u>Whole Red Potatoes</u> Cooking Time, Energy Efficiency, Energy Rate, Production Capacity, and Water Consumption Rate

Heavy-Load:		
Test Voltage		208 V
Cooking Time		21.3 min
Cooking-Energy Efficiency		73.1 ± 1.8 %
Cooking Energy Rate		6.0 kW
Production Capacity		135.3 ± 1.0 lb/h
Water Consumption Rate		6 gal/h
Light-Load:		
Test Voltage		208 V
Cooking Time		18.3 min
Cooking-Energy Efficiency		31.2 ± 1.3 %
Cooking Energy Rate		2.8 ± 0.2 kW
Production Capacity		26.3 ± 0.1 lb/h
Water Consumption Rate		7 gal/h

<u>Ice-Loads</u> Cooking Time, Temperature Uniformity

Test Voltage		208 V
Cooking Time		19.2 min
Initial Average Temperature		-0.4 °F
Average Final Ice Load Temperatures	Pan 1	172.9 °F
	Pan 2	172.9 °F
	Pan 3	202.8 °F
	Pan 4	206.9 °F
	Pan 5	208.2 °F
	Pan 6	202.6 °F
Maximum Temperature Difference		35.3 °F
Maximum Time Delay		6.8 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 Pan(s)	6	6	6
Cook Time (min)	14.7	15.8	15.0
Initial Water Temperature (°F)	61.4	63.3	63.6
Final Water Temperature (°F)	108.1	112.1	111.9
Frozen Food Temperature (°F)	4.4	-2.0	1.5
Weight of Empty Calorimeter (lb)	5.96	5.96	5.96
Weight of Full Calorimeter (lb)	115.4	114.2	113.5
Weight of Calorimeter Water (lb)	60	60	60
Weight of Cooked Food (lb)	49.4	48.2	47.6
Weight of Frozen Food (lb)	48	48	48
Weight of Stainless-Steel Pans (lb)	17.0	17.0	17.0
Moisture Content (%)	81	81	81
Condensate Temperature (°F)	n/a	n/a	n/a
Water Consumption (gal/h)	8	8	8
Calculated Values			
Moisture Weight in Green Peas (lb)	38.9	38.9	38.9
Final Food Temperature (°F)	175.6	184.3	184.3
Cooking Energy (kWh)	3.82	3.94	3.96
Energy Consumed by Green Peas (Btu)	12,145	12,485	12331
Energy to Food (Btu/lb)	253.0	260.1	256.9
Energy Consumed by Pans (Btu)	320.6	346.8	342.3
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	13,034	13,443	13,512
Energy to Steamer (Btu/lb of food cooked)	271.5	280.1	281.5
Cooking Energy Rate (kW)	15.6	15.0	15.8
Productivity (lb/h)	196	183	192
Energy Efficiency (%)	95.6	95.5	93.8

Cooking-Energy Efficiency Data

Table D-3. Light-Load Peas Data

	Replication 1	Replication 2	Replication 3
Measured Values			
Number of Pan(s)	1	1	1
Cook Time (min)	10.5	10.5	10.5
Initial Water Temperature (°F)	64.5	60.4	61.6
Final Water Temperature (°F)	111.3	107.5	108.0
Frozen Food Temperature (°F)	0.0	-1.6	1.0
Weight of Empty Calorimeter (lb)	5.96	5.96	5.96
Weight of Full Calorimeter (lb)	23.7	23.7	23.8
Weight of Calorimeter Water (lb)	10.0	10.0	10.0
Weight of Cooked Food (lb)	7.78	7.74	7.79
Weight of Frozen Food (lb)	8.0	8.0	8.0
Weight of Stainless-Steel Pans (lb)	2.8	2.8	2.8
Moisture Content (%)	81	81	81
Condensate Temperature (°F)	n/a	n/a	n/a
Water Consumption (gal/h)	11	11	11
Calculated Values			
Moisture Weight in Green Peas (lb)	6.5	6.5	6.5
Final Food Temperature (°F)	181.6	180.0	178.9
Cooking Energy (kWh)	0.96	0.96	0.92
Energy Consumed by Green Peas (Btu)	2,023	2,013	2,004
Energy to Food (Btu/lb)	252.9	251.6	250.5
Energy Consumed by Pans (Btu)	56.1	56.1	55.1
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	3,276	3,276	3.139
Energy to Steamer (Btu/lb of food cooked)	409.5	409.5	392.4
Cooking Energy Rate (kW)	5.5	5.5	5.3
Productivity (lb/h)	45.7	45.7	45.7
Energy Efficiency (%)	63.5	63.2	65.6

Cooking-Energy Efficiency Data

Table D-4. Heavy-Load Potatoes Data

	Replication 1	Replication 2	Replication 3
Measured Values			
Number of Pan(s)	6	6	6
Cook Time (min)	21.3	21.3	21.3
Temperature of Uncooked Potatoes (°F)	74.4	72.6	72.7
Temperature of Cooked Potatoes (°F)	196.3	194.5	196.6
Weight of Stainless-Steel Pans (lb)	16.4	16.4	16.4
Weight of Potatoes (lb)	47.9	48.0	48.0
Total Potato Count	150	150	150
Moisture Content (%)	84	84	84
Condensate Temperature (°F)	n/a	n/a	n/a
Water Consumption (gal/h)	6	6	6
Calculated Values			
Moisture Weight in Potatoes (lb)	40.3	40.2	40.3
Average Weight of Each Potato (lb)	0.16	0.16	0.16
Cooking Energy (kWh)	2.14	2.14	2.14
Energy Consumed by Potatoes (Btu)	5,082	5,089	5,176
Energy to Food (Btu/lb)	105.9	106.0	107.8
Energy Consumed by Pans (Btu)	220.0	219.8	223.6
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	7,302	7,302	7,302
Energy to Steamer (Btu/lb of food cooked)	152.4	152.1	152.1
Cooking Energy Rate (kW)	6.0	6.0	6.0
Productivity (lb/h)	135	136	136
Energy Efficiency (%)	72.6	72.7	73.9

Cooking-Energy Efficiency Data

Table D-5. Light-Load Potatoes Data

	Replication 1	Replication 2	Replication 3
Measured Values			
Number of Pan(s)	1	1	1
Cook Time (min)	18.3	18.3	18.3
Temperature of Uncooked Potatoes (°F)	70.8	73.7	70.6
Temperature of Cooked Potatoes (°F)	195.2	195.5	195
Weight of Stainless-Steel Pans (lb)	2.8	3.2	2.8
Weight of Potatoes (lb)	8.0	8.0	8.0
Total Potato Count	50	50	50
Moisture Content (%)	84	84	84
Condensate Temperature (°F)	n/a	n/a	n/a
Water Consumption (gal/h)	7	7	7
Calculated Values			
Moisture Weight in Potatoes (lb)	6.8	6.7	6.8
Average Weight of Each Potato (lb)	0.16	0.16	0.16
Cooking Energy (kWh)	0.86	0.82	0.86
Energy Consumed by Potatoes (Btu)	868.0	847.3	867.1
Energy to Food (Btu/lb)	108.5	105.9	108.4
Energy Consumed by Pans (Btu)	38.5	42.9	38.4
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	2,934	2,798	2,934
Energy to Steamer (Btu/lb of food cooked)	366.8	349.8	366.8
Cooking Energy Rate (kW)	2.8	2.7	2.8
Productivity (lb/h)	26.4	26.3	26.3
Energy Efficiency (%)	30.9	31.9	30.9

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	95.6	63.5	196.3
Replicate #2	95.5	63.2	182.9
Replicate #3	93.8	65.6	192.0
Average	95.0	64.1	190.4
Standard Deviation	1.01	1.31	6.84
Absolute Uncertainty	2.51	3.26	17.0
Percent Uncertainty	2.6%	5.1%	8.9%

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

	Cooking-Energy Efficiency		Production Capacity
	Heavy Load	Light Load	
Replicate #1	72.6	30.9	134.8
Replicate #2	72.7	31.8	135.5
Replicate #3	73.9	30.9	135.8
Average	73.1	31.2	135.3
Standard Deviation	0.72	0.54	0.40
Absolute Uncertainty	1.79	1.33	0.99
Percent Uncertainty	2.4%	4.3%	0.7%