Pitco SGM24-US
Gas Fryer Performance Tests

Application of ASTM Standard
Test Method F 2144-05

FSTC Report 5011.07.18

Food Service Technology Center
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Specific appreciation is extended to Pitco for supplying the FSTC with a gas fryer, Model SGM24-US for controlled testing in the appliance laboratory.

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Figure ES-1.
Pitco SGM24-US Fryer.

Pitco's SGM24-US large-vat gas fryer features six heat transfer tubes running from front to back in a stainless steel frypot, and a programmable cooking computer that controls the input to the fryer providing for a more consistent product. Figure ES-1 illustrates the SGM24-US fryer, as tested at the Food Service Technology Center (FSTC).

FSTC engineers tested the fryer under the tightly controlled conditions of the American Society for Testing and Materials' (ASTM) standard test method.[1] Fryer performance is characterized by preheat time and energy consumption, idle energy consumption rate, cooking-energy efficiency, and production capacity.

Cooking performance was determined by cooking breaded 8-piece cut 2 ¾ pound frying chicken under two load scenarios: heavy—64 pieces per load and light—8 pieces per load. The SGM24-US's heavy-load cook time was 17.3 minutes. Production capacity includes the cooking time and the time required for the frying medium to recover to 320°F (recovery time).

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:

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

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

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[1] American Society for Testing and Materials. 2005. *Standard Test Method for the Performance of Large Open, Deep Fat Fryers.* ASTM Designation F 2144-05, in *Annual Book of ASTM Standards,* West Conshohocken, PA.

Executive Summary

Table ES-1. Summary of Fryer Performance.

Rated Energy Input Rate (Btu/h)	165,000
Measured Energy Input Rate (Btu/h)	167,709
Preheat Duration to 325°F (min)	20.8
Preheat Energy to 325°F (Btu)	34,283
Idle Energy Rate @ 325°F (Btu/h)	15,356
Heavy-Load Cooking-Energy Efficiency (%)[a]	47.5 ± 2.6
Light-Load Cooking-Energy Efficiency (%)[a]	18.2 ± 0.9
Production Capacity (lb/h)[a]	86.8 ± 0.6

[a] This range indicates the experimental uncertainty in the test result based on a minimum of three test runs.

The fryer's 165 kBtu/h input provided plenty of horsepower to produce a competitive heavy-load (64 pieces) cooking-energy efficiency of 47.5% and an impressive production capacity of 86.8 lbs/h. During testing, the SGM24-US was able to cook the heavy-load of chicken in a rapid 17.3 minutes.

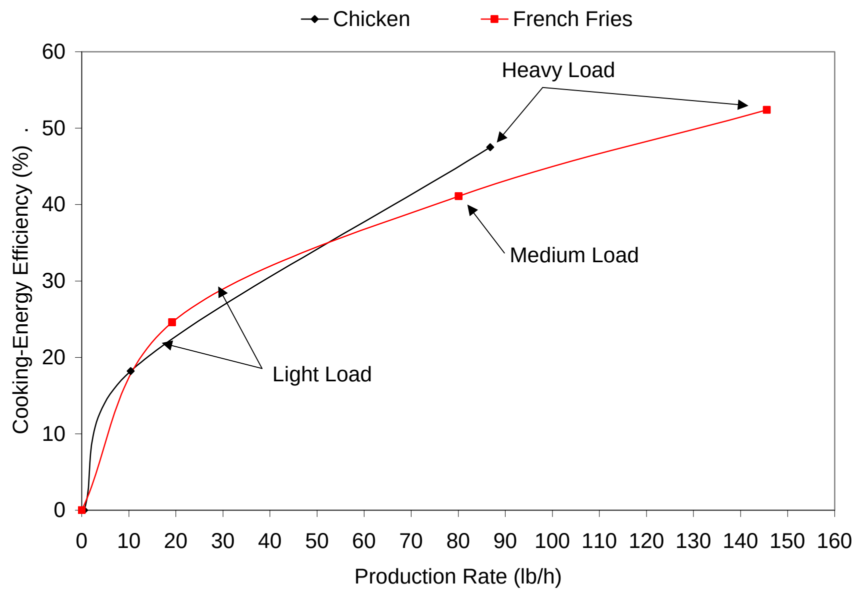
The classic open deep fat fryer design allows this large vat fryer to be used for a variety of food product. FSTC researchers conducted additional French fry tests on the Pitco fryer. Based on the size of the fry vat, the heavy-load was changed from 3 to 8 pounds. The fryer exhibited an impressive French fry production capacity of 145.6 lbs/hr, with a cooking-energy efficiency of 52.4%.

Table ES-3. French Fry Heavy-Load Test Results

Load Size (lbs)	8.0
Production Capacity (lb/h)[a]	145.6 ± 4.4
Energy per Pound of Food Cooked (Btu/lb)	1,084
Cooking Energy Rate (Btu/h)	157,760
Cooking-Energy Efficiency (%)[a]	52.4 ± 1.7

[a] This range indicates the experimental uncertainty in the test result based on a minimum of three test runs.

Figure ES-2 illustrates the relationship between cooking-energy efficiency and production rate for the fryer.



Note: Light-load chicken = 8 pieces/load; Heavy-load chicken = 64 pieces/load. Light-load fries = ¾ lbs/load; Medium-load fries = 3 lbs/load; Heavy-load fries = 8 lbs/load

Figure ES-2.
Fryer part-load cooking-energy efficiency.

Figure ES-3 illustrates the relationship between the fryer's average energy consumption rate and the production rate. This graph can be used as a tool to estimate the daily energy consumption and probable demand contribution for the fryer in a real-world operation. Average energy consumption rates at 10, 30, and 50 pounds of chicken per hour for the SGM24-US fryer are 23,000 Btu/h, 36,800 Btu/h, and 50,600 Btu/h respectively. For an operation cooking an average of 15 pounds of food per hour over the course of the day (e.g., 150 lbs of food over a ten hour day), the average rate for the SGM24-US fryer would be 26,500 Btu/h.

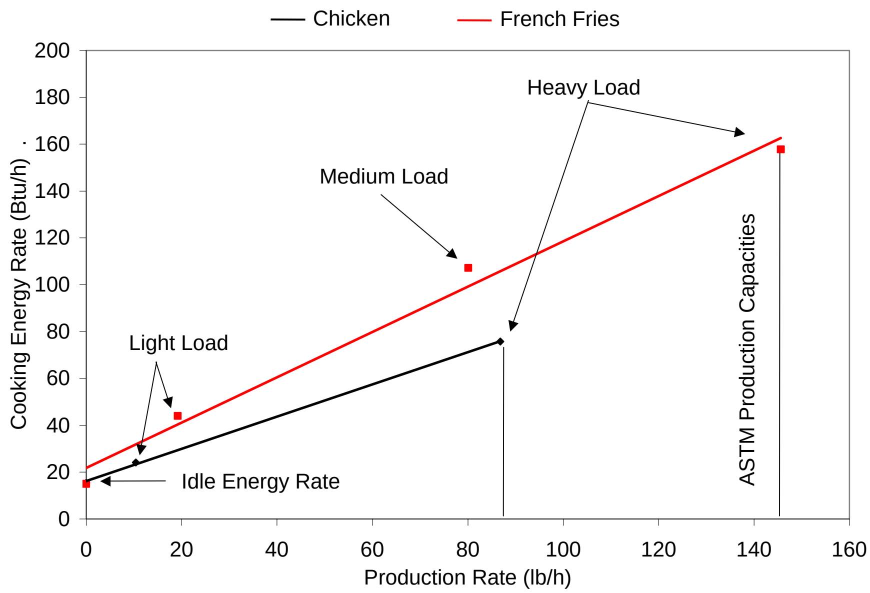


Figure ES-3.
Fryer cooking energy consumption profile.

Note: Light-load chicken = 8 pieces/load; Heavy-load chicken = 64 pieces/load.
Light-load fries = ¾ lbs/load; Medium-load fries = 3 lbs/load; Heavy-load fries = 8 lbs/load

The test results can be used to estimate the annual energy consumption for the fryer in a real-world operation. A simple cost model was developed to calculate the relationship between the various cost components (e.g., preheat, idle and cooking costs) and the annual operating cost, using the ASTM test data. For this model, the fryer was used to cook 150 pounds of chicken over a 12-hour day, with one preheat per day, 365 days per year. The estimated energy consumption and cost calculations appear in Appendix E.

Table ES-4. Estimated Fryer Energy Consumption and Cost.

Preheat Energy (kBtu/day)	34.3
Idle Energy (kBtu/h/day)	93.8
Cooking Energy (kBtu/day)	195.9
Annual Energy (kBtu/year)	118,282
Annual Cost ($/year)[a]	1,183

[a] Fryer energy costs are based on $1.00/therm = 100,000 Btu.

Executive Summary

Pitco's SGM24-US gas fryer established itself as a versatile open deep fat fryer. Its large vat size provides a restaurateur with the option of cooking large quantities of breaded product such as fried chicken or traditional French fries.

1 Introduction

Background

Fried foods continue to be popular on the restaurant scene. Fryers of a larger vat size and input typically are used for cooking foods such as chicken and fish. Recent advances in equipment design have produced fryers that operate more efficiently, quickly, safely and conveniently.

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) [1,2], allow benchmarking of equipment such that users can make meaningful comparisons among available equipment choices. 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.

Fryer performance is characterized by preheat time and energy consumption, idle energy consumption rate, pilot energy, consumption rate, cooking energy efficiency and production capacity.

FSTC researchers modified ASTM (F 1964-99) Standard Test Method for the Performance of Pressure and Kettle Fryers[1] to apply to large open vat, deep fat fryers, which was accepted as a Standard Test Method for Performance of Large Open Vat Fryers (Designation F 2144-05)[2]

Introduction

Pitco's SGM24-US gas fryer features heat transfer tubes submerged in the frying oil with a stainless steel frypot, backsplash, and a programmable cooking computer. An integrated melt cycle prevents solid frying medium from scorching during preheat.

This report presents the results of applying the ASTM test method[1] to the Pitco SGM24-US gas fryer. 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 Pitco's SGM24-US, 24-inch gas fryer at an input rating of 165,000 Btu/h, under the controlled conditions of the ASTM standard test method.[2] 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 appliance from room temperature to 325°F.
3. Characterize the idle energy use with the thermostat set at a calibrated 325°F.
4. Document the cooking energy consumption and efficiency under two fry loading scenarios: heavy (64 piece load) and light (8 piece per load).
5. Determine the production capacity during the heavy-load test.
6. Document the cooking energy consumption and efficiency under three French fry loading scenarios at 350°F: heavy (8 pounds per load), medium (3 pounds per load), and light (¾ pound per load).
7. Determine the production capacity and frying medium temperature recovery time during the heavy-load test.
8. Estimate the annual operating cost for the fryer using a standard cost model.

Appliance Description

Pitco's SGM24-US, 24-inch gas fryer has an input rate of 165,000 Btu/h. The fry pot is of a stainless steel construction and contains submerged heat transfer tubes running from front to back (see Figure 1-1). A cooking computer allows for individualized programming for multiple food products. An integrated melt cycle prevents solid frying medium from scorching during preheat.

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

Figure 1-1.
Pitco SGM24-US frypot.

Table 1-1. Appliance Specifications.

Manufacturer	Pitco
Model	SGM24-US
Generic Appliance Type	Open Deep Fat Fryer
Rated Input	165,000 Btu/h
Frying Area	24.25" x 24.5" x 17"
Oil Capacity	150 lb
Controls	Programmable cooking computer
Construction	Stainless Steel

2 Methods

Setup and Instrumentation

FSTC researchers installed the fryer on a tiled floor 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 300 cfm per linear foot of hood. There was at least 6 inches of clearance between the vertical plane of the fryers and the edge of the hood. All test apparatus was installed in accordance with Section 9 of the ASTM test method.[2] See Figure 2-1.

Researchers instrumented the fryer with thermocouples to measure temperatures in the cold and the cooking zones and at the thermostat bulb. Two thermocouples were placed in the cook zone, one in the geometric center of the frypot, approximately 1 inch above the fry basket support, and the other at the tip of the thermostat bulb. The cold zone thermocouple was supported from above, independent of the frypot surface, so that the temperature of the cold zone reflected the frying medium temperature, not the frypot's surface

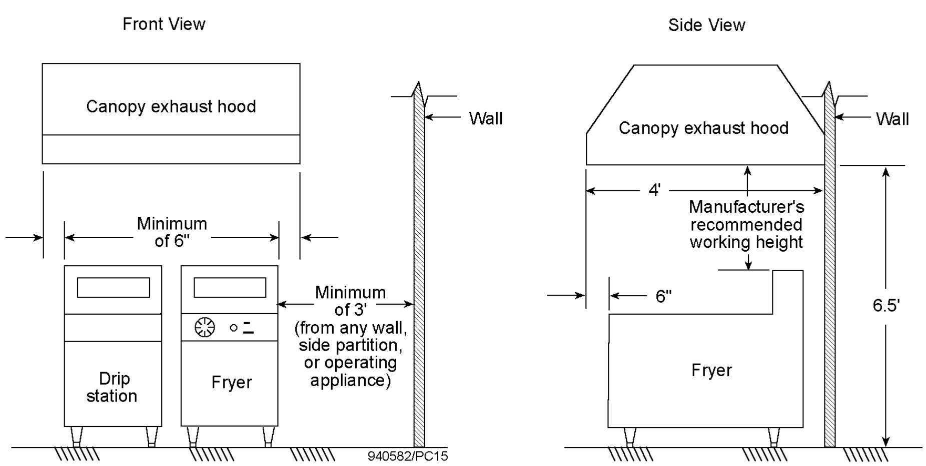


Figure 2-1. Equipment configuration.

temperature. The cold zone temperature was measured toward the rear of the frypot, 1/8-inch from the bottom of the pot (See Figure 2-2).

Natural gas consumption was measured using a positive displacement-type gas meter that generated a pulse every 0.1 ft^3. The gas meter and the thermocouples were connected to an automated data acquisition unit that recorded data every 5 seconds. A Cutler-Hammer calorimeter was used to determine the gas heating value on each day of testing. All gas measurements were corrected to standard conditions.

The fryer was filled with Melfry Brand, partially hydrogenated, 100% pure vegetable oil for all tests except the energy input rate determination test. This test required the fryer to be filled with water to inhibit burner cycling during the test.

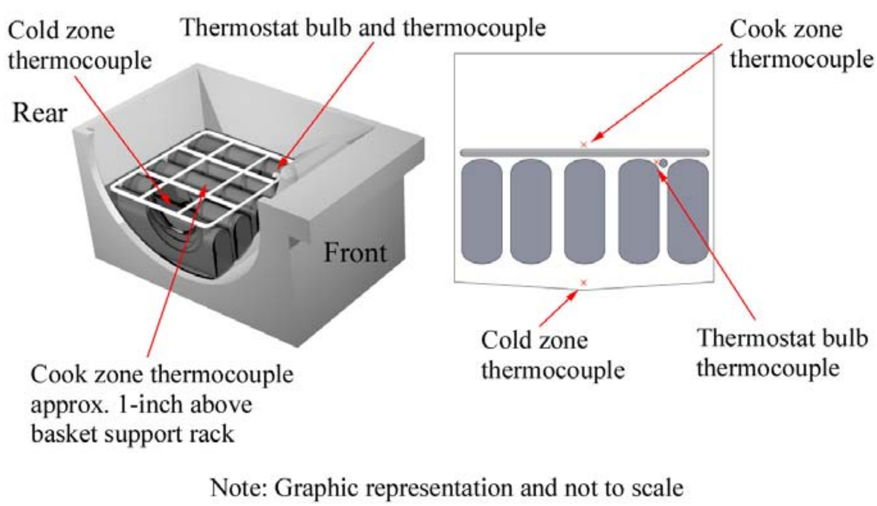


Figure 2-2. Thermocouple placement for testing.

Measured Energy Input Rate

Rated energy input rate is the maximum or peak rate at which the fryer consumes energy—as specified on the fryer's nameplate. Measured energy input rate is the maximum or peak rate of energy consumption, which is recorded during a period when the burners are operating at maximum capacity (such as preheat). For the purpose of this test, the fryer was filled with water to the frypot's indicated fill-line. The controls were set to attain maximum output and the energy consumption was monitored for a period of 15 minutes after a full rolling boil had been established. Researchers compared the measured energy input rate with the nameplate energy input rate to ensure that the fryer was operating properly.

Chicken Tests

The fryer was tested with 8-piece cut, 2 ¾-pound, individually quick frozen frying chicken which had been thawed, breaded, and stabilized in a refrigerator at 38 °F. Researchers tested the fryers using nominal heavy and light-loads of chicken (Table 2-1). Each load comprised an equal number of breasts, wings, legs, and thighs. The chicken was cooked to an average weight loss of 27 ± 2%. This ensured fully cooked chicken with no redness in the center.

Table 2-1. Chicken Load Size.

Heavy-Load (pieces)	64
Light-Load (pieces)	8

During the testing, energy, time and oil temperature were recorded at 5-second intervals. Chicken temperature and weight loss were measured and recorded for use in energy calculations.

Due to logistics in removing one load of cooked chicken and placing another load into the fryer, a minimum preparation time of 10 minutes was incorporated into the cooking procedure. This ensures that the cooking tests are uniformly applied from laboratory to laboratory. Fryer recovery was then based on the frying medium reaching a threshold temperature of 320°F (measured at the center of the cook zone).

The chicken tests were run in the following sequence: three replicates of the heavy-load test and three replicates of the light-load test. This procedure 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.

French Fry Tests

For additional performance information on the fryer, researchers applied the French fry test from the ASTM Test Method for Open Deep Fat Fryers (F1361-05)[3]. Since the frypot could accommodate a larger load than specified in the test method, the heavy-load size was increased from three to eight pounds of frozen French fries. Medium-loads were also increased in size to three pounds.

Simplot® brand ¼-inch blue ribbon product, par-cooked, frozen shoestring potatoes were used for the French fry tests. Each load of French fries was cooked to a 30% weight loss. The tests involved “barreling” six loads of frozen French fries, using fry medium temperature as a basis for recovery. Each test was followed by a 10-minute wait period and was then repeated two more times. Researchers tested the fryers using 8-pound (heavy), 3-pound (medium), and ¾-pound (light) French fry loads.

Due to the logistics involved in removing one load of cooked French fries and placing another load into the fryer, a minimum preparation time of 10 seconds was incorporated into the cooking procedure. This ensures that the cooking tests are uniformly applied from laboratory to laboratory. Fryer recovery was then based on the frying medium reaching a threshold temperature of 340°F (measured at the center of the cook zone). Reloading within 10°F of the 350°F thermostat set point does not significantly lower the average oil temperature over the cooking cycle, nor does it extend the cook time. The fryer was reloaded either after the cook zone thermocouple reached the threshold temperature or 10 seconds after removing the previous load from the fryer, whichever was longer.

The first load of each six-load cooking test was designated as a stabilization load and was not counted when calculating the elapsed time and energy used.

Energy monitoring and elapsed time of the test were determined after the second load contacted the frying medium. After removing the last load and allowing the fryer to recover, researchers terminated the test. Total elapsed time, energy consumption, weight of fries cooked, and average weight loss of the French fries were recorded for the last five loads of the six-load test.

Each loading scenario (heavy, medium and light) was replicated a minimum of three times. This procedure 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.

3 Results

Energy Input Rate

Prior to testing, the energy input rate was measured and compared with the manufacturer's nameplate value. This procedure ensured that the fryer was operating within its specified parameters. The measured energy input rate was 167,709 Btu/h (a difference of 1.64% from the nameplate rating).

Preheat and Idle Tests

These tests show how the fryer uses energy when it is not cooking food. The preheat time allows an operator to know precisely how long it takes for the fryer to be ready to cook. The idle energy rate represents the energy required to maintain the set temperature of 325°F, or the appliance's stand-by losses.

Preheat Energy and Time

Researchers filled the fryer with new oil, which was then heated to 325°F at least once prior to any testing. The preheat tests were conducted at the beginning of a test day, after the oil had stabilized at room temperature overnight. Pitco's cooking computer has an integrated melt cycle to prevent scorching of solid shortening. The integrated melt cycle was disabled during the preheat test. Pitco's SGM24-US fryer was ready to cook in 20.8 minutes. Figure 3-1 shows the fryer's preheat characteristics.

Idle Energy Rate

Once the frying medium reached 325°F, the fryer was allowed to stabilize for half an hour. Time and energy consumption was monitored for an additional two-hour period as the fryer maintained the oil at 325°F. The idle energy rate during this period was 15,356 Btu/h.

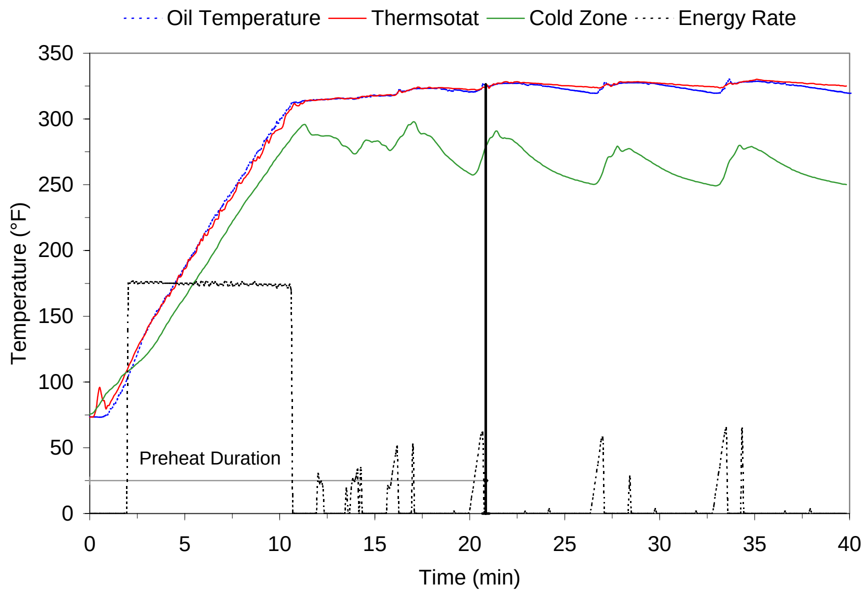


Figure 3-1.
Pitco SGM24-US preheat characteristics.

Test Results

Input, preheat, and idle test results are summarized in Table 3-1.

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

Rated Energy Input Rate (Btu/h)	165,000
Measured Energy Input Rate (Btu/h)	167,709
Percentage Difference (%)	1.64
Preheat	
Duration (min)	20.8
Preheat Energy (Btu)	34,283
Control Energy (Wh)	8.03
Preheat Rate to 325°F (°F/min)	12.1
Idle Energy Rate @ 325°F (Btu/h)	15,356
Control Energy Rate (W)	19.1

Results

Chicken Tests

The fryer was tested using 8-piece cut, 2 ¾-pound chickens that had been thawed, breaded, and stabilized at 38°F to 40°F. For heavy-load tests, the SGM24-US fryer was used to cook 64 pieces per load (16 of each type of piece–breast, wings, legs and thighs), light-load tests used 8 pieces per load. Researchers monitored chicken cooking time and weight loss, frying medium temperature, and fryer energy consumption during these tests.

Heavy-Load Tests

The heavy-load cooking tests were designed to reflect a fryer's maximum performance. The fryer was used to cook three or more heavy loads of chicken–one load after another in rapid succession, simulating a peak cooking period. Cooking-energy efficiency and production capacity were determined from a minimum of three tests. The characteristic temperature curve, or temperature signature, during a single heavy-load indicates how well the fryer maintained the oil temperature during a cooking event. This curve is also an indicator of product quality as the chicken pieces begin to absorb more oil at lower cooking temperatures. Figure 3-2 shows the temperature signature during a heavy-load test.

The heavy-load cook time for the Pitco fryer was 17.3 minutes. Production capacity includes the cook time and a 30 second reload time.

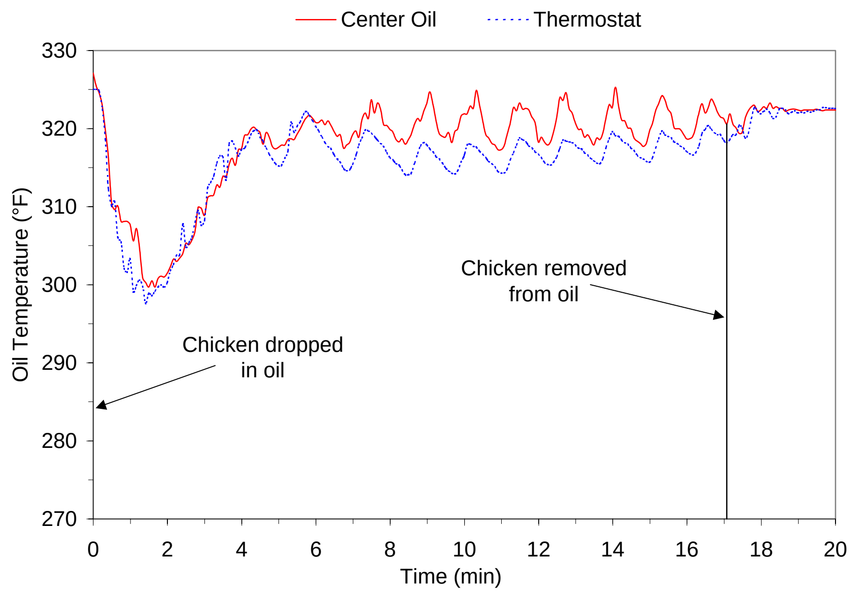


Figure 3-2.
Chicken cook cycle tempeature signature.

Light-Load Tests

Light-load tests represent the fryer's performance under non-peak conditions. Since a fryer is often used to cook single-basket loads during slow periods, this part-load efficiency can be used to estimate a fryer's performance in an actual operation.

Light-load tests were conducted using a single fry basket. The fryer, during light-load testing, demonstrated a cooking-energy efficiency of 18.2%, while producing 10.4 lb/h.

Test Results

Energy imparted to the chicken was calculated by separating the various components of the chicken (water, fat, and solids) and determining the amount of heat gained by each component (Appendix D). The fryer's cooking energy efficiency for a given loading scenario is the amount of energy imparted to the chicken, expressed as a percentage of the amount of energy consumed by the fryer during the cooking process.

Heavy-load cooking-energy efficiency results were 48.6%, 47.3%, 46.5% and 46.5%, yielding a maximum uncertainty of 2.6%. Table 3-2 summarizes the results of the ASTM cooking-energy efficiency and production capacity tests for chicken.

Table 3-2. Chicken Cooking Test Results.

	Heavy-Load	Light-Load
Load Size (pieces)	64	8
Cook Time (min)	17.3	17.4
Production Rate (lb/h)[a]	86.8 ± 0.6	10.4 ± 1.3
Energy to Food (Btu/lb)	414	418
Cooking Energy Rate (Btu/h)	75,831	24,064
Control Energy Rate (W)	21.3	19.7
Energy per Pound of Food Cooked (Btu/lb)	874	2,301
Cooking-Energy Efficiency (%)[a]	47.5 ± 2.6	18.2 ± 0.9

[a] This range indicates the experimental uncertainty in the test result based on a minimum of three test runs.

French Fry Tests

Since large-vat fryers are occasionally used for high-volume French fry production, researchers applied the French fry test from the ASTM Standard Test Method for the Performance of Open Deep Fat Fryers (F1361-05)[3]. To accommodate the larger vat size, the load sizes were increased proportionately.

The fryer was tested with frozen ¼-inch shoestring potatoes under three loading scenarios: heavy (8 pounds of fries per load), medium (3 pounds of fries per load) and light (¾ pound of fries per load). The fries used for the cooking tests consisted of approximately 6% fat and 70% moisture, as specified by ASTM F1361-05. Researchers monitored French fry cook time and weight loss, frying medium recovery time, and fryer energy consumption during these tests.

Heavy-Load Tests

The fryer was used to cook six 8-pound loads of frozen French fries—one load after the other in rapid succession, similar to a batch-cooking procedure. The first load was used to stabilize the fryer, and the remaining five loads were used to calculate cooking-energy efficiency and production capacity. Figures 3-3 shows the average temperature of the frying medium during the heavy-load tests. The heavy-load cook time for the fryer was 2.38 minutes with an average recovery time of less than 10 seconds, the mandatory reload period. Figure 3-4 illustrates the temperature response of the Pitco fryer while cooking a 6-pound load of frozen French fries. Production capacity includes the time required to remove the cooked fries and reload the fryer with a new batch of frozen fries (approximately 10 seconds per load).

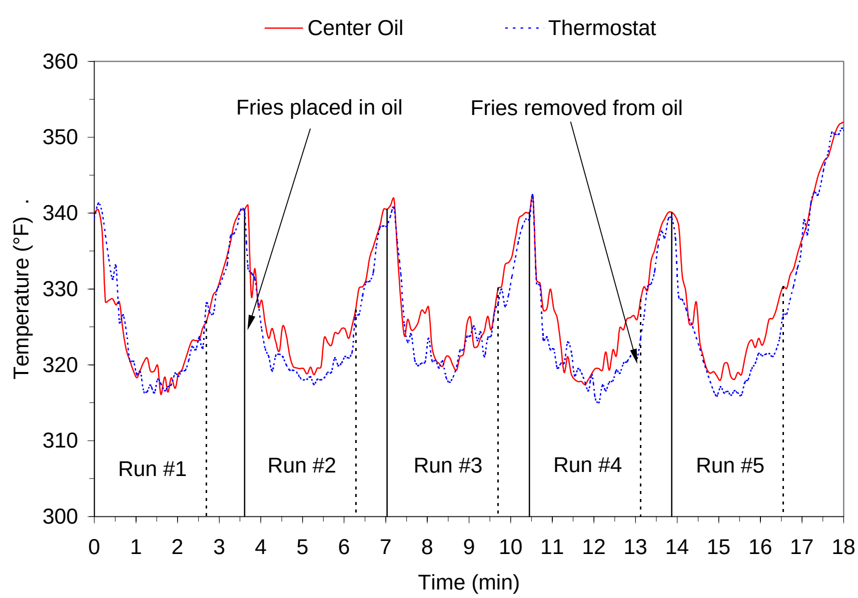


Figure 3-3.
Frying medium temperarture during a heavy-load test for the SGM24-US fryer.

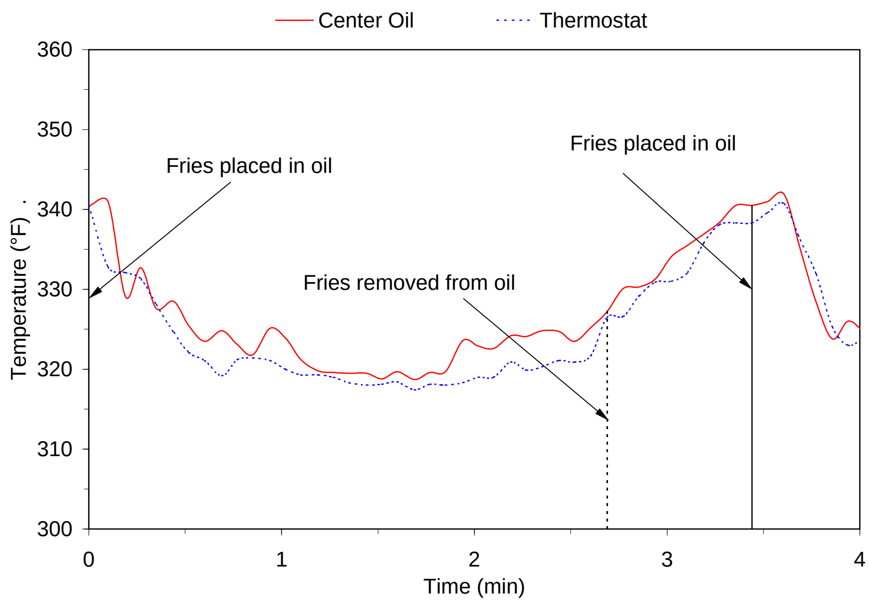


Figure 3-4.
Fryer cooking cycle temperature signature.

Medium- and Light-Load Tests

Medium- and light-load tests represent a more typical usage pattern for a fryer in cook-to-order applications. Since a fryer is often used to cook single basket loads in many food service establishments, these part-load efficiencies can be used to estimate the fryer's performance in an actual operation.

Both the medium- and light-load tests were conducted using a single fry basket. The medium-load tests used 3 pounds of fries per load and the light load tests used ¾ pounds of fries per load. Cooking-energy efficiencies during testing were 41.3% for medium- and 24.6% for light-loads while producing 80.1 lbs/h and 19.2 lbs/h of cooked French fries, respectively.

Test Results

Energy imparted to the French fries was calculated by separating the various components of the fries (water, fat, and solids) and determining the amount of heat gained by each component (Appendix D). The fryer's cooking-energy efficiency for a given loading scenario is the amount of energy imparted to the fries, expressed as a percentage of the amount of energy consumed by the fryer during the cooking process.

Heavy-load cooking-energy efficiency results were 52.4%, 51.7% and 53.1%, yielding a maximum uncertainty of 1.7%. Table 3-3 summarizes the results of the ASTM cooking-energy efficiency and production capacity tests for French fries.

Table 3-3. French Fry Cooking Test Results.

	Heavy-Load	Medium-Load	Light-Load
Load Size (lb)	8.0	3.0	¾
French Fry Cook Time (min)	2.53	2.07	2.20
Average Recovery Time (sec)	45.7	< 10	< 10
Production Rate (lb/h)[a]	145.6 ± 4.4	80.1 ± 2.8	19.2 ± 0.2
Energy to Food (Btu/lb)	568	551	565
Cooking Energy Rate (Btu/h)	157,760	107,152	43,965
Control Energy Rate (W)	21.6	23.2	21.0
Energy per Pound of Food Cooked (Btu/lb)	1,084	1,338	2,296
Cooking-Energy Efficiency (%)[a]	52.4 ± 1.7	41.3 ± 2.4	24.6 ± 1.3

[a] This range indicates the experimental uncertainty in the test result based on a minimum of three test runs.

Results Analysis

The rate at which food cooks in a fryer depends on the amount of surface area exposed to the hot oil and the relative thickness (volume) of the food product. Breaded chicken pieces and frozen ¼-inch shoestring potatoes represent two extremes in cooking. Frozen French fries have a large surface area to volume ration, which promotes quick heat transfer to the interior of the food product. Breaded chicken is more difficult to cook, due to the low surface area to volume ratio and slower rate of heat transfer to the interior of the food product.

Figure 3-5 illustrates the relationship between cooking-energy efficiency and production rate for this fryer. Fryer production rate is a function of both the

French fry cook time and the frying medium recovery time. Appendix D contains a synopsis of test data for each replicate of the chicken and French fry cooking tests.

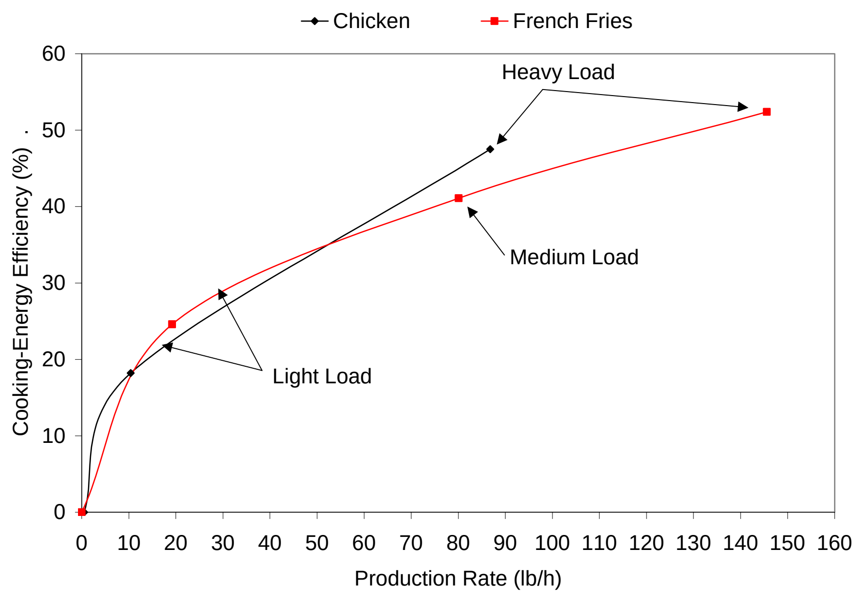
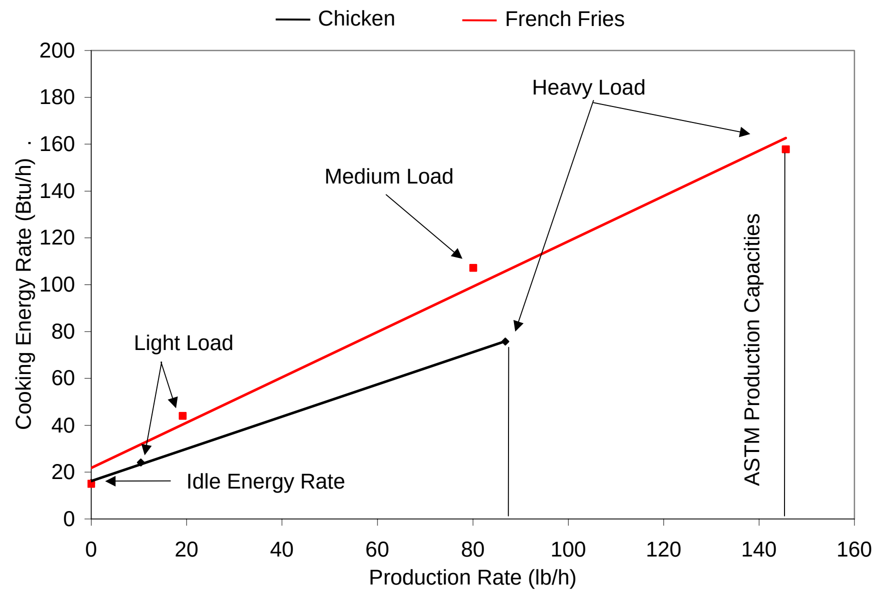


Figure 3-5.
Fryer part-load cooking-energy efficiency.

Note: Light-load chicken = 8 pieces/load; Heavy-load chicken = 64 pieces/load.
Light-load fries = ¾ lbs/load; Medium-load fries = 3 lbs/load; Heavy-load fries = 8 lbs/load

Figure 3-6 illustrates the relationship between the fryer's average energy consumption rate and the production rate. This graph can be used as a tool to estimate the daily energy consumption and probable demand for the fryer in a real-world operation. Average energy consumption rates at 10, 30, and 50 pounds of chicken per hour were 23,000 Btu/h, 36,800 Btu/h, and 50,600 Btu/h, respectively. For an operation cooking an average of 15 pounds of chicken per hour over the course of the day (e.g., 150 lb of food over a ten hour day), the fryer's average energy consumption would be 26,500 Btu/h.



Note: Light-load chicken = 8 pieces/load; Heavy-load chicken = 64 pieces/load.
Light-load fries = ¾ lbs/load; Medium-load fries = 3 lbs/load; Heavy-load fries = 8 lbs/load

Figure 3-6.
Fryer cooking energy consumption profile.

Energy Cost Model

The test results can be used to estimate the annual energy consumption for the fryer in a real-world operation. A simple cost model was developed to calculate the relationship between the various cost components (e.g., preheat, idle and cooking costs) and the annual operating cost, using the ASTM test data. For this model, the fryer was used to cook 150 pounds of chicken over a 12-hour day, with one preheat per day, 365 days per year. The idle (ready-to-cook) time for the fryer was determined by taking the difference between the total daily on-time (12 hours) and the equivalent full-load cooking time. This approach produces a more accurate estimate of the operating cost for the fryer. The estimated energy consumption and cost calculations appear in Appendix E.

Table 3-4. Estimated Fryer Energy Consumption and Cost.

Preheat Energy (kBtu/day)	34.3
Idle Energy (kBtu/day)	93.8
Cooking Energy (kBtu/day)	195.9
Annual Energy (kBtu/year)	118,282
Annual Cost ($/year)[a]	1,183

[a] Fryer energy costs are based on $1.00/therm = 100,000 Btu.

4 Conclusions

Pitco's SGM24-US gas fryer was successfully tested in accordance with the ASTM standard test method for large vat fryers[2] and exhibited comparable performance to other large vat fryers tested at the Food Service Technology Center.[12, 21] During the heavy-load cooking tests the fryer produced an impressive 86.8 lbs/h of cooked chicken while demonstrating a cooking-energy efficiency of 47.5%. Light-load cooking tests achieved an efficiency of 18.2% while a producing 10.4 lb/h of chicken.

During non-cooking (standby) periods, the fryer consumed 15,356 Btu/h while maintaining a ready-to-cook state (325°F oil temperature). Since fryers typically spend a good portion of the day in a ready-to-cook state, this idle energy rate has a direct impact on operating costs. Furthermore, an operator can expect this large vat fryer to preheat in 20.8 minutes, while consuming 34,283 Btu.

Additional cooking tests were applied to the SGM24-US large vat fryer, based on the French fry tests from ASTM standard test method for open deep fat fryers[3]. During the heavy-load (8.0 lb) French fry tests, the fryer produced 145.6 lbs/h while achieving a 52.4% cooking-energy efficiency. Under medium- (3.0 lb) and light-load (0.75 lb) testing the fryer achieved a cooking-energy efficiency of 41.1% and 24.6%, while producing 80.1 lbs/h and 19.2 lb/h, respectively.

The estimated operational cost of the SGM24-US large vat gas fryer is $1,183 per year. The model assumes the fryer is used to cook 150 lbs of chicken over a 12-hour day, 365 days a year. The model also assumes one preheat each day with the remaining on-time being in an idle (ready-to-cook) state.

Conclusions

The Pitco SGM24-US fryer provides a facility or institution with a flexible high volume appliance that offers more versatility than conventional pressure and kettle fryers.

5 References

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A Glossary

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.

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.

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.

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

Glossary

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).

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 cook zone heats during a preheat.

Preheat Time (minute)
Preheat Period

The time required for an appliance to warm 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.

Recovery Time (minute, second)

The average time from the removal of the fry baskets from the fryer until the frying medium is within 5°F of the thermostat set point and the fryer is ready to be reloaded.

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.

B Appliance Specifications

Appendix B includes the product literature for the Pitco SGM24-US fryer.

Table B-1. Appliance Specifications.

Manufacturer	Pitco
Model	SGM24-US
Generic Appliance Type	Open Deep Fat Fryer
Rated Input	165,000 Btu/h
Frying Area	24.25" x 24.5" x 17"
Oil Capacity	150 lb
Controls	Programmable cooking computer
Construction	Stainless Steel

Project________________________

Item No.________________________

Quantity________________________

Model SGM34, SGM24 and SGM1824 MEGAFRY Gas Fryers with Filtration

Unit shown:SGM34 with optional I12 computer, Filter and Casters

STANDARD FEATURES

- Tank - stainless steel construction
- Cabinet - stainless steel front, door, sides & splash back.
- Solstice Burner Technology
- Solid State T-Stat with melt cycle and boil out mode
- Matchless Ignition with DVI drain valve interlock
- 1 ¼" (3.2 cm) Full port drain valve
- Manual gas shutoffs and Rear gas manifold connection
- Integrated flue deflector
- 11" (27.9 cm) adjustable legs
- Tube screen
- Removable basket hanger(s)
- Drain Line Clean out rod & Cleaning brush
- Filter scoop shovel & Fryer crumb scoop
- Filter powder and fryer cleaner sample packets
- Filter paper envelope 14" x 22" (36 x 56 cm) 25 sheet pkg

OPTIONS & ACCESSORIES (AT ADDITIONAL COST)

- ❑ Digital Controller
- ❑ Intellifry I12 Computer
- ❑ Backup thermostat
- ❑ Stainless Steel back
- ❑ 11" (27.9 cm) adjustable rear and front locking casters
- ❑ Flexible gas hose with quick disconnect
- ❑ Tank cover
- ❑ Flush hose
- ❑ Filter heater for solid shortening
- ❑ Paperless stainless steel mesh filter
- ❑ Institutional Prison security package
- ❑ Baskets see Configuration Table for options

STANDARD SPECIFICATIONS

CONSTRUCTION

- Solstice Burner Technology provides dependable heat transfer without the need for complex power blowers.
  - ✓ High volume production with 62% thermal efficiency
- Tank constructed of durable stainless steel with an extra smooth peened finish for easy cleaning.
- Long-lasting, high-temperature alloy stainless steel heat baffles for maximum heating and combustion efficiency.
- Stainless steel cabinet front, door, side and splash back
- Heavy duty 3/16" (.48 cm) door hinges
- Front 1 ¼" (3.2 cm) full port drain for quick draining.

CONTROLS

- Matchless Ignition and drain valve interlock safety system
- Solid State Thermostat with melt cycle and boil out mode
  - *Optional:* Digital Controller: Displaying 2 product timer
  - *Optional:* I12 Intellifry Computer: Time compensating computer with 12 product timer keys
- Integrated gas control valve acts as a manual valve, safety pilot valve, main valve, gas filter, pressure and regulator.
- Temperature limit switch safely shuts off all gas flow if the fryer temperature exceeds the upper limit.

FILTER SYSTEM

- Extra Large 3" (7.6 cm) curved drain spout virtually eliminates splashing and swivels for oil disposal.
- Filter pan is stainless steel with rear wheels for easy movement during cleaning.
- Connection to fryer is self-aligning for ease of use.
- Easy two step filtering. 1) Blue handle to drain tank
  2) Red Handle to return oil
- High flow pump and large return lines produce faster oil refill times.
- Filter pan lid stows in the cabinet and out of the way.
- Battery up to 4 MegaFry fryers per filter.

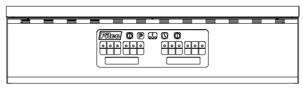
Optional Basket Configuration Table

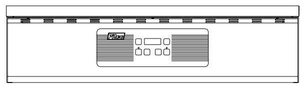
Model	Option	Basket Size/Quantities	
		5-3/4 X 23-1/4 (14.6 X 59.1)	10 X 23-1/4 (25.4 X 59.1)
SGM34	A	5	0
SGM34	B	4	1
SGM34	C	2	2
SGM34	D	0	3
SGM24	A	4	0
SGM24	B	2	1
SGM24	C	0	2
SGM1824	A	3	0
SGM1824	B	1	1

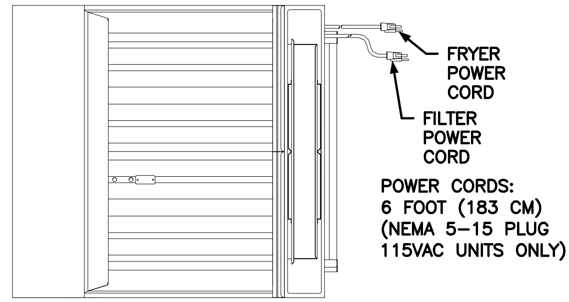
Model SGM34, SGM24 and SGM1824 MEGAFRY Gas Fryers with Filtration

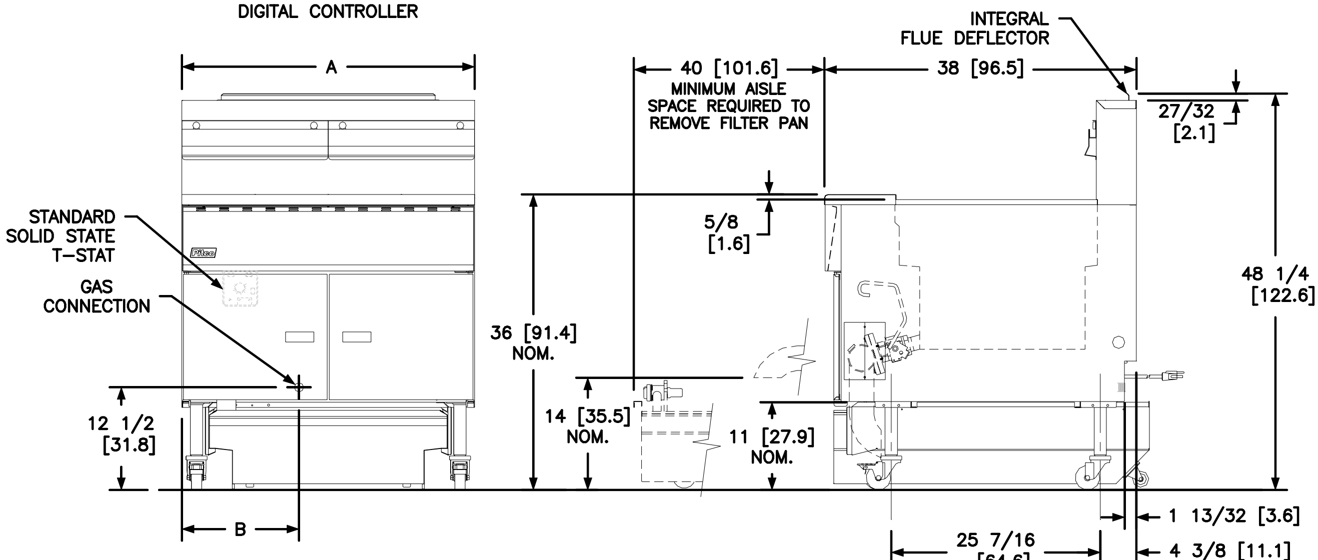
Model SGM34, SGM24 and SGM1824 MEGAFRY Gas Fryers with Filtration

Model SGM34, SGM24 and SGM1824 MEGAFRY Gas Fryers with Filtration









Models	"A" Dim	"B" Dim	Cook Area \ Depth	Oil Capacity	Gas Input / Hour	Shipping Weight / Unit	Shipping Cube	Shipping Dimensions H x W x L
	FRYER DIMENSIONS					**SHIPPING INFORMATION**		
SGM34	35-5/8 in 90.5 cm	14-1/4 in 36.2 cm	34 x 24 x 4 in 86.4 x 61.0 x 10.2cm	200-210 lbs 91-95 Kg	210,000 BTU 61.6KW / 220 MJ	495 lbs 225 Kg	72 ft^3 2.04 m^3	58 x 41 x 52 in 147.3 x 104.1 x 132 cm
SGM24	25-5/8 in 65.1 cm	9-1/4 in 23.5 cm	24 x 24 x 4 in 61.0 x 61.0 x 10.2cm	140-150 lbs 64-68 Kg	165,000 BTU 48.4KW / 174 MJ	375 lbs 170 Kg	56 ft^3 1.56 m^3	57 x 36 x 47 in 144.8 x 91.4 x 119.4 cm
SGM1824	19-5/8 in 49.8 cm	6-1/4 in 15.9 cm	18 x 24 x 4 in 45.7 x 61.0 x 10.2cm	100-110 lbs 45-50 Kg	120,000 BTU 35.2KW / 128 MJ	250 lbs 113 Kg	33 ft^3 .93m^3	58 x 22½ x 43½ in 147.3 x 57.2 x 110.5 cm
Filter	N/A	N/A	Filter must be under the largest fryer in the battery	8% more than largest fryer in battery.	N/A	125 lbs / 57Kg Add 20 lbs / 9 Kg per fryer position	N/A Ships with fryer	N/A

GAS REQUIREMENTS

Gas Rear Tee Manifold	Fryers Per Manifold	Rear Tee Gas Connection Location	Gas Connection Size
SGM34, SGM24, SGM1824	Maximum 560KBtu / 164 KW / 591 MJ per manifold. See Gas Input / Hour above.	Default location is to the left.Connection is field reversible to the right.	1-¼" NPT (1-¼" BSP CE) for 367KBtu / 108 KW / 387 MJ to 560 Kbtu / 164 KW / 591 MJ. 1" NPT (1" BSP CE) up to 366KBtu / 107 KW / 386 MJ. ¾" NPT (¾" BSP CE) for single units.
Gas Type	**Store Manifold Pressure**	**Burner Manifold**	*** Recommended Minimum**
Natural Gas	7" W.C. / 17.4 mbars / 1.75 KPa	4" W.C. / 10 mbars / 1 kPa	Check plumbing/gas codes for proper gas supply line sizing to sustain burner pressure when all gas appliance are full on.
Propane Gas	13" W.C. / 32.4 mbars / 3.25 KPa	10" W.C. / 25 mbars / 2.5 kPa	
Clearance Information	**Fryer Front**	**Fryer Sides, Rear, Bottom to any combustible materials**	**Fryer Flue Area**
All models	30" (76.2cm) minimum	6" (15.2 cm) Do not Curb Mount	Do not block / restrict flue gases from into hood or install vent hood drains over the flue.

ELECTRICAL REQUIREMENTS

Options		Voltage / Phase / Frequency	Amps	Additional Amps for Filter Heater	Number of Power Cords	Power Cord Locations
Filter	8.0 GPM (30.3 LPM) 1/3 HP	115 / 1 / 60	7	3	1	At filter location
	6.7 GPM (25.4 LPM) 1/3 HP	220-230-240 / 1 / 50	3.6	1.5		
Fryer	Upgrade Controls, Solid State, Digital, Computer	115 / 1 / 60	1.7	N/A	1 cord per 4 fryers	Default is left
		220-230-240 / 1 / 50	0.9	N/A		

SHORT FORM SPECIFICATIONS

Provide Pitco Model SGM 34, 24 or 1824 tube fired gas fryer with Filtration. 304 SS tank, Fryer shall have a blower free Solstice atmospheric burner system, 62% thermal efficiency, thermostatic controls with melt cycle and boil mode. Indicator lights for power, heat and trouble. Matchless ignition system and drain valve interlock safety, separate manual gas shut off, 3/4" npt rear gas connection, recessed cabinet back, 1-1/4" Full port drain valve, 5/16" bottom hinge, manual reset high limit, easy to field upgraded controls. Drain line shall be 3" (7.6cm) diameter with a swivel drain spout for oil disposal. Filter pickup assembly shall have handles and utilize envelope type filter paper. Filter pump shall pump 8 GPM, 60 Hz (25.4 LPM, 50 Hz). Filter piping to be self-aligning for easy assembly. Filter lid shall be attached to the cabinet for ease of use. Filter pan shall have front stabilizer legs and rear rigid casters for portability. Provide accessories as follows.

TYPICAL APPLICATIONS

High volume production restaurants, stadiums, prisons, casinos, hotels frying a multitude of fried products fast and wanting to maintain food quality through filtering.

C Results Reporting Sheets

Manufacturer: Pitco
Models: SGM24-US
Date: December 2005

Test Fryer and Burners

Description of operational characteristics: Pitco's SGM24-US gas fryer is rated at 165,000 Btu/h. The SGM24-US fryer features six heat transfer tubes submerged in the frying oil. A cooking computer controls the burners with features such as a melt cycle and multiple programmable cook times.

Apparatus

__√__ Check if testing apparatus conformed to specifications in section 6.

Deviations: None.

Energy Input Rate

Rated (Btu/h)	165,000
Measured (Btu/h)	167,709
Percent Difference between Measured and Rated (%)	1.64

Thermostat Calibration

Thermostat Setting (°F)	325
Oil Temperature (°F)	323

Oil Capacity

Results Reporting Sheets

Rated Capacity (ib)	150
Measured Capacity (lb)	150

Preheat Energy and Time

Starting Temperature (°F)	73.6
Preheat Energy (Btu)	34,283
Control Energy (Wh)	8.03
Duration (min)	20.8
Preheat Rate to 325°F (°F/min)	12.1

Idle Energy Rate

Idle Energy Rate @ 325°F (Btu/h)	15,356
Control Energy Rate (W)	19.1

Heavy-Load Chicken Cooking-Energy Efficiency and Cooking Energy Rate

Load Size (pieces)	64
Cook Time (min)	17.3
Production Capacity (lb/h) [a]	86.8 ± 0.6
Energy to Food (Btu/lb)	414
Cooking Energy Rate (Btu/h)	75,831
Control Energy Rate (W)	21.3
Energy per Pound of Food Cooked (Btu/lb)	874
Cooking-Energy Efficiency (%)[a]	47.5 ± 2.6

[a] This range indicates the experimental uncertainty in the test result based on a minimum of three test runs.

Light-Load Chicken Cooking-Energy Efficiency and Cooking Energy Rate

Load Size (lb)	8
French Fry Cook Time (min)	17.4
Production Rate (lb/h) [a]	10.4 ± 1.3
Energy to Food (Btu/lb)	418
Cooking Energy Rate (Btu/h)	24,064
Control Energy Rate (W)	19.7
Energy per Pound of Food Cooked (Btu/lb)	2,301
Cooking-Energy Efficiency (%)[a]	18.2 ± 0.9

[a] This range indicates the experimental uncertainty in the test result based on a minimum of three test runs.

Heavy-Load French Fry Cooking-Energy Efficiency and Cooking Energy Rate

Load Size (lb)	8.0
French Fry Cook Time (min)	2.53
Average Recovery Time (sec)	45.7
Production Capacity (lb/h) [a]	145.6 ± 4.4
Energy to Food (Btu/lb)	568
Cooking Energy Rate (Btu/h)	157,760
Control Energy Rate (W)	21.6
Energy per Pound of Food Cooked (Btu/lb)	1,084
Cooking-Energy Efficiency (%)[a]	52.4 ± 1.7

[a] This range indicates the experimental uncertainty in the test result based on a minimum of three test runs.

Medium-Load French Fry Cooking-Energy Efficiency and Cooking Energy Rate

Load Size (lb)	3.0
French Fry Cook Time (min)	2.07
Average Recovery Time (sec)	< 10
Production Rate (lb/h) [a]	80.1 ± 2.8
Energy to Food (Btu/lb)	551
Cooking Energy Rate (Btu/h)	107,152
Control Energy Rate (W)	23.2
Energy per Pound of Food Cooked (Btu/lb)	1,338
Cooking-Energy Efficiency (%)[a]	41.1 ± 2.4

[a] This range indicates the experimental uncertainty in the test result based on a minimum of three test runs.

Light-Load French Fry Cooking-Energy Efficiency and Cooking Energy Rate

Load Size (lb)	¾
French Fry Cook Time (min)	2.20
Average Recovery Time (sec)	< 10
Production Rate (lb/h) [a]	19.2 ± 0.2
Energy to Food (Btu/lb)	565
Cooking Energy Rate (Btu/h)	43,965
Control Energy Rate (W)	21.0
Energy per Pound of Food Cooked (Btu/lb)	2,296
Cooking-Energy Efficiency (%)[a]	24.6 ± 1.3

[a] This range indicates the experimental uncertainty in the test result based on a minimum of three test runs.

D Cooking-Energy Efficiency Data

Table D-1. Specific Heat and Latent Heat

Specific Heat (Btu/lb, °F)	
Ice	0.500
Fat	0.400
Solids	0.200
Chicken	0.688
Frozen French Fries	0.695
Latent Heat (Btu/lb)	
Fusion, Water	144
Fusion, Fat	44
Vaporization, Water	970

Cooking-Energy Efficiency Data

Table D-2. Heavy-Load Chicken Test Data.

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Electrical Energy Consumption (Wh)	6.05	6.08	6.26
Energy Consumption (Btu)	21,366	21,206	22,923
Total Energy (Btu)	21,387	21,227	22,944
Total Test Time (min)	17.1	17.2	17.5
Weight Loss (%)	26.80	25.80	28.40
Initial Weight (lb)	24.805	24.814	25.352
Final Weight (lb)	18.147	18.404	18.157
Initial Moisture Content (%)	72.6	72.6	72.6
Final Moisture Content (%)	55.4	56.9	56.2
Initial Temperature (°F)	37	38	39
Final Temperature (°F)	194	193	194
Water Loss (lb)	7.96	7.62	8.20
Calculated Values			
Initial Weight of Water (lb)	18.008	18.015	18.406
Final Weight of Water (lb)	10.053	10.472	10.204
Sensible (Btu)	2,679	2,646	2,704
Latent – Heat of Vaporization (Btu)	7,716	7,388	7,956
Total Energy to Food (Btu)	10,395	10,034	10,660
Energy to Food (Btu/lb)	419	404	420
Total Energy to Fryer (Btu)	21,387	21,227	22,944
Energy to Fryer (Btu/lb)	862	855	905
Cooking-Energy Efficiency (%)	48.6	47.3	46.5
Cooking Energy Rate (Btu/h)	74,968	73,931	78,593
Control Energy Rate (W)	21.2	21.2	21.5
Production Rate (lb/h)	87.0	86.5	86.9

Cooking-Energy Efficiency Data

Table D-3. Light-Load Chicken Test Data.

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Electrical Energy Consumption (Wh)	5.65	5.70	5.75
Energy Consumption (Btu)	7,349	6,619	6,960
Total Energy (Btu)	7,368	6,638	6,980
Total Test Time (min)	17.2	17.5	17.5
Weight Loss (%)	27.50	28.90	27.10
Initial Weight (lb)	3.159	2.950	3.009
Final Weight (lb)	2.291	2.097	2.195
Initial Moisture Content (%)	72.6	72.6	72.6
Final Moisture Content (%)	55.8	56.9	56.4
Initial Temperature (°F)	37	39	39
Final Temperature (°F)	194	193	198
Water Loss (lb)	1.02	0.95	0.95
Calculated Values			
Initial Weight of Water (lb)	2.293	2.142	2.185
Final Weight of Water (lb)	1.278	1.193	1.238
Sensible (Btu)	341	313	329
Latent – Heat of Vaporization (Btu)	985	921	919
Total Energy to Food (Btu)	1,326	1,234	1,248
Energy to Food (Btu/lb)	420	418	415
Total Energy to Fryer (Btu)	7,368	6,638	6,980
Energy to Fryer (Btu/lb)	2,332	2,250	2,320
Cooking-Energy Efficiency (%)	18.0	18.6	17.9
Cooking Energy Rate (Btu/h)	25,636	22,694	23,863
Control Energy Rate (W)	19.7	19.5	19.7
Production Rate (lb/h)	11.0	10.1	10.3

Cooking-Energy Efficiency Data

Table D-4. Heavy-Load Fry Test Data

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Electrical Energy Consumption (Wh)	5.93	6.01	5.85
Gas Energy Consumption (Btu)	43,042	44,063	42,891
Total Energy (Btu)	43,062	44,084	42,911
Cook Time (min)	2.50	2.50	2.60
Total Test Time (min)	16.44	16.70	16.30
Weight Loss (%)	29.60	30.10	30.30
Initial Weight (lb)	40.000	40.000	40.000
Final Weight (lb)	28.149	27.969	27.875
Initial Moisture Content (%)	67.8	67.8	67.8
Final Moisture Content (%)	49.6	49.1	49.2
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	212	212	212
Calculated Values			
Initial Weight of Water (lb)	27.120	27.120	27.120
Final Weight of Water (lb)	13.962	13.733	13.715
Sensible (Btu)	5,894	5,894	5,894
Latent – Heat of Fusion (Btu)	3,905	3,905	3,905
Latent – Heat of Vaporization (Btu)	12,763	12,985	13,004
Total Energy to Food (Btu)	22,562	22,784	22,803
Energy to Food (Btu/lb)	564	570	570
Total Energy to Fryer (Btu)	43,062	44,084	42,911
Energy to Fryer (Btu/lb)	1,077	1,102	1,073
Cooking-Energy Efficiency (%)	52.4	51.7	53.1
Cooking Energy Rate (Btu/h)	157,088	158,310	157,881
Control Energy Rate (W)	21.6	21.6	21.5
Production Rate (lb/h)	146.0	143.7	147.2
Average Recovery Time (sec)	47.4	50.4	39.6

Cooking-Energy Efficiency Data

Table D-5. Medium-Load Fry Test Data

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Electrical Energy Consumption (Wh)	4.29	4.30	4.37
Gas Energy Consumption (Btu)	19,744	20,245	20,188
Total Energy (Btu)	19,759	20,260	20,203
Cook Time (min)	2.10	2.00	2.10
Total Test Time (min)	11.2	11.1	11.4
Weight Loss (%)	29.70	29.10	29.60
Initial Weight (lb)	15.000	15.000	15.000
Final Weight (lb)	10.542	10.642	10.558
Initial Moisture Content (%)	67.2	67.2	67.2
Final Moisture Content (%)	50.3	51.4	49.7
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	212	212	212
Calculated Values			
Initial Weight of Water (lb)	10.080	10.080	10.080
Final Weight of Water (lb)	5.303	5.470	5.247
Sensible (Btu)	2,210	2,210	2,210
Latent – Heat of Fusion (Btu)	1,452	1,452	1,452
Latent – Heat of Vaporization (Btu)	4,634	4,472	4,688
Total Energy to Food (Btu)	8,296	8,134	8,350
Energy to Food (Btu/lb)	553	542	557
Total Energy to Fryer (Btu)	19,759	20,260	20,203
Energy to Fryer (Btu/lb)	1,317	1,351	1,347
Cooking-Energy Efficiency (%)	42.0	40.1	41.3
Cooking Energy Rate (Btu/h)	105,771	109,432	106,253
Control Energy Rate (W)	23.4	23.2	23.2
Production Rate (lb/h)	80.4	81.1	78.9
Average Recovery Time (sec)	< 10	< 10	< 10

Cooking-Energy Efficiency Data

Table D-6. Light-Load Fry Test Data

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Electrical Energy Consumption (Wh)	4.12	4.10	4.10
Gas Energy Consumption (Btu)	8,436	8,533	8,823
Total Energy (Btu)	8,450	8,547	8,837
Cook Time (min)	2.20	2.20	2.20
Total Test Time (min)	11.7	11.8	11.7
Weight Loss (%)	29.50	30.00	29.80
Initial Weight (lb)	3.750	3.750	3.750
Final Weight (lb)	2.644	2.625	2.631
Initial Moisture Content (%)	67.2	67.2	67.2
Final Moisture Content (%)	49.0	48.3	48.7
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	212	212	212
Calculated Values			
Initial Weight of Water (lb)	2.520	2.520	2.520
Final Weight of Water (lb)	1.296	1.268	1.281
Sensible (Btu)	553	553	553
Latent – Heat of Fusion (Btu)	362	362	362
Latent – Heat of Vaporization (Btu)	1,187	1,214	1,202
Total Energy to Food (Btu)	2,103	2,130	2,118
Energy to Food (Btu/lb)	561	568	565
Total Energy to Fryer (Btu)	8,450	8,547	8,837
Energy to Fryer (Btu/lb)	2,253	2,279	2,357
Cooking-Energy Efficiency (%)	24.9	24.9	24.0
Cooking Energy Rate (Btu/h)	43,262	43,388	45,246
Control Energy Rate (W)	21.1	21.0	21.3
Production Rate (lb/h)	19.2	19.1	19.2
Average Recovery Time (sec)	< 10	< 10	< 10

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

	Cooking-Energy Efficiency (%)[a]		Production Capacity
	Heavy-Load	Light-Load	(lb/h)[a]
Replicate #1	48.6	18.0	87.0
Replicate #2	47.3	18.6	86.5
Replicate #3	46.5	17.9	86.9
Average	47.5	18.2	86.8
Standard Deviation	1.06	0.38	0.26
Absolute Uncertainty	2.63	0.94	0.64
Percent Uncertainty	5.54	5.17	0.74

[a] This range indicates the experimental uncertainty in the test result based on a minimum of three test runs.

Table D-8. French Fry Cooking-Energy Efficiency and Production Capacity Statistics

	Cooking-Energy Efficiency (%)[a]			Production Capacity
	Heavy-Load	Medium-Load	Light-Load	(lb/h)[a]
Replicate #1	52.4	42.0	24.9	146.0
Replicate #2	51.7	40.1	24.9	143.7
Replicate #3	53.1	41.3	24.0	147.2
Average	52.4	41.1	24.6	145.6
Standard Deviation	0.70	0.96	0.52	1.78
Absolute Uncertainty	1.74	2.38	1.29	4.41
Percent Uncertainty	3.32	5.79	5.24	3.03

[a] This range indicates the experimental uncertainty in the test result based on a minimum of three test runs.

E Energy Cost Model

Procedure for Calculating the Energy Consumption of a Fryer Based on Reported Test Results

Appliance test results are useful not only for benchmarking appliance performance, but also for estimating appliance energy consumption. The following procedure is a guideline for estimating fryer energy consumption based on data obtained from applying the appropriate test method.

The intent of this Appendix is to present a standard method for estimating fryer energy consumption based on ASTM performance test results. The examples contained herein are for information only and should not be considered an absolute. To obtain an accurate estimate of energy consumption for a particular operation, parameters specific to that operation should be used (e.g., operating time, and amount of food cooked under heavy- and light-load conditions).

The calculation will proceed as follows: First, determine the appliance operating time and total number of preheats. Then estimate the quantity of food cooked and establish the breakdown between heavy- (64 pieces) and light- (8 pieces) loads. For example, a fryer operating for 12 hours a day with one preheat cooked 150 pounds of food: 70% of the food was cooked under heavy-load conditions and 30% was cooked under light-load conditions. Calculate the energy due to cooking at heavy- and light-load cooking rates, and then calculate the idle energy consumption. The total daily energy is the sum of these components plus the preheat energy. For simplicity, it is assumed that subsequent preheats require the same time and energy as the first preheat of the day.

The application of the test method to a gas fryer yielded the following results:

Energy Cost Model

Table E-1: Gas Fryer Performance Parameters.

Test	Result
Preheat Time (min)	20.8
Preheat Energy (Btu)	34,283
Idle Energy Rate (Btu/h)	15,356
Heavy-Load Cooking Energy Rate (Btu/h)	75,831
Light-Load Cooking Energy Rate (Btu/h)	24,064
Production Capacity (lb/h)	86.8
Light-Load Production Rate (lb/h)	10.4

***Step 1*—The operation being modeled has the following parameters**

Table E-2: Fryers Operation Assumptions.

Operating Time	12 h
Number of Preheats	1 preheat
Total Amount of Food Cooked	150 lb
Percentage of Food Cooked Under Heavy-Load Conditions	70% (× 150 lb = 105 lb)
Percentage of Food Cooked Under Light-Load Conditions	30% (× 150 lb = 45 lb)

***Step 2*—Calculate the total heavy-load energy.**

The total time cooking heavy-loads is as follows:

$$t_h = \frac{\%_h \times W}{PC},$$

$$t_h = \frac{70\% \times 150\ lb}{86.8\ \ lb/h},$$

$$t_h = 1.21\ h$$

The total heavy-load energy consumption is then calculated as follows:

$E_{gas,h} = q_{gas,h} \times t_h,$

$E_{gas,h} = 75{,}831\ Btu/h \times 1.21\ h,$

$E_{gas,h} = 91{,}756\ Btu$

***Step 3*—Calculate the total light-load energy.**

The total time cooking light-loads is as follows:

$$t_l = \frac{\%_l \times W}{PR_l},$$

$$t_l = \frac{30\% \times 150\ lb}{10.4\ \ lb/h},$$

$t_l = 4.33\ h$

The total light-load energy consumption is then calculated as follows:

$E_{gas,l} = q_{gas,l} \times t_l,$

$E_{gas,l} = 24{,}064\ Btu/h \times 4.33\ h$

$E_{gas,l} = 104{,}197\ Btu$

***Step 4*— Calculate the total idle time and energy consumption.**

The total idle time is determined as follows:

$$t_i = t_{on} - t_h - t_l - \frac{n_p \times t_p}{60},$$

$$t_i = 12.0\ h - 1.21 h - 4.33\ h - \frac{1\ preheat \times 20.8\ min}{60\ min/h}$$

$t_i = 6.11\ h$

The idle energy consumption is then calculated as follows:

$E_{gas,i} = q_{gas,i} \times t_i,$

$E_{gas,i} = 15{,}356\ Btu/h \times 6.11\ h$

$E_{gas,i} = 93{,}825\ Btu$

***Step 5*—The total daily energy consumption is calculated as follows:**

$E_{gas,daily} = E_{gas,h} + E_{gas,l} + E_{gas,i} + n_p \times E_{gas,p},$

$E_{gas,daily}$ = 91,756 Btu + 104,197 Btu + 93,825 Btu +1 × 34,283 Btu

$E_{gas,daily}$ = 324,061 Btu/day = 3.241 therms/day

***Step 6*—The annual energy cost is calculated as follows:**

$Cost_{annual} = E_{gas,daily} \times R_{gas} \times Days$

$Cost_{snnual}$ =3.241 therms/day × 1.00 $/therm × 365 days/year

$Cost_{annual}$ = 1,183 $/year