Groen HyPerSteam, Model HY-3E
Electric Steamer Performance Test

Application of ASTM Standard
Test Method F 1484-93

FSTC Report 5011.98.54

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The information in this report is based on data generated at PG&E's Food Service Technology Center.

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The establishment of a Food Service Technology Center reflects PG&E's commitment to the food service industry. The goal of the research project is to provide PG&E's customers with information to help them evaluate technically innovative cooking appliances and make informed equipment purchases regarding advanced technologies and energy sources. The project was the result of many people and department working together within PG&E and the overwhelming support of the commercial equipment manufacturers who supplied the cooking appliances for testing.

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Specific appreciation is extended to Groen, for supplying the Food Service Technology Center with the HyPerSteam, model HY-3E, electric steamer for controlled testing in the appliance laboratory.

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Executive Summary

The Groen HyPerSteam, model HY-3E, is a sturdy workhorse that is quick and energy efficient. The compact construction and powerful side-mounted blower delivers even steam distribution throughout the cavity, making the HyPerSteam flexible for various types of food product. Steam is continually fed into the cooking chamber to eliminate cavity warmup between loads. Food is cooked quickly and evenly for high energy efficiency and consistent product quality.

The Food Service Technology Center (FSTC) tested the HyPerSteam under the tightly controlled conditions of the American Society for Testing and Materials (ASTM) Standard Test Method for the Performance of Steam Cookers.[1] Steamer performance is characterized by preheat energy consumption and duration, idle energy rate, cooking energy efficiency, production capacity, water consumption and condensate temperature from product testing.

Beside the prescribed ice pan and red potato loads, the test method has been expanded to include frozen green peas as a test product. The spectrum of tests for steamers includes: full-load ice pans, full-load frozen green peas, light-load frozen green peas, full-load red potatoes, and light-load red potatoes.

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

Executive Summary

Table ES-1. Summary of Performance: Groen HyPerSteam, Model HY-3E.

Preheat and Idle	
Rated Energy Input Rate (kW)	8.0
Measured Energy Input Rate (kW)	8.3
Preheat Time (min)	5.7
Preheat Energy (kWh)	0.71
Idle Energy Rate (kW)	0.56
Full-Load Ice Pans	
Cook Time (min)	20.0
Cooking Energy Efficiency (%)	81.4
Production Capacity (lb/h)	73.6
Water Consumption Rate (gal/h)	28.3
Condensate Temperature (°F)	76.2
Full-Load Frozen Green Peas	
Cook Time (min)	15.0
Cooking Energy Efficiency (%)	82.4
Production Capacity (lb/h)	90.1
Water Consumption Rate (gal/h)	26.6
Condensate Temperature (°F)	92.6
Light-Load Frozen Green Peas	
Cook Time (min)	6.5
Cooking Energy Efficiency (%)	64.9
Water Consumption Rate (gal/h)	25.7
Condensate Temperature (°F)	100.5
Full-Load Red Potatoes	
Cook Time (min)	20.4
Cooking Energy Efficiency (%)	28.3
Production Capacity (lb/h)	70.5
Water Consumption Rate (gal/h)	27.1
Condensate Temperature (°F)	147.8
Light-Load Red Potatoes	
Cook Time (min)	17.5
Cooking Energy Efficiency (%)	11.1
Water Consumption Rate (gal/h)	22.4
Condensate Temperature (°F)	150.8

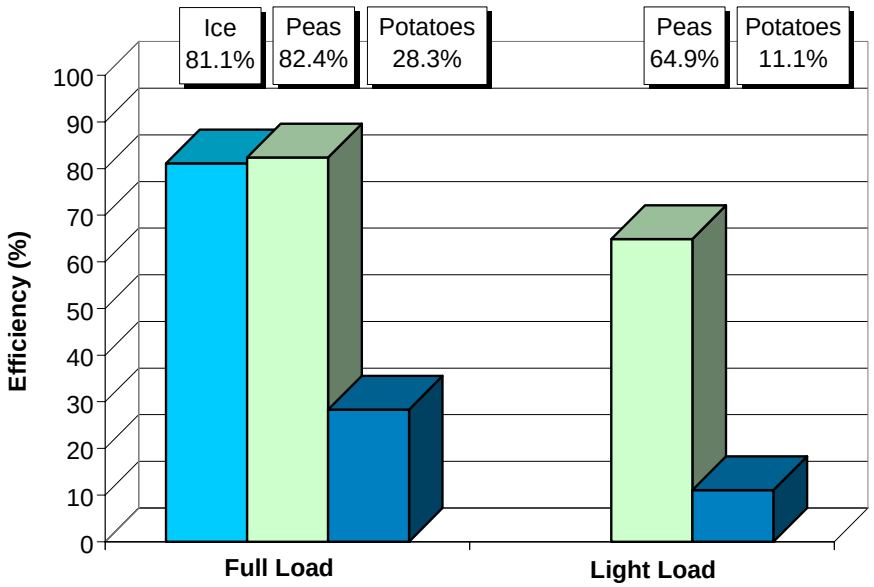

Figure ES-1.
Steamer cooking energy efficiency under two loading scenarios.

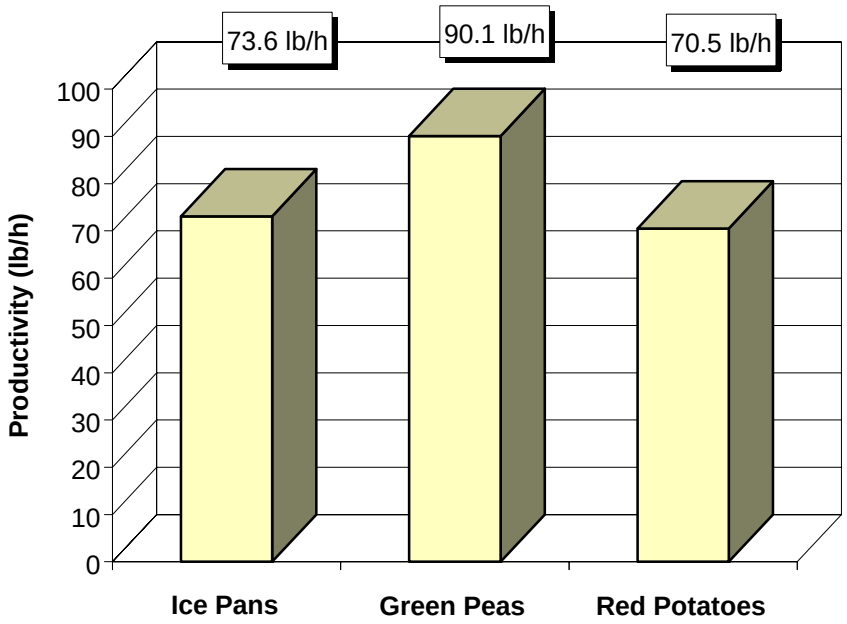

Figure ES-2.
Steamer production capacity.

Executive Summary

The Groen HyPerSteam's strongest feature is its ability to cook partial loads quickly, consistently and efficiently. The time required to cook 1 pan of frozen green peas is less than a third of the full-load cook time while retaining a respectable 64.5% efficiency. Unlike larger steamers, the well-insulated, compact design is ideal for short-order applications with varying load sizes.

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1 Introduction

Background

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

Blower increases circulation for even steam distribution. No warm-up is required between loads since the cavity and boiler are kept warm.

With support from the Electric Power Research Institute (EPRI) and the Gas Research Institute (GRI), PG&E's Food Service Technology Center (FSTC) developed a uniform testing procedure to evaluate the performance of gas and electric steamers. This test procedure was submitted to the American Society for Testing and Materials (ASTM) and accepted as a standard test method (Designation F 1484-93) in December 1993.[1] PG&E's *Development and Validation of a Uniform Testing Procedure for Steam Cooker* documents the developmental procedures and test results of several gas and electric steamers.[2]

In keeping with ASTM's policy that a standard be periodically reviewed, the FSTC is in the process of revising the steamer test method. Since ice pans are not a typical product for steamer cooking, comparable food products are being investigated. In addition to the ice pans and red potatoes specified in the test method, frozen green peas are being added as a test product.

The Groen HyPerSteam, HY-3E, is a one-compartment, 3-pan capacity, electric, atmospheric steamer that delivers 8 kW of cooking energy. A blower is used to increase circulation for even steam distribution, and no warm-up is required between loads since the cavity and boiler are kept warm. The HyPerSteam 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 Groen HyPerSteam, model HY-3E, 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 boiler.
3. Identify the idle energy rate.
4. Determine the cooking energy efficiency under 5 cooking scenarios: full-load ice pans (3 pans), 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 and the water consumption rate of each loading scenario. Measure the condensate temperature of the discharge water.

Appliance Description

The HyPerSteam is a pressureless, stainless-steel steamer powered by 8 kW electric steam generator. A side-mounted blower provides convection within the cavity for even steam distribution. The cooking chamber can accommodate six 12″ x 20″ x 1″ pans, three 12″ x 20″ x 2½″ pans, or two 12″ x 20″ x 4″ pans. During idle, the boiler maintains an incipient boil that continuously feeds steam into the cavity for instant readiness. A spray condenser converts excess steam to water and all collected condensate is discharged through a rear drain.

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

Introduction

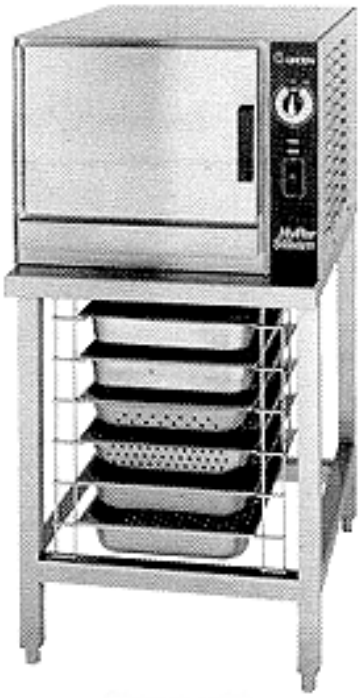

Table 1-1. Appliance Specifications.

Manufacturer	Groen, a Dover Industries Company
Model	HyPerSteam HY-3E
Generic Appliance Type	1-compartment, electric, pressureless, convection steamer
Rated Input	8 kW
Technology	Atmospheric boiler with forced convection mechanisms
Construction	Stainless-steel exterior (cabinet and door). Polished stainless steel interior (cavities and pan support racks).
Controls	Main ON-OFF power switch. 60 minute mechanical timer with continuous steam setting.
Pan Capacity	6 (12″ x 20″ x 1″) pans or 3 (12″ x 20″ x 2½″) pans or 2 (12″ x 20″ x 4″) pans
Dimensions	21 5/8 ″ x 16 ″ x 30 1/8 ″

Stand and pan racks optional

2 Methods

Setup and Instrumentation

The steamer was installed in accordance with the manufacturer's instruction on a metal table 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. 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.

A Signet MK 508 Micet Flosensor ®, using infrared sensing circuit, measured the water consumption rate. The flow meter was connected to the data acquisition unit and recorded pulses at 5-second intervals. Prior to the test, the sensor was calibrated to ensure linearity and repeatability. Figure 2-1 shows the HyPerSteam instrumented with the data acquisition system and voltage regulator.

Figure 2-1.
The HyPerSteam instrumented for testing.

Revisions to the ASTM Test Method

The ice-load test, due to its simplicity, repeatability, and reproducibility, was applied during the developmental phase of the test procedure as a quick indicator of steamer efficiency and productivity. However, ice-load test results do not always mirror the results of food products, particularly with respect to real-world cook times and associated production capacities. The revision to the ASTM steamer test method will list the ice-load test as an optional procedure.

The potato tests remain in the test method with two modifications. The method specified whole, U.S. No. 1, size B, red potatoes with an average weight of 0.14 ± 0.02 lb. Present tests showed a higher average weight of around 0.16 lb. The new method will call for red potatoes weighing 0.16 ± 0.02 lb. The prescribed cook temperature of 205°F is high since the maximum attainable temperature of steam under atmospheric pressure is 212°F. Qualitative tests, using texture, taste, and consistency as criteria, showed that potatoes are cooked to an acceptable doneness at 195°F. The temperature of 195 ± 2°F will be adopted as the potato cook temperature.

The three-loading scenarios described in the test method have been reduced to two scenarios (full- and light-load tests). The full-load test determines the steamer's peak cooking energy efficiency and production capacity while the light-load test (1 pan) evaluates partial-load performance.

Full- and light-load tests of frozen green peas are being incorporated into the ASTM test method as a replacement for the ice-load tests. Since probing proves difficult and erroneous in measuring temperature of the small-sized green peas, a calorimeter was utilized to measure the final bulk temperature of the cooked green peas. The construction, test procedures, calculation and reporting of the green pea loads involving the calorimeter is listed in Appendix E of this report. Figure 2-2 shows the spectrum of products tested on the HyPerSteam: ice pans, frozen green peas, and red potatoes.

Figure 2-2.
Products for steamer tests: ice pans, frozen green peas, and red potatoes.

Measured Energy Input and Idle Rate

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

Ice-Load Efficiency Tests

Standard, solid, stainless-steel hotel pans (12″ x 20″x 2½″) provided the vessel for ice-pan testing. The bulk temperature was measured with a type-T thermocouple probe welded to the center of the pan with the tip of the probe $^{5}/_{8}$″ from the bottom (see Figure 2-3, next page).

Eight pounds of water (± 0.2 lb) were placed into each thermocoupled pan and frozen to 0 ± 5°F. Ice pans were loaded according to the loading scenario outlined in the ASTM test method (Table 1). Ice/water temperatures, energy input rate, Watt-hours, water consumption, and condensate temperature were monitored during the "cooking" process. The test ended when the average temperature of the ice pans reached 180°F.

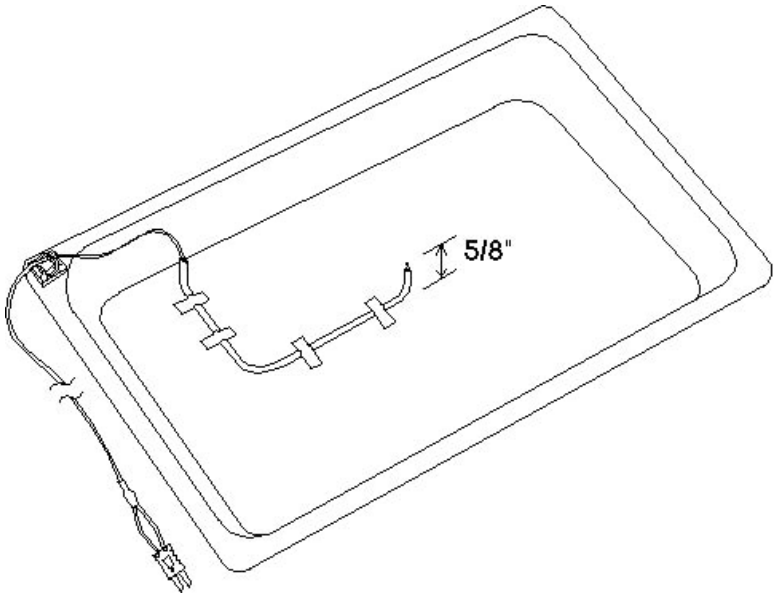

Figure 2-3.
Hotel pan with thermocouple probe for bulk temperature determination.

Green Pea Light- and Full-Load Efficiency Tests

Individually flashed-frozen, grade A green peas represented one of two food products for steamer performance testing. Standard, perforated, stainless-steel hotel pans (12″ x 20″ x 2½″) are specified for cooking the green peas. The HyPerSteam required 3 pans of green peas for a full load, while 1 pan, placed on the center rack of the cavity, is required for a light load, each pan containing 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 to ensure temperature uniformity. 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]

Red Potatoes Light- and Full-Load Efficiency Tests

Freshly packed, size B, red potatoes served as the second food product for steamer performance testing. Again, the HyPerSteam HY-3E 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.

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 cooked to 195°F using a predetermined cook time. The final bulk temperature was determined by randomly probing potatoes using a hand-held digital thermocouple meter within 3 minutes after cooking was terminated.

For the food-load scenarios, iterative cooking time determination tests were required to establish the time necessary for the food product to reach the doneness temperature of 180 ± 2°F (for frozen green peas) and 195 ± 2°F (for red potatoes). The HyPerSteam was tested in the following sequence: three replicates of the full-load ice test, three replicates of the full-load green pea test, three replicates of the light-load green pea test, three replicates of the full-load red potato test, and three replicates of the light-load red potato test.

The replicates ensured that the reported cooking energy efficiency and production capacity results had an uncertainty of less than ±10%. The results from each test run were averaged, and the absolute uncertainty was calculated based on the standard deviation of the results.

The ASTM results reporting sheets appear in Appendix C, and the cooking energy efficiency data sheets appear in Appendix D.

3 Results

Energy Input Rate

The energy input rate was measured and compared with the manufacturer's nameplate value prior to any testing to ensure that the steamer was operating within its specified parameters. The maximum energy input rate was 8.3 kW, 3.8% higher than the nameplate rate of 8.0 kW, but within the 5% tolerance of the ASTM standard.

Preheat and Idle Tests

Preheat Energy and Time

Water filled the boiler during the initial 30 seconds of operation with the boiler preheat beginning immediately afterward. The boiler consumed 0.71 kWh during the 5.2 min of preheat. The preheat time, including the time required to fill the boiler, was 5.7 min.

Idle Energy Rate

The steamer was allowed to stabilize for one hour following the preheat. Thereafter, the energy consumption rate was monitored over a 2-hour period and the boiler idle energy rate was found to be 0.56 kW.

Test Results

Figure 3-1 shows the energy input rate in conjunction with the steamer cavity temperature during the preheat and idle test. During idle period, the cavity temperature was maintained at approximately 210°F due to the "instant steam" feature which continually bleeds steam into the compartment of the HyPerSteam.

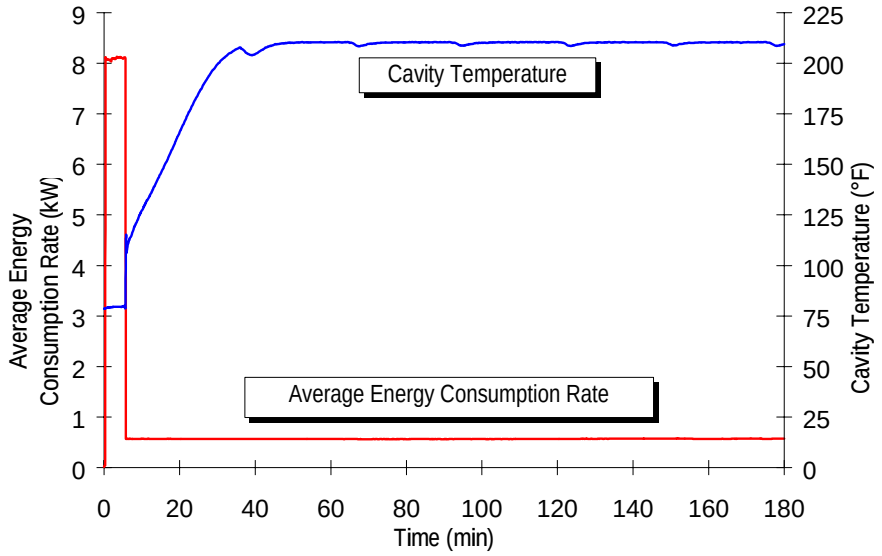

Figure 3-1. Preheat and idle characteristics.

Rated energy input, preheat energy and idle rate test results are summarized in Table 3-1.

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

Rated Energy Input Rate (kW)	8.0
Measured Energy Input Rate (kW)	8.3
Preheat	
Time (min)	5.7
Energy (kWh)	0.71
Idle Energy Rate	
Energy Rate (kW)	0.56

Cooking Tests

The steamer was tested with two food 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 optional full-load ice pan test was also performed for comparison purposes with previous data published by the FSTC. The energy consumption, cook time, product and condensate temperatures, and water consumption rate were monitored for the duration of each test at five-second intervals.

Full-Load Ice-Pan Test

The ice-pan test was intended to emulate cooking frozen vegetables, while better meeting three essential testing criteria (repeatability, reproducibility, and simplicity). Figure 3-2 illustrates the typical temperature profile of the ice pans and the steamer cavity. The HyPerSteam heated the ice pans to 180°F with a cooking time of 20 minutes, while delivering 81.4% cooking efficiency and 73.6 lb/h production capacity. The steamer consumed 28.3 gal/h of water with a condensate temperature of 76.2°F.

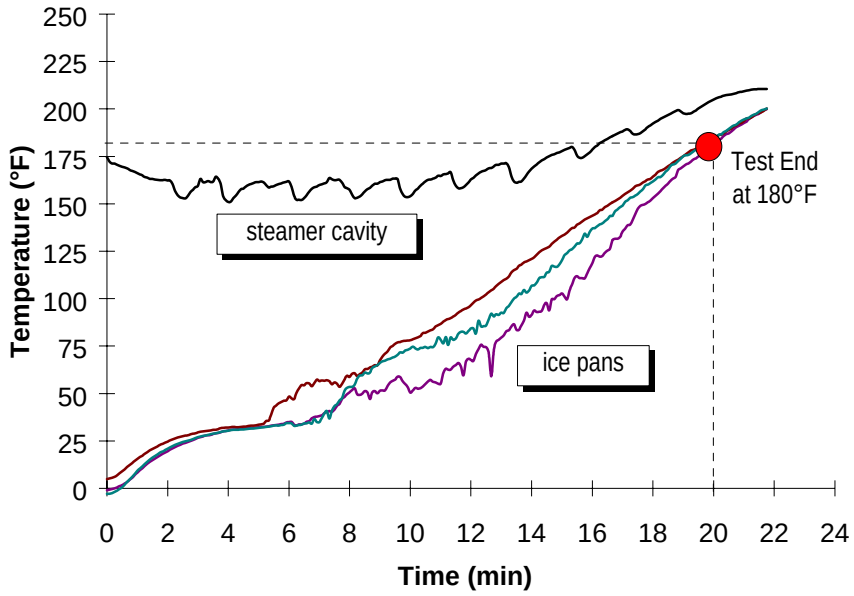

Figure 3-2.
Temperature profiles of ice pans and steamer cavity during a full-load ice-pan test.

Full- and Light-Load Green Peas Test

Moisture content of the green peas was 81% by weight corresponding to specific heats (Cp) of 0.44 Btu/lb°F for frozen and 0.85 Btu/lb°F for thawed peas.[3] The HyPerSteam required 15 minutes to cook the full load of frozen green peas with a cooking energy efficiency of 82.4% and production capacity of 90.1 lb/h. The steamer consumed water at a rate of 26.6 gal/h and expelled condensate water at a temperature of 92.6°F.

Typically, steamers are not loaded to full capacity. The light-load test emulates such a cooking scenario with a single pan of frozen green peas placed in the middle rack of the compartment. The cooking time was reduced to 6.5 minutes with cooking efficiency and productivity of 64.9% and 68.8 lb/h, respectively. The water consumption rate remained nearly the same at 25.7 gal/h, with the condensate water temperature slightly higher at 100.5°F.

Full- and Light-Load Potatoes Test

The red potatoes contained 84% moisture by weight with the specific heat (Cp) of 0.87 Btu/lb°F.[3] The full-load potato test required 20.4 minutes to reach the average bulk cook temperature of 196°F, with potato temperature ranging from 184-204°F. The cooking efficiency and productivity are reduced to 28.3% and 70.5 lb/h, respectively, due to the slow-to-cook nature of potatoes . The steamer consumed water at a rate of 27.1 gal/h and discharged condensate at 147.8°F.

A single pan of red potatoes required 17.5 minutes to achieve an average bulk temperature of 197°F with potato temperatures ranging from 187-205°F. As expected, the light-load potato test resulted a lower cooking energy efficiency of 11.1% and productivity of 27.3 lb/h. Water consumption was 22.4 gal/h and the condensate temperature was 150.8°F.

Figures 3-3 and 3-4 show the temperature distribution of the potatoes that were randomly probed for the full- and light-load tests. The 195 ±10°F temperature range is remarkable since ±20°F is common in some steamers.

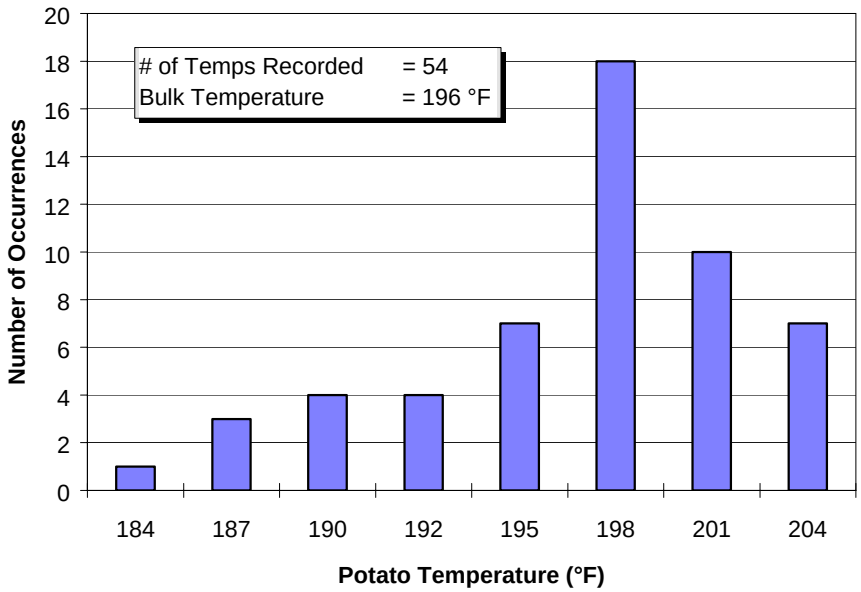

Figure 3-3.
Temperature distribution of potatoes in a full-load test.

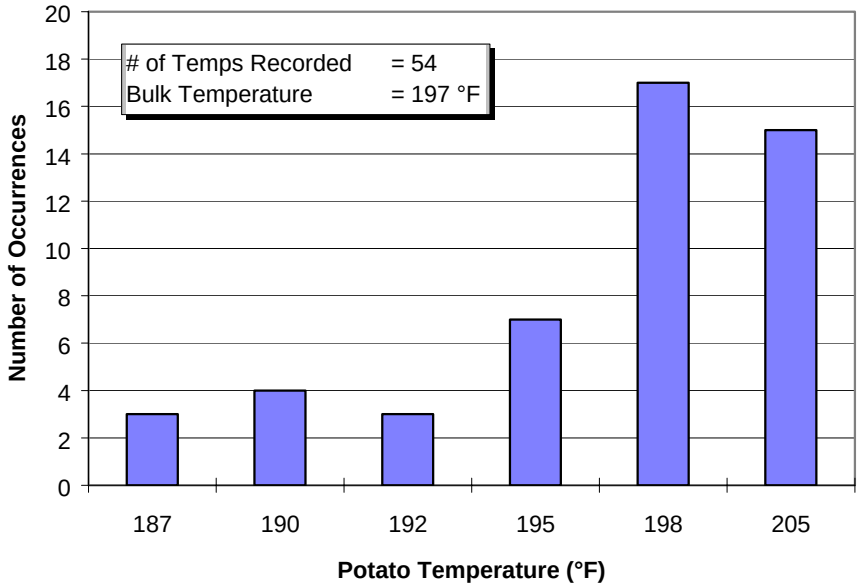

Figure 3-4.
Temperature distribution of potatoes in a light-load test.

Test Results

Cooking energy efficiency is defined as the quantity of energy consumed by the product expressed as a percentage of energy consumed by the steam cooker during the cooking event. The mathematical expression is therefore:

$$\text{Cooking Energy Efficiency \%} = \frac{E_{product}}{E_{steamer}} \times 100\%$$

Energy imparted into the cooked product is calculated by separating its various components. Since products must be cooked in stainless-steel hotel pans, the pan energy consumption is factored into the total energy equation. Ice-load consumption energy is defined as the energy consumed by the stainless-steel pans, heating of ice to 32°F, melting ice to water at 32°F, and heating the water to 180°F. The total energy consumption equation is:

$$E_{ice\ load} = E_{(heat\ pans)} + E_{(heat\ ice)} + E_{(melt\ ice)} + E_{(heat\ water)}$$

Frozen green peas follow similar calculations with several modified terms. The heat capacity changes as it transforms frozen green peas to a thawed state:

$$E_{green\ peas} = E_{(heat\ pans)} + E_{(heat\ frozen\ peas)} + E_{(melt\ ice)} + E_{(heat\ thawed\ peas)}$$

Steaming fresh red potatoes does not involve a phase change (ie. ice to water, frozen to thawed); therefore, the energy consumption is simplified to heating of the pans and the potatoes:

$$E_{red\ potatoes} = E_{(heat\ pans)} + E_{(heat\ potatoes)}$$

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.

The rate at which steam condenses on food depends on the surface temperature and area of the food; therefore, frozen green peas (0°F) and red potatoes (room temperature) represent two extremities in steam cooking. Frozen green peas, having large surface area to weight ratio, promote condensation. The energy transfer from steam to frozen food is high, resulting in greater cooking efficiency and productivity. Potatoes are tough to cook due to the slow nature of condensation. Steam that fails to condense on the potatoes goes unused and the energy wasted down the drain, thus reducing efficiency and productivity. For both the full- and light-load scenarios, approximately 54% reduction in steamer cooking efficiencies were observed when comparing frozen green peas to fresh red potatoes: full load (82.4% - 28.3% = 54.1%) and light load (64.9% - 11.1% = 53.8%).

The condensate temperature is affected by the amount of steam that is forced into the drain. The frozen products (ice pans and frozen green peas) discharge condensate water at lower temperatures due to their high condensation rates: 76.2°F for full-load ice pans, 92.6°F for full-load green peas, and 100.5°F for light-load green peas. The fresh red potatoes discharge condensate water at higher temperatures: 147.8°F for full-load potatoes and 150.8°F for light-load potatoes.

Table 3-2 and 3-3 summarize the HyPerSteam's performance under the strict ASTM test method. Figures 3-5 and 3-6 illustrate these results in graphical format.

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

	Full Ice Pans	Full Pea Load	Light Pea Load	Full Potato Load	Light Potato Load
Number of pans	3	3	1	3	1
Cook Time (min)	20.0	15.0	6.5	20.4	17.5
Energy Rate (kW)	8.3	8.4	8.3	8.4	8.3
Energy Efficiency (%)	81.4	82.4	64.9	28.3	11.1
Production Rate (lb/h)	73.6	90.1	68.8	70.5	27.3

Table 3-3. Water Consumption and Condensate Temperature Test Results.

	Full Ice Pans	Full Pea Load	Light Pea Load	Full Potato Load	Light Potato Load
Water Consumption (gal/h)	28.3	26.6	25.7	27.1	22.4
Condensate Temperature (°F)	76.2	92.6	100.5	147.8	150.8

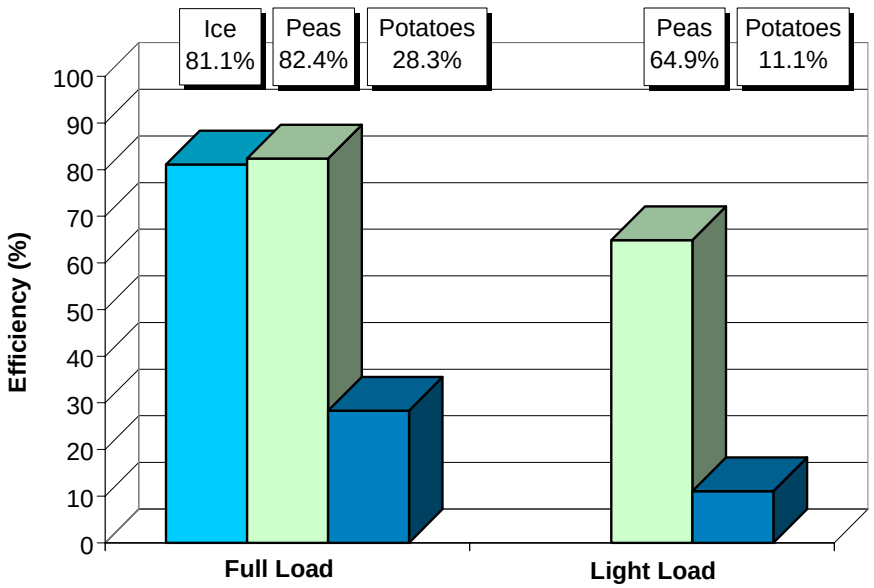

Figure 3-5.
Cooking energy efficiencies of various loading scenarios.

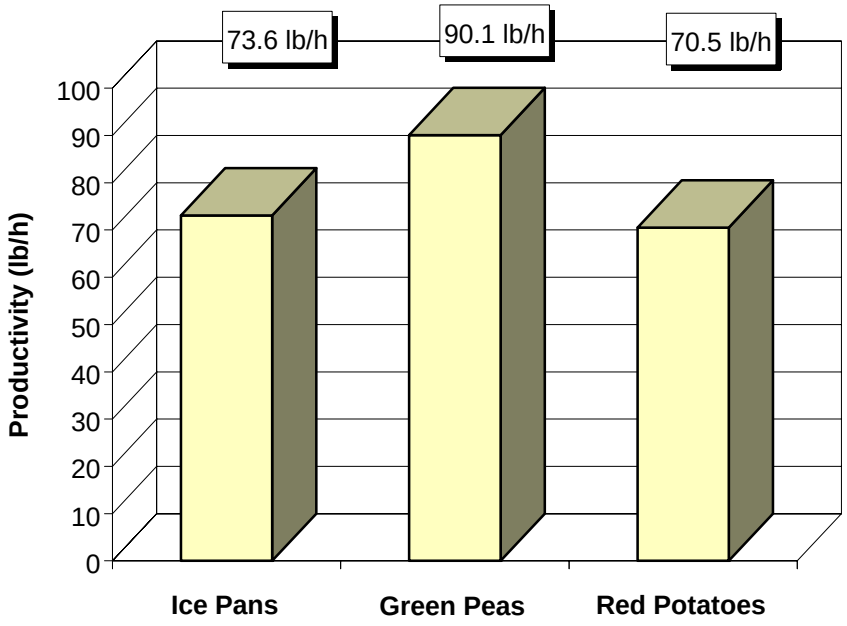

Figure 3-6.
Full-load production capacities of tested products.

4 Conclusions

The HyPerSteam's strongest feature is its ability to cook partial loads quickly, consistently and efficiently.

The Groen HyPerSteam, model HY-3E, steamer performed well under the rigorous conditions of the ASTM standard test method. Its 81.4% full-load ice-pan efficiency is the highest amongst the electric steamers tested at the FSTC during the development of the test procedure.[2] Considering its 3-pan capacity and 8.0 kW input rate, the HyPerSteam's 73.6 lb/h ice-pan production rate compares well with those having twice the capacity and energy input rate.

Since the HyPerSteam is the first to undergo testing using the revised procedures to the ASTM test method, direct comparisons for the frozen green peas and the red potatoes with other steamers are not available. However, the high performance of the HyPerSteam is evident. When cooking frozen green peas, the HyPerSteam delivered 82.4% cooking energy efficiency, higher than the full-load ice-pan efficiency. The 28.3% cooking efficiency for full-load red potatoes is exceptional since potatoes are slow to cook.

The Groen HyPerSteam's strongest feature, however, is its ability to cook partial loads quickly and efficiently. The time required to cook 1 pan of frozen green peas is less than a third of the full-load cook time while retaining a respectable 64.5% efficiency. Unlike larger steamers, the well-insulated, compact design is ideal for short-order applications with varying food quantities.

The Groen HyPerSteam, model HY-3E, has not been evaluated in the real-world setting at the PG&E's production test kitchen, but the performance of a similar model, HY-6E, was documented.[4] The kitchen staff found the HY-6E to be a workhorse with ease in operation and low maintenance. With similar design, construction, and quality, the HY-3E is expected to perform as well in a working kitchen.

5 References

1. American Society for Testing and Materials. 1993. *Standard Test Method for the Performance of Steam Cookers.* ASTM Designation F 1484-93, in *Annual Book of ASTM Standards,* Philadelphia: American Society for Testing and Materials.

2. Food Service Technology Center. 1995. *Development and Application of a Uniform Testing Procedure for Steam Cookers.* Report 1022.95.19. Product and Services Department. San Francisco, California: Pacific Gas and Electric Company.

3. American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc. 1994 ASHRAE Handbook. *Refrigeration Systems and Applications*. *I-P Edition*. Chapter 25: Commodity Storage Requirements. Atlanta, Georgia.

4. Food Service Technology Center. 1996. *Groen HyPerSteam, Model HY-6E, Electric Pressureless Steamer: In-Kitchen Appliance Performance Report*. Report 5011.95.23 prepared for Products and Services Department. San Francisco: Pacific Gas and Electric Company

Appendixes

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). These are used to simulate a food product load in the ice load cooking energy efficiency and production capacity test.

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

Maximum energy input rate
Measured Energy Input
Measured Peak Energy Input Rate
Peak Rate of Energy Input
Peak rate at which an appliance consumes energy.

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

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

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

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

Rated Energy Input Rate
Input Rating (ANSI definition)
Nameplate Energy Input Rate
Rated Input
The maximum or peak rate at which an appliance consumes energy as rated by the manufacturer and specified on the nameplate.

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

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

B Appliance Specifications

Appendix B includes the product literature for the Groen HyPerSteam, Model HY-3E, steamer.

HY-3E
HY-3EF

GROEN®

3-Pan Capacity Stainless Steel Pressureless Steamer

Table Top Self-Contained Electric-Heated

Short Form

Unit shall be a Groen HyPerSteam pressureless steamer Model HY-3E with self-contained, atmospheric electric- heated steam generator, per Bulletin 140802. All stainless steel construction, with powerful blower to circulate steam within cavity. Standard operating controls including:60-minute electro-mechanical timer, constant steam setting, ready light and DELIME cycle button to initiate deliming. Simple generator deliming through port on top. Door is field-reversible, with easy-open latch and hidden magnetic door switch. The atmospheric steam generator requires no pressure gauge or switches, has automatic drain and 8KW power input. Unit shall come up to steam in 8-10 minutes from a cold start, and provide warm cavity-instant steam capability. See other side for required electric, water and drain connections.
Made in the U.S.A.

Model HY-3E Shown

Description

Steamer shall be a Groen Model HY-3E stainless steel pressureless steamer with a self-contained atmospheric 8KW electric steam generator, per Bulletin 140802, as follows:

Construction

Steamer cavity and cabinet shall be all stainless steel construction, with removable right and left-side panels providing access to internal components.

Steamer door is all stainless steel with a strong continuous hinge and is field-reversible for left or right swing, door shall be air insulated and provided with a one-piece, replaceable seal. Easy-open handle and latch shall provide positive lock and seal when door is pushed or slammed shut.

Hidden magnetic door switch cuts power to blower and cuts power to generator when the door is opened. Pan support racks shall be polished stainless steel and removable for easy cleaning. A stainless steel condensate collection tray is positioned under cavity door.

Finish

Cabinet exterior, including door, shall be finished to a No. 4 uniform finish. Cavity interiors are polished stainless steel. Control panel face plates shall be smudge-resistant polyester film, ensuring maximum ease in cleaning and maintaining an attractive appearance.

UL & C.U.L. Listing

Steamer shall be UL and Canadian UL-listed.

Sanitation

Unit shall be designed and manufactured to meet NSF requirements and be NSF-listed. Unit shall allow operator to delime steam generator through access port on top, without tools or service call. Push button auto-DELIME feature is standard.

Controls

Steamer controls shall include an ON-OFF power button; 60-minute electro-mechanical timer, with continuous steam setting; and READY light which indicates when cavity is ready for steaming. Auto-DELIME button initiates deliming cycle.

Performance Features

Steamer cavity shall have a powerful side-mounted blower, which increases steam velocity and provides efficient steam distribution throughout cavity and between loaded pans. Steam generator delivers 2.6 KW power input per 2 1/2" deep steam pan.

Heat-up time to READY shall be 8-10 minutes or less under normal conditions. Cavity is kept warm and ready for instant steam between loads. No cavity warmup required, after READY light comes on.

DELIME indicator light warns operator of need to delime steam generator. Unit will shut off if water level is low. When power switch is turned OFF, unit automatically blows down the steam generator, to reduce sediment build-up.

Atmospheric Steam Generator

Unit shall have an electric-heated, rear-mounted steam generator, to provide atmospheric steam to the chamber at a temperature of approximately 212°F. Steam generator has an electric water sensor. 8KW electric heating element is replaceable from the side.

Pan Capacity

Pan Size / Type	Number
12 x 20 x 1"	6
12 x 20 x 2 1/2"	3
12 x 20 x 4"	2

Installation

Unit requires 208, 240 or 480 Volt, single or three-phase electric service. Unit requires 2 3/4" NH cold water supply lines and 1 1/2" free venting drain.

Water Supply Requirements

All steam systems are subject to contamination and failure due to mineral content found in all water supplies. To minimize service problems, a Groen PureSteem™ Water Treatment System is recommended.

Options/Accessories

- ❒ Groen PureSteem™ Water Treatment System
- ❒ Stainless steel support stand - order HY-3EF
- ❒ Pan racks for support stand
- ❒ 4" adjustable legs - order HY-3EL
- ❒ Single Water Connection (cold water)

Origin of Manufacture

Steamer shall be designed and manufactured in the United States.

Applications

Pasta
Rice
Vegetables (Fresh and Frozen)
Seafood (Fresh and Frozen)
Poultry
Potatoes
Eggs
Meats
Reheat Cook-Chill & Prepared Foods

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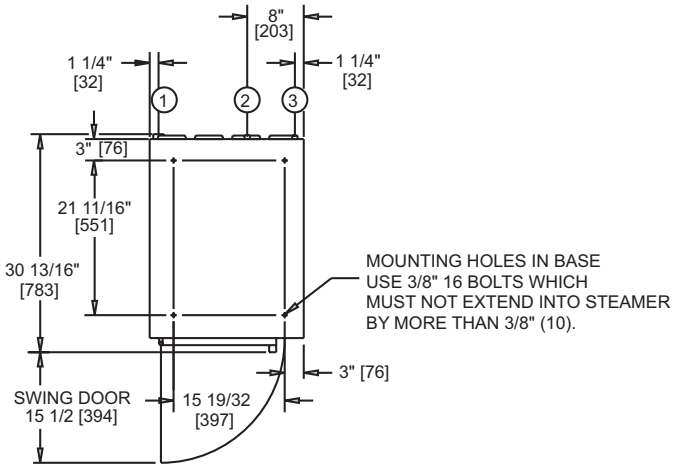
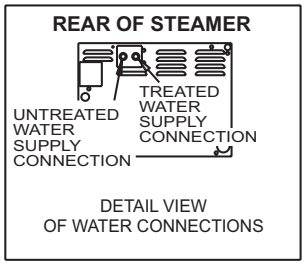
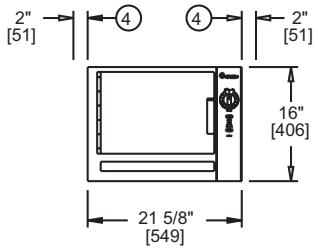
SERVICE CONNECTIONS & NOTES:

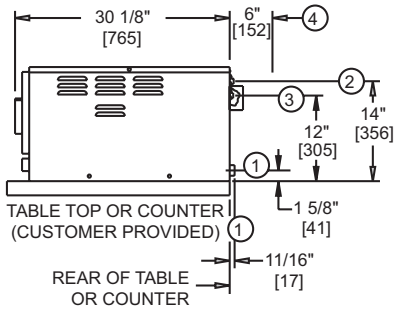
1. DRAIN CONNECTION: 1 1/2" TUBE (DRAIN FREE VENTING).
2. COLD WATER SUPPLY AT 30 TO 60 PSIG WITH A FLOW RATE OF 1.5 - 3.0 GPM AND WITH A 3/4" NH CONNECTION.
3. ONE ELECTRICAL CONNECTION: 3/4 "CONDUIT FITTING. [SEE ELECTRICAL REQUIREMENT TABLE]
4. MINIMUM SIDE AND REAR CLEARANCE.
5. DIMENSIONS IN BRACKETS [ ] ARE MM.

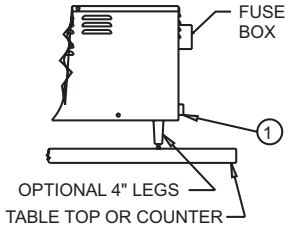
ELECTRICAL REQUIREMENTS			
VOLTAGE	PHASE	AMPS	MAX. KW
208	1	39	8
	3	23	8
240	1	33	8
	3	20	8
480	1	17	8
	3	10	8

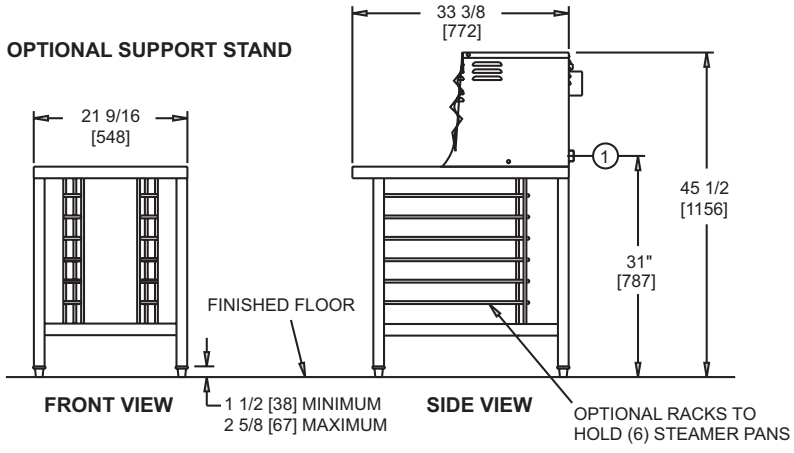












125776 Rev. C

Due to continuous product improvement, designs are subject to change without notice.

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HY-3E
HY-3EF

3-Pan Capacity
Stainless Steel
Pressureless Steamer

140802

Revised 12/02

C Results Reporting Sheets

Manufacturer:	Groen
Model:	HyPerSteam HY-3E
Date:	February, 98

Section 11.1 Test Steam Cooker

ASTM F 1216 Classification (check one for each classification)

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

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

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

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

Description of operational characteristics: Steam is circulated within the stainless steel cooking chamber by a blower. When the unit is in a stand-by condition, water in the steam generators is kept at an incipient boil. Any steam produced during stand by mode is allowed to migrate into the cooking cavity, thereby keeping it continually preheated.

Section 11.2 Apparatus

The steamer was installed on a metal table under a 4-foot-deep canopy hood that was 6 feet 6 inches above the floor. The hood operated at a nominal exhaust rate of 150 cfm per linear foot of hood. There was at least 6 inches of clearance between the vertical plane of the steamer and the edge of the hood.

The steamer was instrumented with an electric transducer to measure power and energy; and a voltage regulator was used to maintain constant voltage for all tests. All test apparatus were installed in accordance with Section 9 of the ASTM test method.

Section 11.4 Energy Input Rate

Test Voltage	208 V
Measured	8.0 kW
Rated	8.3 kW
Percent Difference between Measured and Rated	3.8 %

Section 11.5 Boiler Preheat Energy Consumption and Duration

Test Voltage	208 V
Energy Consumption	0.71 kWh
Duration	5.7 min

Section 11.6 Boiler Idle Energy Rate

Test Voltage	208 V
Idle Energy Rate	0.56 kW

Section 11.7 Ice Pans Cooking Time, Energy Efficiency, Energy Rate, Production Capacity, Water Consumption and Condensate Temperature

Full-Load:

Test Voltage	208 V
Cooking Time	20.0 min
Cooking Energy Efficiency	81.4 ± 1.9 %
Cooking Energy Rate	8.3 kW
Production Capacity	73.6 lb/h
Water Consumption Rate	28.9 gal/h
Condensate Temperature	76.2°F

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

Full Load:

Test Voltage	208 V
Cooking Time	15.0 min
Cooking Energy Efficiency	82.4 ± 1.0%
Cooking Energy Rate	8.4 kW
Production Capacity	90.1 lb/h
Water Consumption Rate	26.6 gal/h
Condensate Temperature	92.6°F

Light Load:

Test Voltage	208 V
Cooking Time	6.5 min
Cooking Energy Efficiency	64.9 ± 2.8%
Cooking Energy Rate	8.3 kW
Production Rate	68.8 lb/h
Water Consumption Rate	25.7 gal/h
Condensate Temperature	100.5°F

Section 11.9 Fresh Red Potatoes Cooking Time, Energy Efficiency, Energy Rate, Production Capacity, Water Consumption and Condensate Temperature

Full Load:

Test Voltage	208 V
Cooking Time	20.4 min
Cooking Energy Efficiency	28.3 ± 2.4%
Cooking Energy Rate	8.4 kW
Production Capacity	70.5 lb/h
Water Consumption Rate	27.1 gal/h
Condensate Temperature	147.8°F

Light Load:

Test Voltage	208 V
Cooking Time	17.5 min
Cooking Energy Efficiency	11.1 ± 0.8%
Cooking Energy Rate	8.3 kW
Production Rate	27.3 lb/h
Water Consumption Rate	22.4 gal/h
Condensate Temperature	150.8°F

D Cooking Energy Efficiency Data

Table D-1. Physical Properties.

Specific Heat (Btu/lb °F)	
Ice	0.50
Water	1.00
Stainless-Steel Pan	0.11
Frozen Green Peas	0.44
Thawed Green Peas	0.85
Fresh Red Potatoes	0.87
Latent Heat (Btu/lb)	
Fusion, Water	144

Cooking Energy Efficiency Data

Table D-2. Full-Load Ice-Pan Test Data.

Measured Values	Repetition #1	Repetition #2	Repetition #3
Number of Pan(s)	3	3	3
Cook Time (min)	20.0	20.0	20.0
Temperature of Water (°F)	180.3	180.6	180.3
Temperature of Ice Pans (°F)	3.6	0.4	0.4
Weight of Stainless-Steel-Pans (lb)	8.04	8.05	8.06
Weight of Ice (lb)	24.36	24.37	24.49
Condensate Temperature (°F)	74.9	75.2	78.4
Water Consumption (gal/h)	28.3	27.6	28.9
Calculated Values			
Cooking Energy (Wh)	2740	2790	2750
Energy Consumed by Ice Pans (Btu)	7465	7514	7546
Energy Consumed by Stainless-Steel Pans (Btu)	156.1	159.6	159.5
Energy of Boiler Re-init (Btu)	0	0	0
Energy Consumed by the Steamer (Btu)	9352	9522	9386
Cooking Energy Rate (kW)	8.2	8.4	8.4
Productivity (lb/h)	73.1	73.1	74.7
Energy Efficiency (%)	81.5	80.6	82.1

Table D-3. Full-Load Frozen Green Peas Test Data.

Measured Values	Repetition #1	Repetition #2	Repetition #3
Number of Pan(s)	3	3	3
Cook Time (min)	15.0	15.0	15.0
Initial Water Temperature (°F)	37.8	40.7	41.4
Final Water Temperature (°F)	72.9	74.7	75.2
Frozen Food Temperature (°F)	0.0	0.8	2.2
Weight of Empty Calorimeter (lb)	36.0	36.0	35.9
Weight of Full Calorimeter (lb)	119.6	119.3	119.3
Weight of Calorimeter Water (lb)	60.0	60.0	60.0
Weight of Cooked Food (lb)	23.6	23.3	23.3
Weight of Frozen Food (lb)	22.5	22.5	22.5
Weight of Stainless-Steel Pans (lb)	8.5	8.5	8.5
Moisture Content (%)	81	81	81
Condensate Temperature (°F)	91.3	93.2	93.2
Water Consumption (gal/h)	26.6	26.4	26.7
Calculated Values			
Moisture Weight in Green Peas(lb)	18.3	18.2	18.2
Final Food Temperature (°F)	178.33	177.99	177.73
Cooking Energy (Wh)	2090	2100	2090
Energy Consumed by Food (Btu)	5746.0	5719.9	5703.5
Energy Consumed by Stainless-Steel Pans (Btu)	166.0	165.3	163.7
Energy of Boiler Re-init (Btu)	0	0	0
Energy Consumed by the Steamer (Btu)	7133.2	7167.3	7133.2
Cooking Energy Rate (kW)	8.4	8.4	8.4
Productivity (lb/h)	80.2	90.0	90.0
Energy Efficiency (%)	82.9	82.1	82.3

Table D-4. Light-Load Frozen Green Peas Test Data.

Measured Values	Repetition #1	Repetition #2	Repetition #3
Number of Pan(s)	1	1	1
Cook Time (min)	6.5	6.5	6.5
Initial Water Temperature (°F)	41.3	36.9	43.6
Final Water Temperature (°F)	65.4	61.8	68.2
Frozen Food Temperature (°F)	-0.9	-1.1	-1.0
Weight of Empty Calorimeter (lb)	35.8	35.8	35.8
Weight of Full Calorimeter (lb)	73.3	73.3	73.3
Weight of Calorimeter Water (lb)	30.0	30.0	30.0
Weight of Cooked Food (lb)	7.5	7.6	7.6
Weight of Frozen Food (lb)	7.5	7.5	7.4
Weight of Stainless-Steel Pans (lb)	2.8	2.8	2.8
Moisture Content (%)	81	81	81
Condensate Temperature (°F)	100.04	99.9	101.6
Water Consumption (gal/h)	26.1	26.2	24.9
Calculated Values			
Moisture Weight in Green Peas(lb)	6.1	6.0	6.0
Final Food Temperature (°F)	178.81	178.47	183.32
Cooking Energy (Wh)	900	880	900
Energy Consumed by Food (Btu)	1909.2	1906.4	1926.8
Energy Consumed by Stainless-Steel Pans (Btu)	55.8	55.1	57.5
Energy of Boiler Re-init (Btu)	0	0	0
Energy Consumed by the Steamer (Btu)	3071.7	3003.4	3071.7
Cooking Energy Rate (kW)	8.3	8.1	8.3
Productivity (lb/h)	68.9	68.9	68.5
Energy Efficiency (%)	64.0	65.3	64.6

Table D-5. Full-Load Red Potatoes Test Data.

Measured Values	Repetition #1	Repetition #2	Repetition #3
Number of Pan(s)	3	3	3
Cook Time (min)	19.3	20.6	21.5
Temperature of Uncooked Potatoes (°F)	69.3	71.5	69.1
Temperature of Cook Potatoes (°F)	194.2	196.8	196.8
Weight of Stainless-Steel Pans (lb)	8.48	8.42	8.42
Weight of Potatoes (lb)	23.98	24.08	24.04
Total Potato Count	170	167	163
Moisture Content (%)	84.1	84.1	84.1
Condensate Temperature (°F)	148.7	145.3	149.5
Water Consumption (gal/h)	28.5	27.4	25.4
Calculated Values			
Moisture Weight in Potatoes(lb)	20.1	20.2	20.2
Average Weight of Each Potatoes (lb)	0.14	0.14	0.15
Cooking Energy (Wh)	2720	2860	2990
Energy Consumed by the Potatoes (Btu)	2605.1	2623.4	2679.8
Energy Consumed by Stainless-Steel Pans (Btu)	116.4	116.0	118.2
Energy of Boiler Re-init (Btu)	0	0	0
Energy Consumed by the Steamer (Btu)	9283.4	9761.2	10204.9
Cooking Energy Rate (kW)	8.5	8.3	8.3
Productivity (lb/h)	74.5	69.9	67.1
Energy Efficiency (%)	29.3	28.1	27.4

Table D-6. Light-Load Red Potatoes Test Data.

Measured Values	Repetition #1	Repetition #2	Repetition #3
Number of Pan(s)	1	1	1
Cook Time (min)	17.9	17.6	17.1
Temperature of Uncooked Potatoes (°F)	72.3	70.7	70.7
Temperature of Cook Potatoes (°F)	197.2	197.0	197.3
Weight of Steel Pans (lb)	2.79	2.82	2.81
Weight of Potatoes (lb)	7.96	7.96	8.01
Total Potato Count	52	53	56
Moisture Content (%)	84.1	84.1	84.1
Condensate Temperature (°F)	149.7	151.6	151.3
Water Consumption (gal/h)	22.8	22.1	22.4
Calculated Values			
Moisture Weight in Potatoes(lb)	6.7	6.7	6.7
Average Weight of Each Potatoes (lb)	0.15	0.15	0.14
Cooking Energy (Wh)	2480	2410	2390
Energy Consumed by the Potatoes (Btu)	868.0	877.4	884.9
Energy Consumed by Stainless-Steel Pans (Btu)	38.3	39.2	39.1
Energy of Boiler Re-init (Btu)	0	0	0
Energy Consumed by the Steamer (Btu)	8464.2	8225.3	8157.1
Cooking Energy Rate (kW)	8.3	8.2	8.4
Productivity (lb/h)	26.7	27.2	28.1
Energy Efficiency (%)	10.7	11.1	11.3

E Procedure for Frozen Green Pea Test

The following is a supplemental procedure to the Standard Test Method for the Performance of Steam Cooker: ASTM Destination F 1484-93. The instruction details the construction of the water-bath calorimeter and the performance testing of frozen green pea in steam cookers.

1 Apparatus

1.1 *Hotel pans,* perforated 12 x 20 x 2½ in. (300 x 500 x 65 mm) stainless steel, weighing 2.8±0.2 lb (1.3±0.1 kg).

1.2 *Water-Bath Calorimeter*, for temperature determination of the green peas load. Comprised of 5 components: Inner Container— cylindrical, 0.087-in (2.2-mm) thick walled, plastic drum. Container capacity may vary depending on the tested load. Drum insulation— R-25 fiberglass insulation. Drum Lid— plastic lid double re-enforced with 2-in (50 mm) thick polystyrene board. Stirrer— 3-ft long, 1/4-in diameter, steel rod with propeller welded to one end. Thermocouple tree— 1/4-in diameter, copper pipe with 5 temperature sensor points placed 3-in laterally apart. A convenient way to construct the water-bath calorimeter is to place the inner container on a 2-in (50 mm) thick polystyrene board. Wrap the outside of the drum with 1 ft thick R-25 fiberglass insulation so no drum wall is exposed. Cover the fiberglass insulation with plastic liner to waterproof the interior. Construct the thermocouple tree by affixing 5 type T thermocouple probes 3 inches apart along the copper pipe. Fix the thermocouple tree vertically along the drum wall as to avoid contact with the stirrer. Drill a ½-in hole in the center of the plastic/polystyrene lid. Place the propeller end of the stirrer in the drum and close the lid, allowing the opposite end of the stirrer to pass through the center of the lid. Place the water-bath calorimeter on castors for ease in mobility. During test, the content could be agitated manually or with the aid of a mechanical stirrer.

1.3 *Platform Balance Scale* or appropriate load cells, used to measure the weight of the water-bath calorimeter and content during the frozen green peas test. Shall have capacity to accommodate the total

weight of calorimeter plus the cooked food product and water. The resolution shall be 0.2 lb (10 g) and an uncertainty of 0.2 lb (10 g).

2 Green Peas Load Preparation

2.1 This section outlines preparation of the frozen green peas used in the green peas load cooking energy-efficiency and production-capacity test.

2.2 The number of green peas loads to be prepared depends on which loading scenario is to be performed. There are two loading scenarios: light and heavy. The heavy load is the manufacturer's stated capacity of 12 x 20 x 2½-in. (300 x 500 x 65-mm) hotel pans. Consult Table 1 for the number of green peas loads to prepare for the light loading scenarios.

NOTE 1—When the test calls for a less than capacity number of loads for a compartment, the loads should be placed in the most centrally located slots. When symmetry about the center is not possible, then use the upper central slots first. For example, one pan in a 4-pan capacity compartment should be located in the second slot from the top. Two loads in a 4-pan capacity compartment should be located in the second and third slots from the top (yielding symmetry about the center). One load in a 3-pan capacity compartment would be located in the center, and two loads would be located in the top and middle slots. Two pans in a 5 pan capacity compartment would be located in the second slot from the top and third slot from the top (center slot).

Table 1 Number of Loads for Light Loading Scenario

	Light Loading Scenario
1 Compartment **3 Pan Capacity**	1 Pan
1 Compartment **4 Pan Capacity**	1 Pan
1 Compartment **5 Pan Capacity**	1 Pan
1 Compartment **6 Pan Capacity**	1 Pan
2 Compartments **3 Pan Capacity Per Compartment**	1 Pan in top compartment None in bottom
2 Compartments **4 Pan Capacity Per Compartment**	1 Pan in top compartment None in bottom
2 Compartments **5 Pan Capacity Per Compartment**	2 Pans in top compartment None in bottom
2 Compartments **6 Pan Capacity Per Compartment**	2 Pans in top compartment None in bottom

	Light Loading Scenario
2 Compartments **8 Pan Capacity Per Compartment**	2 Pans in top compartment None in bottom
3 Compartments **3 Pan Capacity Per Compartment**	2 Pans in middle compartment None in top None in bottom
3 Compartments **4 Pan Capacity Per Compartment**	2 Pans in middle compartment None in top None in bottom
3 Compartments **5 Pan Capacity Per Compartment**	2 Pans in middle compartment None in top None in bottom
3 Compartments **6 Pan Capacity Per Compartment**	2 Pans in middle compartment None in top None in bottom
3 Compartments **8 Pan Capacity Per Compartment**	2 Pans in middle compartment None in top None in bottom

2.3 The perforated hotel pans shall be 12 x 20 x 2½-in. (300 x 500 x 65-mm) stainless steel, weighing 2.8±0.2 lb (1.3±0.1 kg).

2.4 Number each pan and record the weight of each of the (dry) pans. The weight of the pan(s) will be the total weight of all pan(s) used for the test.

2.5 Load each pan with 8.0 ± 0.2 lb (3.6 ± 0.1 kg) of grade A, frozen, green peas sealed in plastic zip bags. Record the weight of the frozen green peas in each pan. Place the green peas load in the freezer and allow the temperature to stabilize at 0±5°F (-18±2°C) for a 24 hour period. The weight of the frozen green peas will be the total weight of the green peas in each of the pan(s).

2.6 The water-bath calorimeter shall be as specified in 1.2. Record the weight of the empty calorimeter using the platform balance scale.

2.7 For every load of green peas, place 10 lb of potable water into the calorimeter drum. (For example, the total weight of water for a heavy load test of a six-pan capacity, steamer would be 10 lb water/pan x 6 pans = 60 lb).

2.8 Record the weight of the water in the water-bath calorimeter.

NOTE 2—The initial water temperature for the water-bath need not be 70±5°F (21±3°C). As long as the initial and final temperatures are recorded, the change in water-bath temperature can be calculated.

3 Green Peas Load Cooking Energy Efficiency, Production Capacity, Water Consumption, and Condensate Temperature

3.1 This procedure applies to two possible loading scenarios: light and heavy. Repeat each loading scenario a minimum of three times. Additional test runs may be necessary to obtain the required precision for the reported test results. The reported values of cooking energy efficiency, production capacity, condensate temperature, and water consumption shall be the average of the replications (runs).

3.2 Prepare the frozen green peas load(s) in accordance with section 2. Record the weight of the empty pan(s) and the weight of the green peas load(s).

3.3 Measure and record the average temperature of the green peas by probing the content of the sealed bags. Confirm that they are at 0±5° F (-18±3°C).

3.4 Choose a cooking time either based on the manufacturer's recommendation or by experience.

3.5 Allow the steam cooker to sit idle (boiler(s) on) for a minimum of one hour. If the manufacturer recommends leaving the cooking cavity doors open when not cooking, then leave them open during the idle period and record the door position during the idle period.

3.6 Start monitoring time. Transport the green pea loads to the testing location. Empty the zip-bagged green peas into the pan(s). Open one steam compartment, load the pan(s) into it, close it, and start steam to it. Note the starting time for that compartment. Open the next steam compartment (if applicable), empty peas into pan(s), load it, close it, start it, and note the starting time. Open, load, close, start, and note the starting time of the last compartment (if applicable). After starting steam to the first compartment, commence monitoring energy consumption, water consumption, and condensate temperature. For gas steam cookers, monitor and record the electric energy as well as gas consumption. The total loading time (the time from opening the first compartment to closing and starting the last compartment) shall be the total of 5 s per compartment plus 5 s for each load used. (For example, the total loading time for a heavy load test of a six-pan capacity, two-compartment steam cooker would be 5 s/compartment x 2 compartments + 5 s/ load x 6 loads = 40 s).

NOTE 3—Care shall be taken to minimize heat gain by the frozen green pea load(s) on the way from the freezer to the steam cooker. During that time, the load(s) shall be isolated from any warmer surface by R10 or better insulation. PG&E found 2 in (50 mm) thick square-edged polystyrene boards to be convenient as an insulating surface.

NOTE 4—For gas steamers, the "electric energy rate" during the heavy load test will be reported separately from the gas "cooking energy rate". The two values are reported separately so that the respective fuel prices may be applied to estimate energy costs.

NOTE 5—The boiler is at maximum pressure when the test starts, but it may be at a lower pressure at the end of the test. This difference between the initial and final energy content (pressure/temperature) of the boiler must be added back to the boiler to correctly calculate the energy efficiency. Maximum, minimum and final boiler pressure is measured so that this energy deficit can be estimated. There are situations where the measurement of pressure in step 3.7 is not necessary, as noted in steps 3.9 and 3.11.

NOTE 6—The average condensate temperature for the final 3 minutes of the run is what will be reported, rather than the average over the entire run; therefore, condensate temperature monitoring need not begin immediately upon commencement of the test run.

3.7 For three cycles of the boiler pressure near the end of the test, measure the maximum and minimum pressures. Record the average maximum and average minimum boiler pressure.

3.8 Terminate steam to the compartments as the predetermined cooking time elapses for each compartment. After stopping steam to the last compartment, record the final time, water consumption, and average condensate temperature.

3.9 If the boiler is on when the cooking time for the last compartment has elapsed, continue to monitor energy consumption until the primary burners, elements, or steam coils cycle off. Record final energy. Note that the initial and final energy content of the boiler is the same; therefore, the pressure measurements in step 3.7 are not needed.

3.10 If the boiler is not on when the last compartment cooking time elapsed, proceed to one of the next two conditional steps (3.11 or 3.12).

3.11 Perform this step if the boiler pressure is controlled by a pressure switch that can be manually actuated. Otherwise, proceed directly to step 3.12. When the time for the last compartment has elapsed, continue to monitor energy consumption and actuate the pressure switch.

This returns the boiler energy content to the initial test condition; therefore, the pressure measurements in step 3.7 and the energy measurements in step 10.4.2 (from the test method) are not necessary. Record the final energy.

3.12 Perform this step if the boiler pressure control cannot be manually actuated. When the cooking time for the last compartment has elapsed, record the final energy and the boiler pressure (used to calculate the energy deficit of the boiler, as described in note 5).

3.13 Record the initial temperature of the water-bath calorimeter immediately after the cook time elapsed. The unloading time shall be the same as the loading time. Remove the calorimeter lid and empty the cooked green peas load into the water-bath calorimeter. Replace the lid on the water-bath calorimeter.

3.14 Allow the contents of the water-bath calorimeter to stabilize for 5 minutes. Using the stirrer, agitate the content for 1 min. Repeat the stabilization and agitation process every 5 min until the final bulk temperature fluctuate less than ±0.1°F within a 5 min period. Record the final bulk temperature.

3.15 Record the total weight of the water-bath calorimeter containing the cooked green peas and water with the platform balance scale. This will be used to determine the thawed green peas weight.

3.16 In accordance with 4.2, calculate the final cooked bulk temperature of the green peas. The cook temperature must be 180 ± 2°F (82 ± 1°C). If the temperature does not fall in this range, the test must be repeated with an adjusted cook time.

3.17 If the temperature is within the range, prepare the next frozen green peas load (1) and the water-bath calorimeter, unless this was the final run (Run No. 3), and perform the test again (2).

3.18 Calculate the cooking energy efficiency, production capacity, water consumption, and average condensate temperature in accordance with 4.3, 4.6, 4.7, and 4.8 and report the results as the average of three replications.

4.0 Frozen Green Peas Load Cooking Energy Efficiency, Production Capacity, Water Consumption, and Condensate Temperature

4.1 Report the average value from a minimum of three test runs for frozen green peas load cooking energy efficiency, production capacity, and water consumption.

4.2 Calculate the final cooked green peas load temperature by applying the following relationship:

$$T_{peas,\ f} = \frac{W_{water} \times Cp_{water}}{W_{peas} \times Cp_{peas}} \times (T_{water,\ f} \times T_{water,\ i}) + T_{water,\ f}$$

where:

W_{water} = weight of water in water-bath calorimeter, lb
Cp_{water} = specific heat of water, Btu/lb°F
= 1 Btu/lb°F
W_{peas} = weight of cooked green peas load, lb
= $W_{full\ calorimeter} - W_{calorimeter} - W_{water}$
$T_{water,\ i}$ = initial water temperature in water-bath calorimeter, °F
$T_{water,\ f}$ = final equilibrium temperature of water and cooked green peas mixture in water-bath calorimeter, °F
$Cp_{peas,thawed}$ = specific heat of thawed green peas, Btu/lb°F
= 0.84 Btu/lb°F

4.3 Calculate the green pea load cooking energy efficiency according to the following relationship:

$$\eta_{peas} = \frac{E_{peas} + E_{pan} + E_{boiler\ re\ -\ init}}{E_{steam\ cooker}} \times 100\%$$

where:

η_{cpeas} = cooking energy efficiency (%)

E_{peas} = heat gained by the green peas load

= $[W_{peas,frozen} \times Cp_{peas,frozen} \times \Delta T_{peas,frozen}] + [W_{peas,thawed} \times Cp_{peas,thawed} \times \Delta T_{peas,thawed}] + [W_{moisture} \times E_{fusion}]$

where:

$W_{peas,frozen}$ = weight of frozen green peas, lb

$Cp_{peas,frozen}$ = specific heat of frozen green peas, Btu/lb°F
= 0.44 Btu/lb°F

$\Delta T_{peas,frozen}$ = temperature rise in frozen green peas, °F
= 32°F - initial temperature of frozen green peas load

$W_{peas,thawed}$ = weight of thawed green peas, lb
= weight of full calorimeter - weight of empty calorimeter - weight of water in calorimeter

$Cp_{peas,thawed}$ = specific heat of thawed green peas, Btu/lb°F
= 0.84 Btu/lb°F

$\Delta T_{peas,thawed}$ = temperature rise in thawed green peas, °F
= final temperature of cooked peas load - 32°F

E_{fusion} = latent heat of fusion of ice
= 144 Btu/lb

$W_{moisture}$ = weight of moisture in frozen green peas-- 81%
= 0.81 x $W_{peas,frozen}$

E_{pan} = heat gained by the stainless-steel hotel pan(s)
= $W_{pan} \times Cp_{pan} \times \Delta T_{pan}$

where:

W_{pan} = weight of pan (s), lb

Cp_{pan} = specific heat of stainless-steel, Btu/lb°F
= 0.11 Btu/lb°F

ΔT_{pan} = temperature rise in pan °F
= $T_f - T_i$
= final temperature of cooked green peas load - initial temperature frozen green peas load

$E_{steam\ cooker}$ = total energy consumed by the steam cooker, Btu(kJ). Includes sum of all fuel types used (e.g. gas energy for heating plus electric energy used by steam circulating fans and/or controls)

$E_{boiler\ re\text{-}init}$ = energy required to restore the final boiler energy content (pressure) to the initial boiler energy content (Btu(kJ)). Calculation of this energy quantity is required only if the conditional step 3.12 was applicable. Otherwise this energy quantity is already included in the $E_{steam\ cooker}$ value. If conditional step 3.12 was applicable, then $E_{boiler\ re\text{-}init}$ is calculated as follows:

$$= E_{cycle} \times \frac{P_{max} - P_{final}}{P_{max} - P_{min}}$$

where:

E_{cycle} =energy required to raise the boiler pressure from minimum operating pressure to maximum operating pressure, Btu(kJ)

P_{max} =the average maximum boiler pressure, psi(kPa)

P_{min} =the average minimum boiler pressure, psi(kPa)

P_{final} =the boiler pressure at the end of the test, psi(kPa)

4.4 Calculate the frozen green peas load cooking energy rate as follows:

$$q_{peas} = \frac{E_{steam\ cooker} + E_{boiler\ re\ -\ init}}{t} \times 60$$

where:

q_{peas} = frozen green peas load cooking energy rate, Btu/h(kJ/h)

t = test period, min

$E_{steam\ cooker}$ and $E_{boiler\ re\text{-}init}$ are as defined in the test method.

For gas steam cookers, $E_{steam\ cooker}$ in the above equation does not include the electric energy. The electric energy rate is reported separately in step 4.5. For direct steam or steam coil steam cookers, report the cooking energy rate in both Btu(kJ)/h and $lb(kg)_{steam}/h$.

4.5 This step applies to heavy load tests of gas, direct steam, and steam coil steam cookers only. Calculate the frozen green peas load electric energy rate as follows:

$$q_{peas,ele} = \frac{E_{steam\ cooker,\ ele}}{t} \times 60$$

where:

$q_{peas,ele}$ = frozen green peas load electric cooking energy rate, Btu/h(kJ/h)
t = test period, min
$E_{steam\ cooker,\ ele}$ = electric energy consumed by the steam cooker, Btu(kWh).

4.6 Calculate frozen green peas load production capacity (lb(kg)) using the following definition:

$$PC_{peas} = \frac{W_{pea}}{t} \times 60$$

where:

PC_{peas} = production capacity, lb/h(kg/h)
W_{peas} = weight of frozen green peas load, lb(kg)
t = test period, min

4.7 Report the frozen green peas load cooking water consumption rate, gal/h (L/h).

4.8 Report the average temperature of the frozen green peas load cooking condensate during the last five minutes of the test, °F(°C)