AccuTemp STEAM 'N' HOLD, Model 208-D12-300
Electric Steamer Performance Test

Application of ASTM Standard
Test Method F 1484-99

FSTC Report # 5011.03.02 (Revised)

Food Service Technology Center

June 2003

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Acknowledgments

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Specific appreciation is extended to AccuTemp Products, Inc. for supplying the FSTC with STEAM 'N' HOLD, Model 208-D12-300 connectionless steamer for controlled testing in the appliance laboratory.

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Executive Summary

The Food Service Technology Center (FSTC) tested the AccuTemp STEAM 'N' HOLD, Model 208-D12-300 connectionless 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 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 frozen green peas and red potatoes. Since the D12 does not employ a condensate drain, condensate temperature was not monitored during testing.

The AccuTemp STEAM 'N' HOLD, Model D12 is a productive and energy efficient connectionless electric steamer. With its 6-pan loading capacity and fast cook times, the D12 has one of the highest production capacities of any connectionless steamer tested to date at the FSTC. Researchers established an average 22.0 minute cook time for a full load (6 pans) of frozen green peas. When tasked with cooking a "tough" food product, such as red potatoes, the D12 had an average heavy-load cook time of 22.7 minutes resulting in a maximum production capacity of 130 lb/h.

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:

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

[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, West Conshohocken, PA.

Executive Summary

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

Table ES-1. Summary of D12 Steamer Performance.

Rated Energy Input Rate (kW)	12.0
Measured Energy Input Rate (kW)	12.0
Preheat Time (min)	6.5
Preheat Energy (kWh)	1.3
Idle Energy Rate (kW) (Revised Testing)	0.4
Frozen Green Peas	
Light-Load Cooking-Energy Efficiency (%)	64.2 ± 2.5
Heavy-Load Cooking-Energy Efficiency (%)	88.4 ± 0.6
Production Capacity (lb/h)	131 ± 0.0
Red Potatoes	
Light-Load Cooking-Energy Efficiency (%)	31.2 ± 2.0
Heavy-Load Cooking-Energy Efficiency (%)	67.5 ± 1.4
Production Capacity (lb/h)	130 ± 4.8

Beyond its respectable productivity and high cooking-energy efficiencies, the D12 steamer also exhibited low water usage. Typical water consumption during heavy-load cooking tests was much lower than the unit's 2.5-gallon reservoir capacity. Other steam cooking technologies, such as boiler-based or steam generator-type steamers, typically consume between 20 and 60 gal/h while cooking.

The D12 is AccuTemp's latest addition to their family of connectionless steamers. Earlier STEAM 'N' HOLD models, the D6 and the D8, have been tested under the rigors of the ASTM test method at the FSTC. Testing of the D12 revealed a marked improvement in cooking performance over the earlier STEAM 'N' HOLD models. The D12 was nearly 20 minutes faster, when cooking a full load of frozen green peas, than the D6 and almost 10 minutes

faster than the D8 when cooking the same food product. A full load of red potatoes required 22.7 minutes to cook in the D12, whereas the D6 and D8 required an additional 6 minutes to cook this "tough" food product to a temperature of 195°F. Figure ES-1 graphically compares the production capacities of the D12, D8 and D6 steamers.

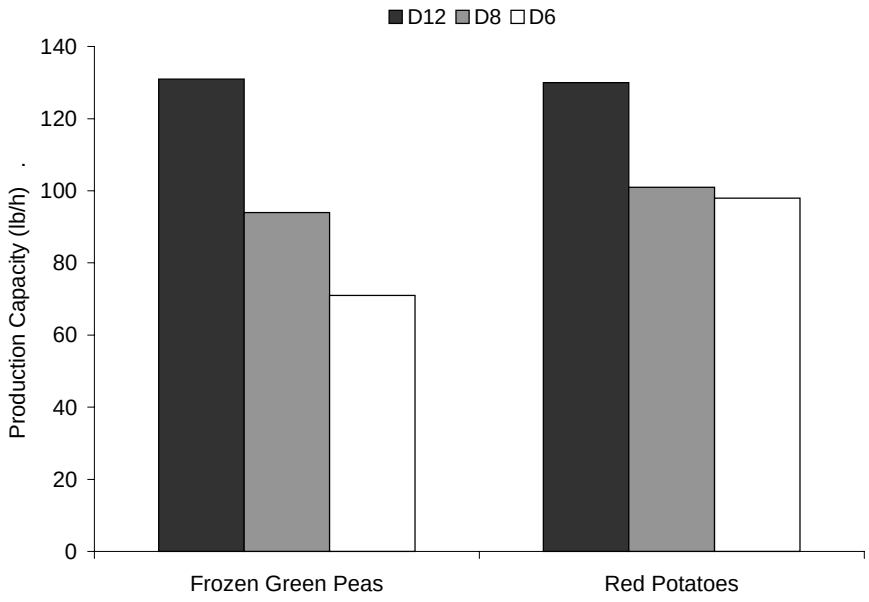

Figure ES-1. Comparison of steamer production capacities.

The additional horsepower was not wasted however, as demonstrated by the D12's comparable cooking-energy efficiencies to those of the D6 and D8.

The D12 minimized standby energy losses when the timer was turned to the "Hold" position. The timer automatically switches to the "Hold" mode after a preset cooktime has elapsed. Researchers performed tests to characterized the idle energy rate using the steamer's two modes of operation, "Fast Cook" and "Thermostat". In the "Thermostat" mode the steamer's thermostat was set to

200°F. In both control settings the D12 exhibited a low idle energy rate of 420 W.

AccuTemp Products, Inc. has markedly increased the maximum production capacity of its connectionless steamer through the addition of higher input, 12-kW heating elements. The STEAM 'N' HOLD, Model 208-D12-300 offers greater productivity in the same platform of earlier models and maintains the same, high cooking energy efficiencies as well. Operators will find the D12 a qualified candidate that can satisfy menu demands with its high productivity, while minimizing utility costs.

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 meaningful 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,[2–14] including other versions of the AccuTemp STEAM N' HOLD steamer.[15,16]

Introduction

AccuTemp's STEAM 'N' HOLD Model 208-D12-300 is the newest generation of connectionless steamers offered by AccuTemp Products, Inc. It follows in the footsteps of the first unit introduced—the D6 (6 kW input rate) and its subsequent offspring, the 8-kW input D8. Each model shares a similar design—the heating element is positioned beneath the water reservoir, eliminating the need for a separate boiler. Testing of the two earlier units at the FSTC highlighted the D8's considerable cooking performance improvements over the D6.[15,16] Testing of the D12 under the ASTM test method once again allowed for fair and precise comparison of the three AccuTemp steamers.

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 D12 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 4 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.

Appliance Description

The AccuTemp STEAM 'N' HOLD, Model 208-D12-300 is a 6-pan capacity, single compartment, electric connectionless steamer. The steamer is powered

by a 12.0-kW heating element placed beneath the cooking compartment's water reservoir (Figure 1-1). 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 accommodates six standard full-size, 2½-inch deep hotel pans. The D12 has two cooking modes: timed and continuous. The timed mode allows operators to set a pre-determined cooktime of up to 90 minutes. When the cook time has expired, the unit automatically switches to a hold mode. In the continuous cooking mode, steam generation is controlled manually by shutting the unit on or off manually. The unit also has a hold feature that allows the operator to set a desired cooking compartment temperature between 140°F and 212°F.

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 D12 steamer in stacked configuration.

Table 1-1. Appliance Specifications.

Manufacturer	AccuTemp Products, Inc.
Model	Model 208-D12-300
Generic Appliance Type	Connectionless, 1-compartment, electric, vacuum, connectionless steamer.
Rated Input	12.0 kW
Technology	Boiler-less steamer with natural-convection.
Construction	Double-wall, stainless-steel.
Interior	14 Ga. stainless-steel
Exterior	33 Ga. stainless-steel
Controls	Main ON/OFF buttons. 90 minute mechanical timer with continuous steam and hold setting. Thermostat ranging from 140 °F to 212 °F.
Compartment Capacity	6 (12" x 20" x 2$^{1}/_{2}$") pans, 4 (12" x 20" x 4") pans, or 3 (12" x 20" x 6") pans
Dimensions	23" x 23$^{1}/_{4}$" x 30"(w×d×h)

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 ±5°F. All test apparatus were installed in accordance with Section 9 of the ASTM test method.[1]

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 D12 instrumented with the data acquisition system.

Figure 2-1. The D12 instrumented and ready 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.

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 D12 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 ± 0.2 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 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 ± 2°F was determined through an iterative process. Once the cook time was determined, the test was replicated a minimum of three times to minimize the uncertainty in the test results.

Red Potato Efficiency Tests

Freshly packed, size B, red potatoes (Figure 2-3) served as the second food product for steamer performance testing. Again, the D12 required 6 pans of red potatoes for a full load and a single pan for a light load. Each pan contained 8.0 ± 0.2 pounds of red potatoes.

Figure 2-3.
Red potato load.

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 using a predetermined cook time. The final temperature was determined by 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.

The ASTM results reporting sheets appear in Appendix C.

3 Results

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 D12 drew its maximum specified energy input rating of 12.0 kW.

Preheat and Idle Tests

Preheat Energy and Time

The cavity was manually filled with two and a half gallons of water at 70 ±5°F. The steamer was placed in its "Fast Cook" mode of operation and the timer turned to the "Continuous" position. Preheat was judged complete when the primary elements had cycled off, indicating a ready-to-cook state. Figure 3-1 illustrates the pre-heat and idle characteristics of the D12.

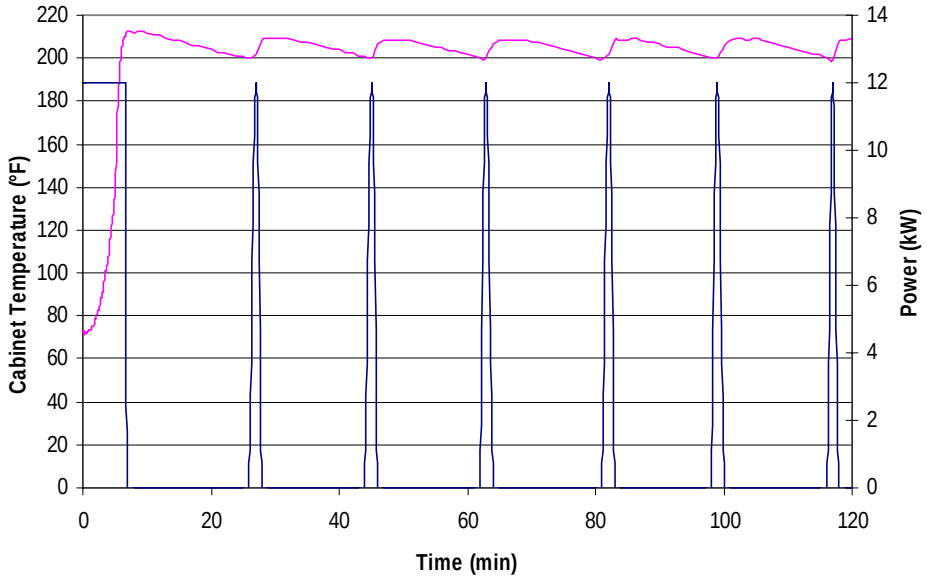

Figure 3-1. **Preheat and Idle Characteristics.**

Results

Idle Energy Rate

During the original course of testing, researchers performed the idle tests with the steamer in the "Fast Cook" mode of operation and the timer set to "Continuous". The energy consumption was monitored over a 2-hour period following an one-hour stabalization period and the idle energy rate was determined to be 1.4 kW. This result was reported in the original version of this performance report.

In an effort to optimize the D12's idle energy performance, researchers changed the control settings used in the above testing. Once again, after stabilizing for one hour, the steamer remained in the "Fast Cook" mode of operation but the timer was set to "Hold". Note: the steamer automatically enters "Hold" when time has expired if the timer function is used. Researchers monitored the energy consumption over a 2-hour period and calculated an idle energy rate of 420 W. The same idle energy rate was exhibited when the unit was placed in the "Thermostat" mode of operation and the thermostat set to 200°F with the timer turned to "Hold".

Test Results

Rated energy input, preheat energy and idle rate test results are summarized in Table 3-1. The D12 had a preheat time of 6.5 minutes, whereas the D6 required 16.2 minutes to reach full operational capacity. The D8 had a measured preheat time of 12.3 minutes. The Accutemp line of steamers utilize identical control features, therefore, both the D6 and D8 have similar idle rates to the 420 W exhibited by the D12 using the new control setting.

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

Rated Energy Input Rate (kW)	12.0
Measured Energy Input Rate (kW)	12.0
Preheat to Operational Capacity:	
Time (min)	6.5
Energy (kWh)	1.30
Idle Energy Rate (kW)[a]	1.40
Idle Energy Rate (kW)[b]	0.42

[a] Original testing data. [b] Revised testing data in the "Hold" control setting.

Results

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 of operation with the timer set in the "Continuous" position.

The AccuTemp D12 steamer does not employ a separate boiler, water connection or drain. Two and a half gallons of water were poured into the reservior at the bottom of the cooking compartment before testing began. The steamer was emptied at the end of the day, as directed by the manufacturer's instructions. Typical water usage for each cooking scenario was less than the water reservoir's 2.5-gallon capacity.

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 D12 required 22.0 minutes to cook a full load of frozen green peas and had a cooking-energy efficiency of 88.4% and a production capacity of 131 lb/h.

The light-load test required an average of 10.6 minutes when cooking a single pan of frozen green peas. Cooking energy efficiency and productivity during the light-load tests were determined to be 64.2% and 45 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 22.7 minutes to reach a bulk cooked temperature of 195 ± 2°F. The cooking-energy efficiency and production capacity was 67.5% and 130 lb/h, respectively.

The single pan of red potatoes required 21.7 minutes to achieve an average bulk temperature of 195 ± 2°F. The light-load potato test exhibited a cooking-energy efficiency of 31.2% and productivity of 23 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 extremities 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 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 D12's cooking performance.

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

	Heavy-Load	Light-Load
Number of Pans	6	1
Cook Time (min)	22.0	10.6
Cooking Energy Rate (kW)	11.5	5.5
Cooking-Energy Efficiency (%)	88.4	64.2
Production Rate (lb/h)	131	45
Energy Consumption (Btu/lb)	299	312

Results

Table 3-3. Red Potato Cooking Test Results.

	Heavy-Load	Light-Load
Number of Pans	6	1
Cook Time (min)	22.7	21.7
Cooking Energy Rate (kW)	6.2	2.4
Cooking-Energy Efficiency (%)	67.5	31.2
Production Rate (lb/h)	130	23
Energy Consumption (Btu/lb)	164	358

Heavy-load cook times and consequent production capacities were greatly improved in the Model D12 when compared to previous versions of AccuTemp's STEAM 'N' HOLD steamer. The D12 exhibited a heavy-load frozen green pea cook time of 22.0 minutes, compared to the 40.7-minute cook time of the D6 and the 30.7-minute cook time of the D8. A produciton capacity of 131 lb/h was calculated for the D12 under this cooking scenario. On the other hand, the D6 and the D8 demonstrated green pea production capacities of 71 lb/h and 94 lb/h, respectively. The D12 also exhibited faster cook times when cooking a "tough" food product like red potatoes. A 22.7-minute cook time was recorded during the D12's heavy-load potato tests, compared to 29.4 minutes for the D6 and 28.6 minutes for the D8. This led to a 130 lb/h potato production capacity for the D12 versus 98 lb/h for the D6 and 101 lb/h for the D8. Figure 3-2 compares the production capacities for the three different versions of the AccuTemp steamer.

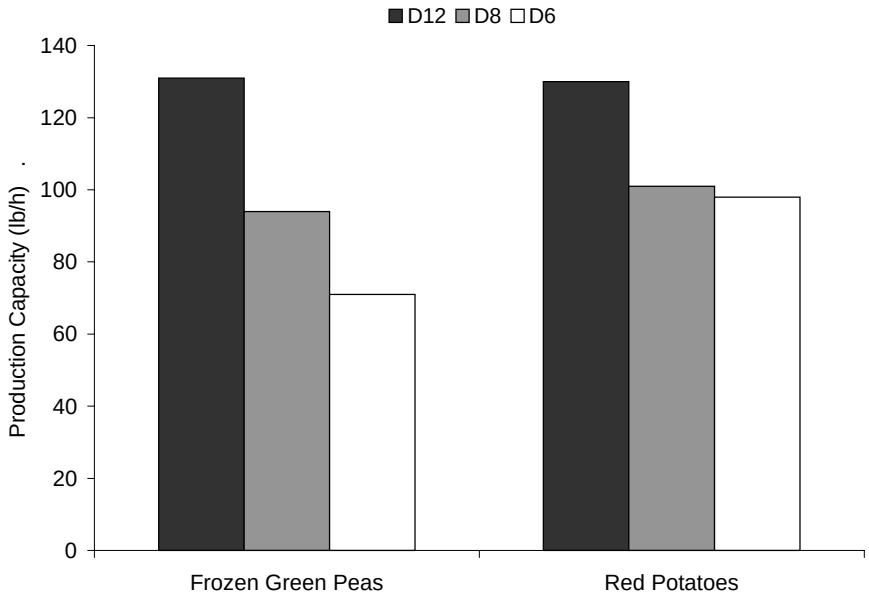

Figure 3-2. Comparison of steamer production capacities.

Light-load cook times also benefited from the D-12's increased horsepower. The D12 required a mere 10.6 minutes to cook a single pan of frozen green peas, whereas the D6 needed 11.9 minutes and the D8 11.0 minutes under the same loading conditions. The light-load red potato cook time for the D12 was 21.7 minutes, while the D6 needed 26.2 minutes and the D8 required 26.1 minutes.

The D12 steamer's faster cook times were not achieved at the expense of efficiency. Cooking-energy efficiencies were comparable to the other two models. Each unit demonstrated an 88% cooking-energy efficiency while cooking a heavy-load of frozen green peas, and 65% during the light-load pea test. Red potato cooking-energy efficiency for the three steamers was approximately 66%, and the light-load potato test yielded a 30% cooking cooking-energy efficiency for all three steamers. Figure 3-3 graphically compares the cooking-energy efficiencies of the three AccuTemp STEAM 'N' HOLD steamers.

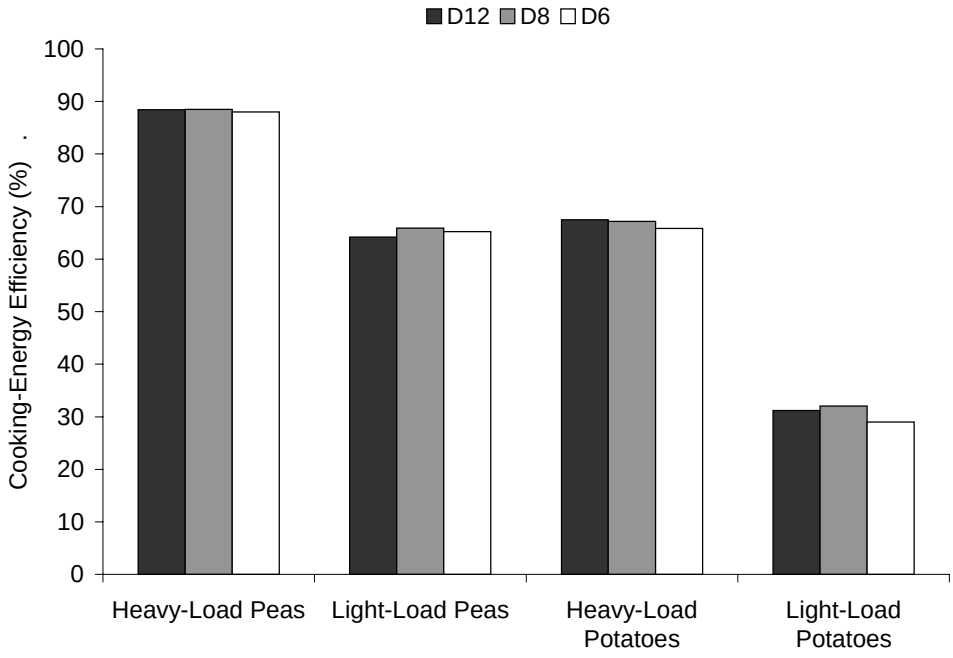

Figure 3-3. Comparison of steamer cooking-energy efficiencies.

Figure 3-4 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.

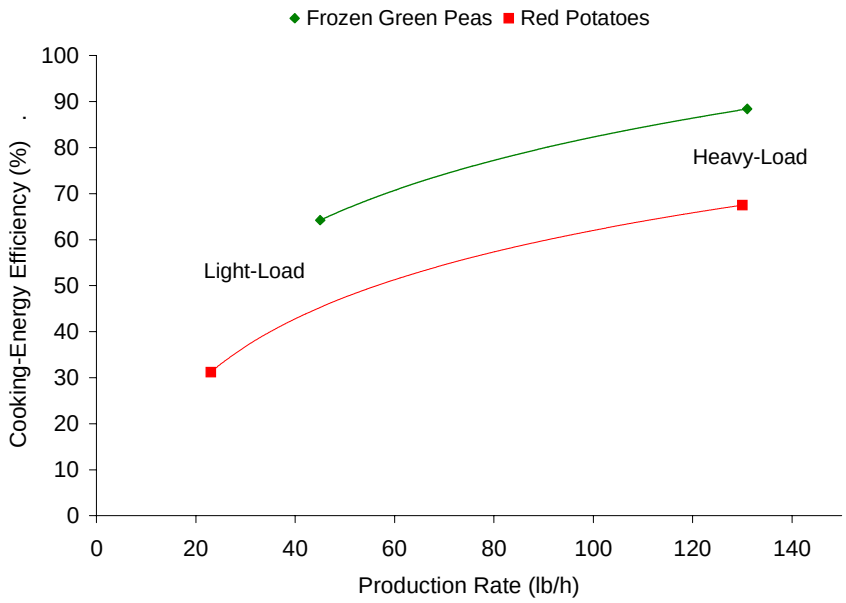

Figure 3-4. Steamer part-load cooking-energy efficiency.

Figure 3-5 illustrates the relationship between the D12 steamer's average energy consumption rate and the production rate for different types of food product. 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. 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 2.8 kW, 4.2 kW, and 6.6 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 2.8 kW.

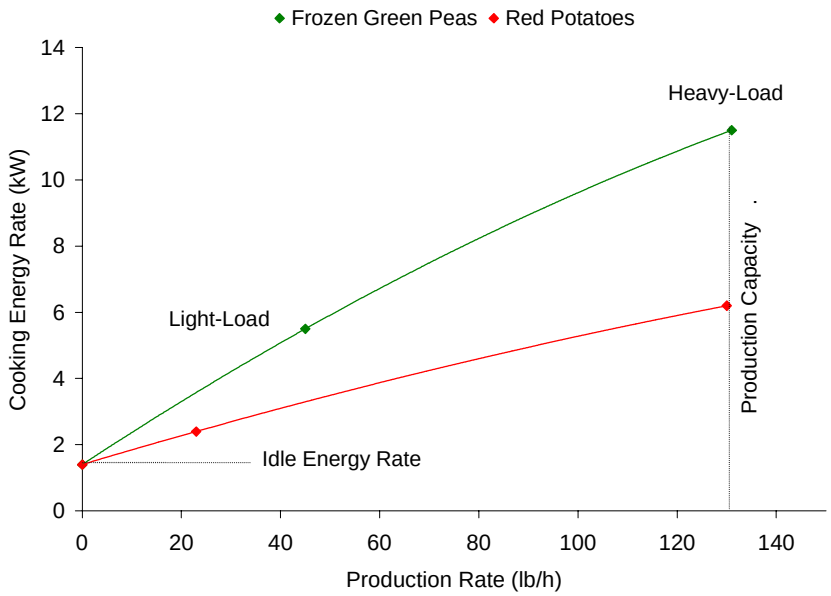

Figure 3-5.
Steamer cooking energy consumption profile.

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

4 Conclusions

The AccuTemp Model 208-D12-300 is a highly productive and energy efficient connectionless, electric steamer. With its six-pan loading capacity, the unit achieved one of the highest frozen green pea production capacities of any FSTC tested connectionless steamer (131 lb/h). Also, its 130 pounds-per-hour red potato production capacity was the highest of any connectionless steamer tested to date at the FSTC.[3–10, 15, 16] Complementing the D12's high productivity was the unit's ability to transfer the majority of its cooking energy to both of the test method's specified food product during heavy-load cooking conditions, approximately 88% to the frozen green peas and 68% to the red potatoes.

The AccuTemp steamer also was quick to achieve full operational capacity from a cold start. Only 6.5 minutes was required to preheat the cooking compartment to 212°F. With its rapid preheat time, the unit can potentially be shut off during extended periods of non-use, thus eliminating stand-by energy losses entirely.

The signature characteristic of the connectionless steamer design was the D12's negligible water consumption. For each cooking scenario, the steamer consumed less than 2.5 gallons per cooking test. On average, researchers needed only to replenish the water reservoir with a gallon of water after multiple cooking tests. Steam-generator and boiler-based units typically consume between 20 and 60 gal/h while cooking.[2, 11–14]

During the original course of testing, researchers calculated an idle energy rate of 1.4 kW when the steamer was operated in the "Fast Cook" mode with the timer set to "Continuous". The Accutemp D12's high cooking energy efficiencies, however, suggested the unit was capable of a much lower idle energy rate. Consequently, researchers re-evaluated the control settings used during the original testing and determined that the idle energy rate could be

Conclusions

significantly reduced by changing the control settings. Researchers successfully reduced the idle energy rate to 420 W by taking advantage of the steamer's "Hold" feature. Furthermore, the D12's average cavity temperature remained above 205°F during the idle period. Through minor changes in the control panel labeling and clear instructions in the appliance manual, Accutemp can ensure that end users take full advantage of the D12's low idle rate potential.

AccuTemp Products, Inc. has markedly increased the maximum production capacity of its connectionless steamer through the addition of higher input, 12-kW heating elements. The STEAM 'N' HOLD, Model 208-D12-300 offers greater productivity in the same platform of earlier models and maintains the same, high cooking energy efficiencies as well. Operators will find the D12 a qualified candidate that can satisfy menu demands with its high productivity, while minimizing utility costs.

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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 preheat.

Frozen Green Peas Load

12 x 20 x 2½ in. hotel pan filled with 8.0 ± 0.2 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/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-energy efficiency and production capacity 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 (ASTM F1217-92 Classification Type II).

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

Glossary

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 STEAM 'N' HOLD, Model 208-D12-300 steamer.

C Results Reporting Sheets

Manufacturer: AccuTemp
Model: STEAM 'N' HOLD, 208-D12-300
Date: January 2002

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: Approximately 2.5 gallons of water is manually poured in the bottom of the cooking compartment. Upon starting the preheat, a pump draws a vacuum within the stainless-steel chamber to reduce vapor pressure, inducing quicker steam generation. Food is cooked with natural-convection steam to a desired temperature and held until ready to be served.

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 10-seconds 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.

Energy Input Rate

Test Voltage	208 V
Measured	12.0 kW
Rated	12.0 kW
Percent Difference between Measured and Rated	0.0%

Appliance Preheat Energy Consumption and Duration

Test Voltage	208 V
Energy Consumption	1.3 kWh
Duration	6.53 min

Appliance Idle Energy Rate (Original Testing)

Test Voltage	208 V
Idle Energy Rate	1.4 kW

Appliance Idle Energy Rate (Revised Testing)

Test Voltage	208 V
Idle Energy Rate	0.4 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	22.0 min
Cooking-Energy Efficiency	88.4 ±0.6%
Cooking Energy Rate	11.5 ± 0.2 kW
Production Capacity	130.9 ±0.0 lb/h
Water Consumption Rate	< 2.5 gal/h

Light-Load:

Test Voltage	208 V
Cooking Time	10.6 min
Cooking-Energy Efficiency	64.2 ±2.5%
Cooking Energy Rate	5.5 ± 0.1 kW
Production Rate	45.1 ± 0.5 lb/h
Water Consumption Rate	< 2.5 gal/h

Results Reporting Sheets

<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	22.7 min
Cooking-Energy Efficiency	67.5 ±1.4%
Cooking Energy Rate	6.2 ± 0.2 kW
Production Capacity	129.6 ± 4.8 lb/h
Water Consumption Rate	< 2.5 gal/h

Light-Load:	
Test Voltage	208 V
Cooking Time	21.7 min
Cooking-Energy Efficiency	31.2 ± 2.0%
Cooking Energy Rate	2.4 ± 0.1kW
Production Capacity	24.1 ± 0.3 lb/h
Water Consumption Rate	< 2.5 gal/h

D Cooking-Energy Efficiency Data

Table D-1. Preheat and Idle Data (Original Testing)

	Replication 1	Replication 2	Replication 3
Measured Values			
Preheat Time (min)	**6.50**	**6.67**	**6.42**
Preheat Energy (kWh)	**1.28**	**1.32**	**1.28**
Idle Time (min)	120.00	120.00	120.00
Idle Energy (kWh)	2840.00	2860.00	2880.00
Calculated Values			
Preheat Energy Rate (kW)	11.82	11.88	11.97
Idle Energy Rate (kW)	**1.42**	**1.43**	**1.44**

Table D-2. Idle Data (Revised Testing)

Calculated Values	Replication 1	Replication 2	Replication 3
Idle Energy Rate (kW)	**0.41**	**0.41**	**0.43**

Cooking-Energy Efficiency Data

Table D-3. Heavy-Load Peas Data

	Replication 1	Replication 2	Replication 3
Measured Values			
Number of Pan(s)	6	6	6
Cook Time (min)	**22.00**	**22.00**	**22.00**
Initial Water Temperature (°F)	46.2	45.8	42.7
Final Water Temperature (°F)	100.2	99.7	97.4
Frozen Food Temperature (°F)	-4.4	-4.4	-4.4
Weight of Empty Calorimeter (lb)	44.7	44.7	44.8
Weight of Full Calorimeter (lb)	152.3	152.6	152.8
Weight of Calorimeter Water (lb)	60.1	60.0	60.1
Weight of Cooked Food (lb)	47.5	47.9	47.9
Weight of Frozen Food (lb)	48.0	48.0	48.0
Weight of Stainless-Steel Pans (lb)	16.8	15.3	16.4
Moisture Content (%)	81	81	81
Condensate Temperature (°F)	n/a	n/a	n/a
Water Consumption (gal/h)	<2.5	<2.5	<2.5
Calculated Values			
Moisture Weight in Green Peas (lb)	38.9	38.9	38.9
Final Food Temperature (°F)	180.7	179.3	178.3
Cooking Energy (kWh)	4.24	4.20	4.18
Energy Consumed by Green Peas (Btu)	12,417	12,358	12,318
Energy to Food (Btu/lb)	**258.7**	**257.5**	**256.6**
Energy Consumed by Pans (Btu)	341.6	307.5	329.5
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	14,471	14,335	14,266
Energy to Steamer (Btu/lb of food cooked)	301.5	298.6	297.2
Cooking Energy Rate (kW)	**11.6**	**11.5**	**11.4**
Productivity (lb/h)	**130.9**	**130.9**	**130.9**
Energy Efficiency (%)	**88.2**	**88.4**	**88.7**

Cooking-Energy Efficiency Data

Table D-4. Light-Load Peas Data

	Replication 1	Replication 2	Replication 3
Measured Values			
Number of Pan(s)	1	1	1
Cook Time (min)	**11.00**	**10.92**	**10.75**
Initial Water Temperature (°F)	49.7	47.5	45.4
Final Water Temperature (°F)	84.2	82.4	77.7
Frozen Food Temperature (°F)	-4.4	-4.4	-4.4
Weight of Empty Calorimeter (lb)	44.4	44.5	44.2
Weight of Full Calorimeter (lb)	72.4	72.3	72.2
Weight of Calorimeter Water (lb)	20.0	20.0	20.0
Weight of Cooked Food (lb)	8.0	7.8	8.0
Weight of Frozen Food (lb)	8.0	8.0	8.0
Weight of Stainless-Steel Pans (lb)	3.2	2.8	2.4
Moisture Content (%)	81	81	81
Condensate Temperature (°F)	n/a	n/a	n/a
Water Consumption (gal/h)	< 2.5	< 2.5	< 2.5
Calculated Values			
Moisture Weight in Green Peas (lb)	6.5	6.5	6.5
Final Food Temperature (°F)	179.1	179.8	181.3
Cooking Energy (kWh)	0.98	0.96	0.96
Energy Consumed by Green Peas (Btu)	2,058	2,063	2,074
Energy to Food (Btu/lb)	**257.2**	**257.9**	**259.3**
Energy Consumed by Pans (Btu)	48.4	56.9	49.1
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	3,345	3,277	3,277
Energy to Steamer (Btu/lb of food cooked)	418.1	415.9	409.6
Cooking Energy Rate (kW)	**5.5**	**5.4**	**5.4**
Productivity (lb/h)	**45.0**	**45.4**	**45.0**
Energy Efficiency (%)	**63.0**	**64.7**	**64.8**

Cooking-Energy Efficiency Data

Table D-5. Heavy-Load Potatoes Data

	Replication 1	Replication 2	Replication 3
Measured Values			
Number of Pan(s)	6	6	6
Cook Time (min)	**23.00**	**22.25**	**22.75**
Temperature of Uncooked Potatoes (°F)	73.4	74.0	72.0
Temperature of Cooked Potatoes (°F)	195.0	197.0	195.0
Weight of Stainless-Steel Pans (lb)	17.38	15.88	17.37
Weight of Potatoes (lb)	48.96	48.80	49.06
Total Potato Count	284	283	291
Moisture Content (%)	84	84	84
Condensate Temperature (°F)	n/a	n/a	n/a
Water Consumption (gal/h)	<2.5	<2.5	<2.5
Calculated Values			
Moisture Weight in Potatoes (lb)	41.16	41.02	41.24
Average Weight of Each Potato (lb)	0.17	0.17	0.17
Cooking Energy (kWh)	2.34	2.36	1.92
Energy Consumed by Potatoes (Btu)	5,257	5,154	5,182
Energy to Food (Btu/lb)	**107.4**	**105.6**	**105.6**
Energy Consumed by Pans (Btu)	235.19	211.36	231.23
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	8,055	7,986	8,055
Energy to Steamer (Btu/lb of food cooked)	164.5	163.6	164.2
Cooking Energy Rate (kW)	**6.16**	**6.31**	**6.22**
Productivity (lb/h)	**127.7**	**131.6**	**129.4**
Energy Efficiency (%)	**68.2**	**67.2**	**67.2**

Cooking-Energy Efficiency Data

Table D-6. Light-Load Potatoes Data

	Replication 1	Replication 2	Replication 3
Measured Values			
Number of Pan(s)	1	1	1
Cook Time (min)	**22.00**	**21.50**	**21.50**
Temperature of Uncooked Potatoes (°F)	72.6	72.0	72.0
Temperature of Cooked Potatoes (°F)	195.0	195.0	195.0
Weight of Stainless-Steel Pans (lb)	2.43	2.82	2.62
Weight of Potatoes (lb)	8.04	8.18	8.18
Total Potato Count	49	49	48
Moisture Content (%)	84	84	84
Condensate Temperature (°F)	n/a	n/a	n/a
Water Consumption (gal/h)	<2.5	<2.5	<2.5
Calculated Values			
Moisture Weight in Potatoes (lb)	6.76	6.88	6.88
Average Weight of Each Potato (lb)	0.16	0.17	0.17
Cooking Energy (kWh)	0.86	0.88	0.76
Energy Consumed by Potatoes (Btu)	863.33	878.36	878.36
Energy to Food (Btu/lb)	**107.4**	**107.4**	**107.4**
Energy Consumed by Pans (Btu)	32.88	38.15	35.44
Energy of Boiler Re-init (Btu)	n/a	n/a	n/a
Energy Consumed by the Steamer (Btu)	2,799	2,935	3,003
Energy to Steamer (Btu/lb of food cooked)	348.1	358.8	367.1
Cooking Energy Rate (kW)	**2.24**	**2.40**	**2.46**
Productivity (lb/h)	**21.9**	**22.8**	**22.8**
Energy Efficiency (%)	**32.0**	**31.2**	**30.4**

Cooking-Energy Efficiency Data

Table D-7. Frozen Green Pea Cooking-Energy Efficiency and Production Capacity Statistics.

	Cooking-Energy Efficiency		Production Capacity
	Heavy Load	Light Load	
Replicate #1	88.2	63.0	130.9
Replicate #2	88.4	64.7	130.9
Replicate #3	88.7	64.8	130.9
Average	**88.4**	**64.2**	**130.9**
Standard Deviation	0.25	1.01	0.00
Absolute Uncertainty	0.62	2.51	0.00
Percent Uncertainty	0.71%	3.91%	0.00%

Table D-8. Red Potato Cooking-Energy Efficiency and Production Capacity Statistics.

	Cooking-Energy Efficiency		Production Capacity
	Heavy Load	Light Load	
Replicate #1	68.2	32.0	127.7
Replicate #2	67.2	31.2	131.6
Replicate #3	67.2	30.4	129.4
Average	**67.5**	**31.2**	**129.6**
Standard Deviation	0.58	0.80	1.96
Absolute Uncertainty	1.43	1.98	4.85
Percent Uncertainty	2.12%	6.36%	3.74%