

**Dean HD50 Gas
Fryer Performance Tests**

Application of ASTM Standard
Test Method F 1361-99

FSTC Report 5011.05.12

**Food Service Technology Center
August 2005**

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

Acknowledgments

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Contents

	Page
Executive Summary	iii
1 Introduction	1-1
Background	1-2
Objectives	1-2
Appliance Description	1-3
2 Methods	2-1
Setup and Instrumentation	2-1
Measured Energy Input Rate	2-2
Cooking Tests	2-3
3 Results	3-1
Energy Input Rate	3-1
Preheat and Idle Tests	3-1
Cooking Tests	3-3
Energy Cost Model.....	3-7
4 Conclusions	4-1
5 References	5-1
Appendix A: Glossary	
Appendix B: Appliance Specifications	
Appendix C: Results Reporting Sheets	
Appendix D: Cooking-Energy Efficiency Data	
Appendix E: Energy Cost Model	

List of Figures and Tables

Figures

		Page
1-1	Dean HD50 Frypot	1-3
2-1	Equipment Configuration	2-1
2-2	Thermocouple Placement For Testing	2-2
3-1	Dean HD50 Preheat Characteristics	3-2
3-2	Frying Medium Temperature During A Heavy-Load Test For The HD50 Fryer.....	3-3
3-3	Fryer Cooking Cycle Temperature Signature	3-4
3-4	Fryer Part-Load Cooking-Energy Efficiency	3-6
3-5	Fryer Cooking Energy Consumption Profile	3-7

Tables

		Page
1-1	Appliance Specifications	1-3
3-1	Input, Preheat, and Idle Test Results	3-2
3-2	Cooking-Energy Efficiency and Production Capacity Test Results	3-5
3-3	Energy Cost Model.....	3-8

Executive Summary

Dean's HD50 gas fryer features four heat transfer tubes, for a combined total rated input of 100,000 Btu/h. The frypot is made of stainless steel and is surrounded by insulation. An optional cooking computer allows for programming of specific food product as well as controlling the input to the fryer and an integrated melt cycle. Figure ES-1 illustrates the HD50 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 frozen French fries under three different loading scenarios (heavy—3 pounds per load, medium—1½ pounds per load, and light—¾ pound per load). The HD50's heavy-load cook time was 2.30 minutes. Production capacity includes the cooking time and the time required for the frying medium to recover to 340°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:



Figure ES-1.
Dean HD50 Fryer.

¹ American Society for Testing and Materials. 2000. *Standard Test Method for the Performance of Open, Deep Fat Fryers*. ASTM Designation F 1361-99, in *Annual Book of ASTM Standards*, West Conshohocken, PA.

Executive Summary

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

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

Table ES-1. Summary of Fryer Performance.

Rated Energy Input Rate (Btu/h)	100,000
Measured Energy Input Rate (Btu/h)	95,650
Preheat Time to 350°F (min) ^a	7.58
Preheat Energy to 350°F (Btu)	11,117
Idle Energy Rate @ 350°F (Btu/h)	8,386
Heavy-Load Cooking-Energy Efficiency (%) ^b	52.1 ± 2.4
Medium-Load Cooking-Energy Efficiency (%) ^b	43.9 ± 1.4
Light-Load Cooking-Energy Efficiency (%) ^b	35.9 ± 1.5
Production Capacity (lb/h) ^b	71.6 ± 0.9
Average Frying Recovery Time (sec) ^c	12.6

^a The melt cycle was disabled during preheat.

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

^c Based on the heavy-load cooking test with a minimum 10-second preparation time between loads.

During heavy-load testing, Dean's HD50 gas fryer demonstrated a production capacity of 71.6 pounds of French fries per hour, while achieving a cooking-energy efficiency of 52.1%. The HD50 required 2.30 minutes to cook a single heavy-load test (3-pounds) of French fries, with the fryer recovered and ready-to-cook another load of French fries after the 10-second reload time specified by the test method.

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

Executive Summary

HD50 fryer are 20,300 Btu/h, 40,500 Btu/h, and 60,800 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 lb of food over a ten hour day), the average energy consumption rate for the HD50 fryer would be 25,300 Btu/h.

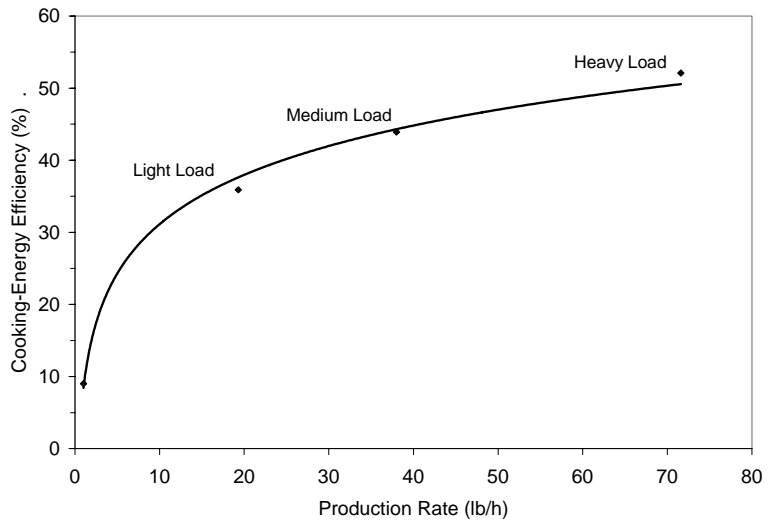


Figure ES-2.
Fryer part-load cooking-energy efficiency.

Note: Light-load = ¾ pounds/load; Medium-load = 1½ pounds/load; Heavy-load = 3 pounds/load.

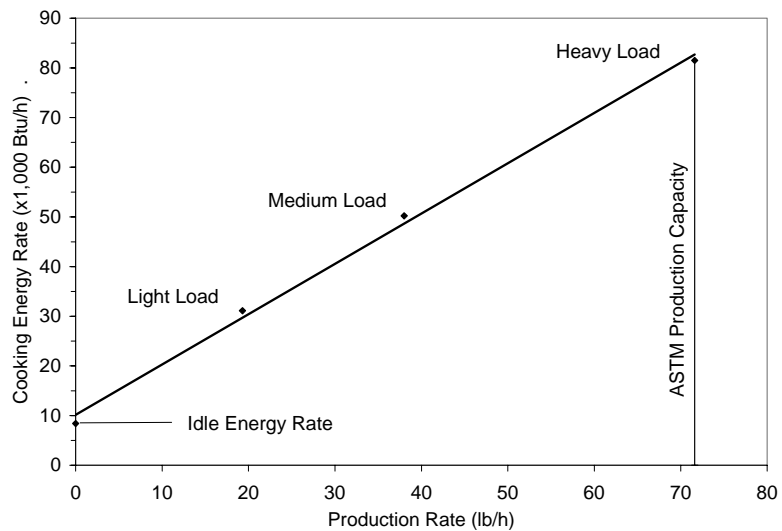


Figure ES-3.
Fryer cooking energy consumption profile.

Note: Light-load = ¾ pounds/load; Medium-load = 1½ pounds/load; Heavy-load = 3 pounds/load.

Executive Summary

The ASTM 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. Table ES-2 summarizes the estimated annual energy consumption and associated cost based on the model.

Table ES-2. Estimated Fryer Energy Consumption and Cost.

Preheat Energy (kBtu/day)	11.1
Idle Energy (kBtu/day)	77.8
Cooking Energy (kBtu/day)	129.7
Annual Energy (kBtu/year)	79,803
Annual Cost (\$/year)^a	798

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

The estimated operational cost of the HD50 gas fryer is \$798 per year. The model assumes the fryer is used to cook 100 pounds of French fries 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.

Quick response times and rapid oil temperature recovery during cooking provide a food service operator with a workhorse fryer that can handle high volume, while its 52.1% cooking-energy efficiency securely places it among the top performing gas fryers on the market.

1 Introduction

Background

Fried foods continue to be popular on the restaurant scene. French fried potatoes are still the most common deep fried food, along with onion rings, 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), allow benchmarking of equipment such that users can make meaningful comparisons among available equipment choices. Since the development of the ASTM test method for fryers in 1991^{1,2}, the FSTC has tested a wide range of gas and electric fryers.³⁻¹⁸ 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.

Dean's HD50 features a stainless steel open frypot and backsplash design with four tube burners, and an optional programmable cooking computer. The frypot features insulation to reduce standby losses during operation. An

Introduction

optional melt cycle prevents solid frying medium from scorching during pre-heat.

This report presents the results of applying the ASTM test method to the Dean HD50 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 Dean's HD50, 14-inch gas fryer at an input rating of 100,000 Btu/h under the controlled conditions of the ASTM standard test method. The scope of this testing is as follows:

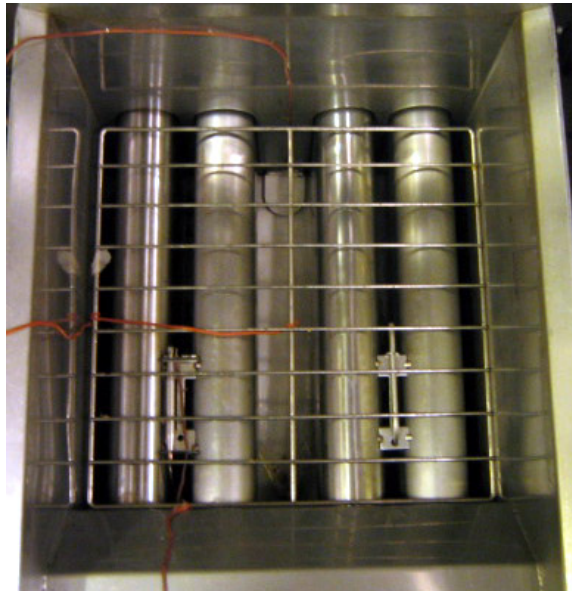
1. Verify that the appliance is operating at the manufacturer's rated energy input.
2. Determine the time and energy required to preheat the appliance from room temperature to 350°F.
3. Characterize the idle energy use with the thermostat set at a calibrated 350°F.
4. Document the cooking energy consumption and efficiency under three French fry loading scenarios: heavy (3 pounds per load), medium (1 ½ pounds per load), and light (¾ pound per load).
5. Determine the production capacity and frying medium temperature recovery time during the heavy-load test.
6. Estimate the annual operating cost for the fryer using a standard cost model.

Appliance Description

Dean's HD50, 14-inch gas fryer has an input rating of 100,000 Btu/h. The fry pot is of stainless steel construction with heat transfer tubes running from front to back in the frying medium. The frypot is surrounded with insulation to help reduce standby losses. Figure 1-1 shows the frypot for this Dean gas fryer. A cooking computer allows individualized programming for multiple food products.

Introduction

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



*Figure 1-1.
Dean HD50 frypot.*

Table 1-1. Appliance Specifications.

Manufacturer	Dean
Model	HD50
Generic Appliance Type	Open Deep Fat Fryer
Rated Input	100,000 Btu/h
Frying Area	14" x 13.75" x 17"
Oil Capacity	50 lb
Controls	Programmable cooking computer
Construction	Stainless Steel

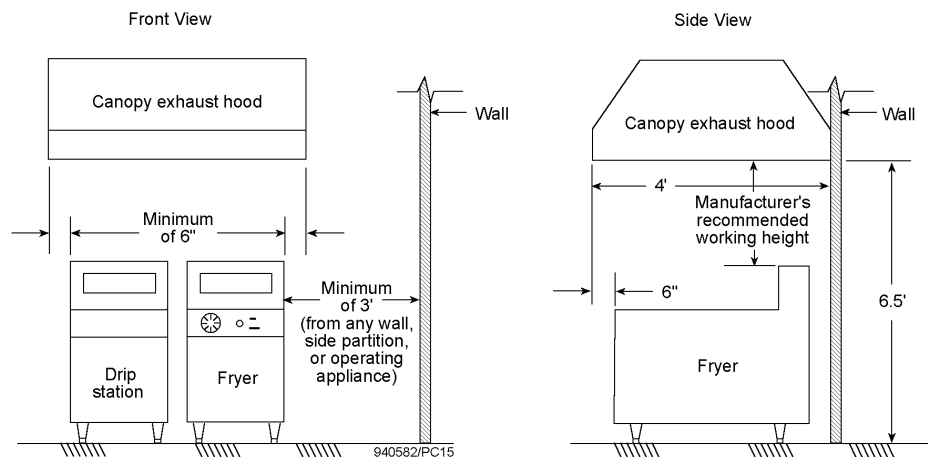
2 Methods

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.¹ 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).

Methods

Natural gas consumption was measured using a positive displacement-type gas meter that generated a pulse every 0.1 ft³. 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.

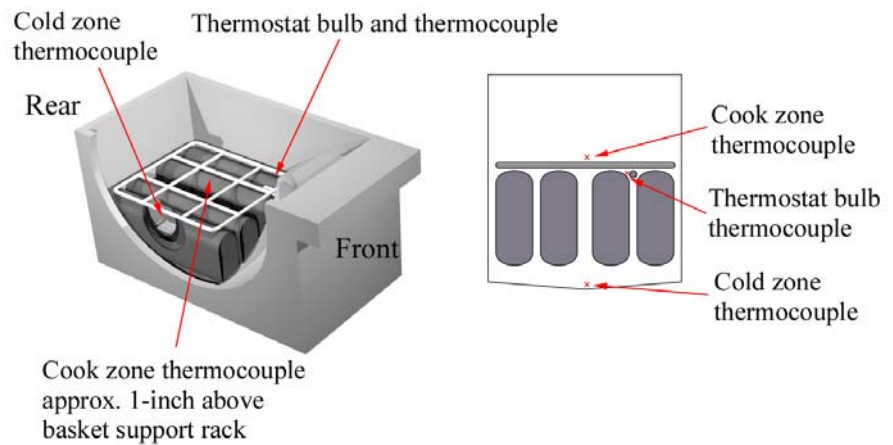


Figure 2-2.
Thermocouple placement
for testing.

Note: Graphic representation and not to scale

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 firing (such as preheat). For the purpose

Methods

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.

Cooking Tests

Researchers specified ¼-inch, blue ribbon product, par-cooked, frozen shoe-string potatoes for all cooking tests. Each load of French fries was cooked to a 30% weight loss. The cooking 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 fryer using 3-pound (heavy), 1 ½-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 did not significantly lower the average oil temperature over the cooking cycle, nor did 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 consumed. 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

Methods

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 $\pm 10\%$. 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 95,650 Btu/h (a difference of 4.4% 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 350°F, or the appliance's stand-by losses.

Preheat Energy and Time

Researchers filled the fryer with new oil, which was then heated to 350°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. Dean's cooking computer has an integrated melt cycle to prevent scorching of solid shortening, but this feature was disabled to accommodate the liquid shortening specified by the ASTM test procedure. Dean's HD50 fryer was ready to cook in 7.58 minutes, while consuming 11,117 Btu during preheat. Figure 3-1 shows the fryer's preheat characteristics.

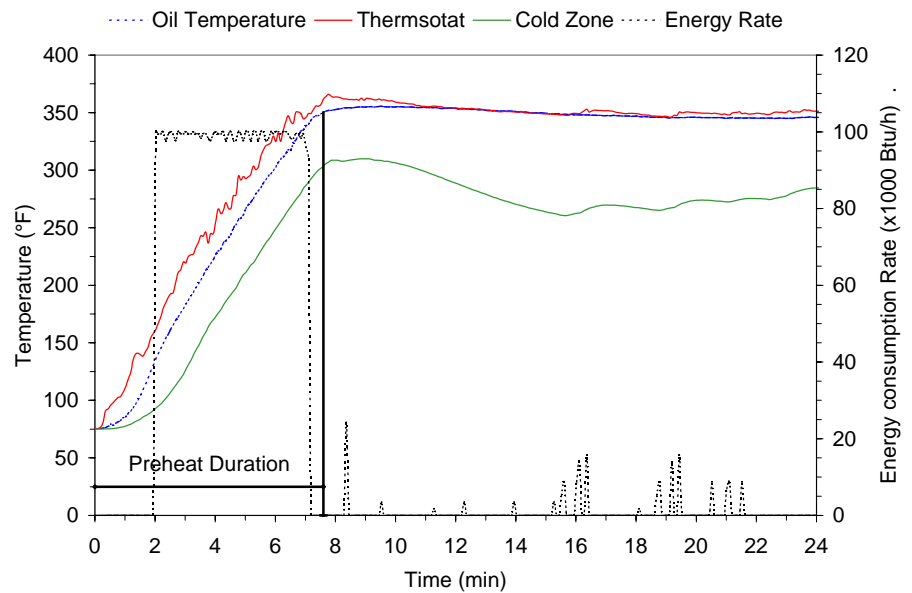
Results

Idle Energy Rate

Once the frying medium reached 350°F, the fryer was allowed to stabilize for half an hour. Time and energy consumption was monitored for an additional two-hour period as each fryer maintained the oil at 350°F. The idle energy rate during this period was 8,386 Btu/h.

Test Results

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



*Figure 3-1.
Dean HD50
preheat characteristics.*

Results

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

Rated Energy Input Rate (Btu/h)	100,000
Measured Energy Input Rate (Btu/h)	95,650
Percentage Difference (%)	4.35
Preheat ^a	
Time to 350°F (min)	7.58
Energy Consumption (Btu)	11,117
Control Energy (Wh)	1.41
Preheat Rate to 350°F (°F/min)	36.1
Idle	
Idle Energy Rate (Btu/h)	8,386
Control Energy Rate (W)	3.09

^a melt cycle was disabled for preheat

Cooking Tests

The fryer was tested under three loading scenarios: heavy (3 pounds of fries per load), medium (1 ½ 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. Researchers monitored French fry cook time and weight loss, frying medium recovery time, 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 six 3-pound loads of frozen French fries—one load after the other in rapid succession, similar to a batch-cooking procedure. Figure 3-2 shows the average temperature of the frying medium at the center of the cook zone during the heavy-load tests.

Results

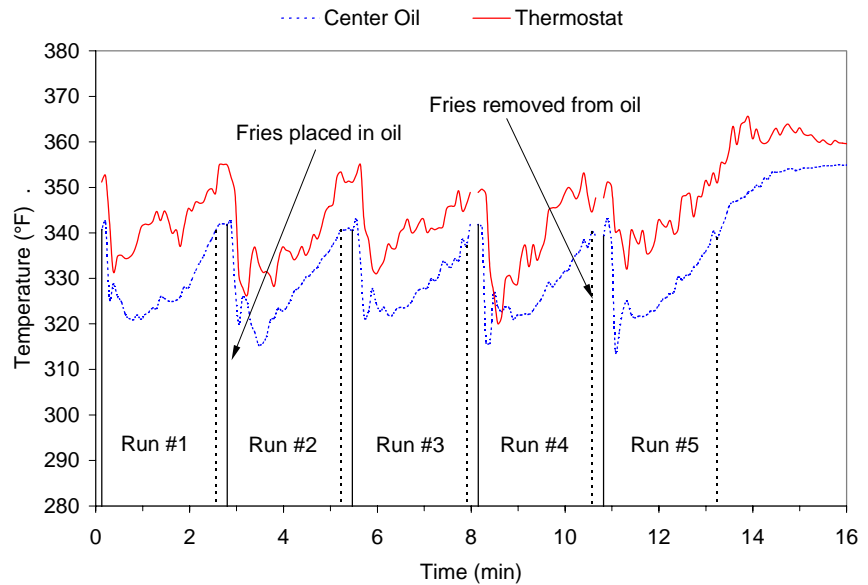


Figure 3-2.
Frying medium
temperature during a
heavy-load test for the
HD50 fryer.

The first load was used to stabilize the fryer, and the remaining five loads were used to calculate cooking-energy efficiency and production capacity. The average frying medium temperature during the heavy-load tests was 328°F. The heavy-load cook time for the fryer was 2.30 minutes, and the fryer was recovered within the 10-second reload time. Figure 3-3 illustrates the temperature response of the Dean fryer while cooking a 3-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).

Results

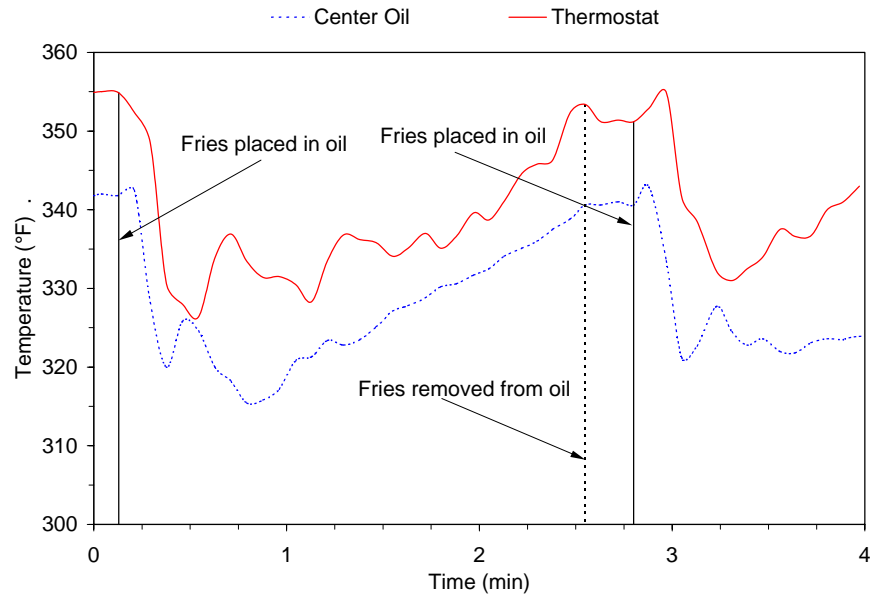


Figure 3-3.
Fryer cooking cycle
temperature signature.

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 1½ pounds of fries per load and was cooked in a time of 2.20 minutes. The light load tests used ¾ pounds of fries per load and resulted in a cooking time of 2.17 minutes.

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

Results

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 51.2%, 52.0% and 53.1%, yielding a maximum uncertainty of 2.4%. The production capacity during testing was 71.6 pounds per hour of cooked French Fries. The medium- and light-load tests demonstrated cooking-energy efficiencies of 43.9% and 35.9%, while producing 38.7 and 19.3 pounds per hour, respectively.

Table 3-2 summarizes the results of the ASTM cooking-energy efficiency and production capacity tests.

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

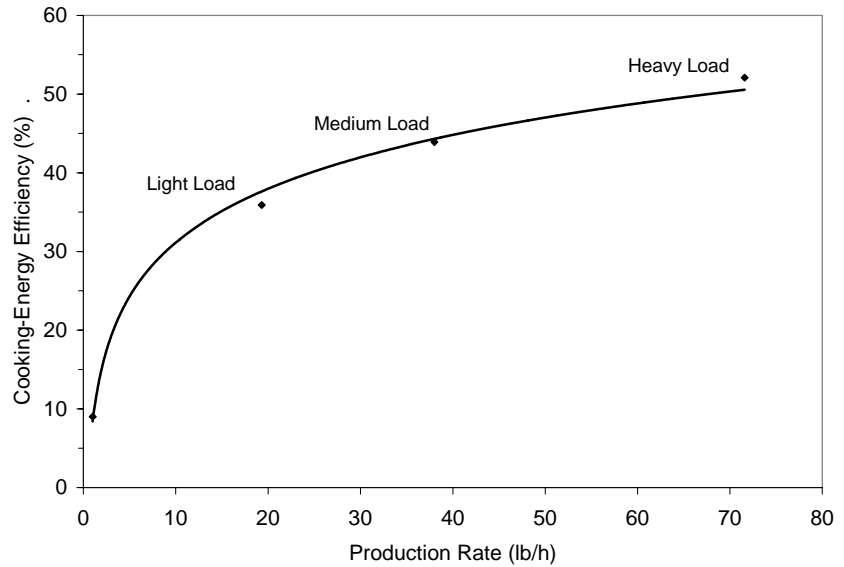
	Heavy-Load	Medium-Load	Light-Load
Load Size (lb)	3.0	1 ½	¾
French Fry Cook Time (min)	2.30	2.20	2.17
Average Recovery Time (sec)	12.6	< 10	< 10
Production Rate (lb/h) ^a	71.6 ± 0.9	38.0 ± 1.3	19.3 ± 0.3
Energy to Food (Btu/lb)	593	580	579
Cooking Energy Rate (Btu/h)	81,513	50,212	31,074
Control Energy Rate (W)	10.0	7.13	5.31
Energy per Pound of Food Cooked (Btu/lb)	1,139	1,321	1,612
Cooking-Energy Efficiency (%) ^a	52.1 ± 2.4	43.9 ± 1.4	35.9 ± 1.5

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

Figure 3-4 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 cooking tests.

Results

*Figure 3-4.
Fryer part-load cooking-
energy efficiency.*



Note: Light-load = ¾ pounds/load; Medium-load = 1½ pounds/load; Heavy-load = 3 pounds/load.

Figure 3-5 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 per hour were 20,300 Btu/h, 40,500 Btu/h, and 60,800 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 lb of food over a ten hour day), the average energy consumption rate for this fryer would be 25,300 Btu/h.

Results

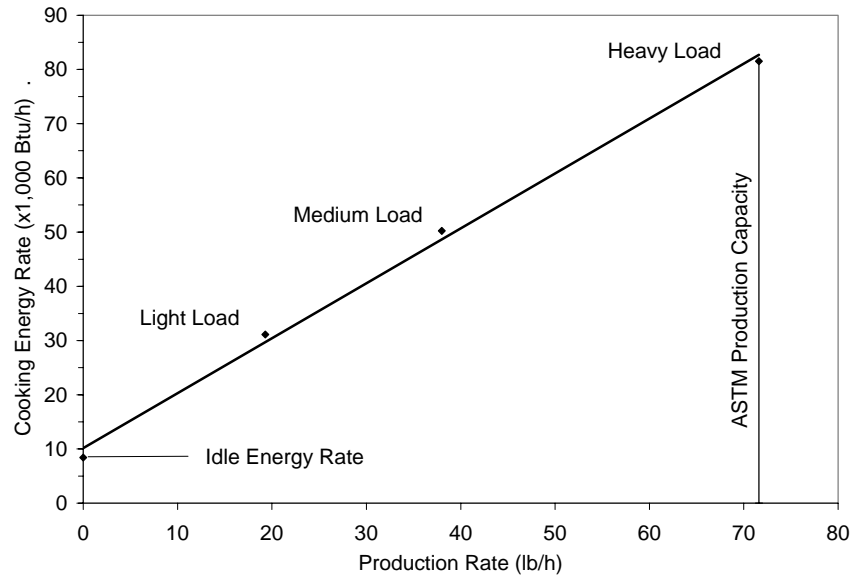


Figure 3-5.
Fryer cooking energy consumption profile.

Note: Light-load = ¼ pounds/load; Medium-load = 1½ pounds/load; Heavy-load = 3 pounds/load.

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 100 pounds of fries 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. Table 3-3 summarizes the estimated energy consumption and cost based on the model.

Results

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

Preheat Energy (kBtu/day)	11.1
Idle Energy (kBtu/day)	77.8
Cooking Energy (kBtu/day)	129.7
Annual Energy (kBtu/year)	79,803
Annual Cost (\$/year)^a	798

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

4 Conclusions

The Dean HD50 gas fryer demonstrated solid performance for a classic tube fryer. The fryer demonstrated a competitive idle energy rate, high cooking-energy efficiency and solid production capacity. The HD50 benefited in performance with the addition of insulation around the frypot. Studies have shown that fryers spend a good portion of the day in a ready-to-cook standby (idle) mode.²⁰ The HD50 exhibited low standby idle losses, with an idle energy rate of 8,386 Btu/h.

The HD50 fryer performed very well under heavy-load testing in comparison to other gas fryers tested at the Food Service Technology Center (FSTC).^{4,7-14,19} The fryer required 2.30 minutes to cook a single heavy-load test (3-pounds) of French fries, with the fryer recovered and ready to cook another load of French fries in just over 10 seconds. During heavy-load testing, the HD50 fryer achieved an impressive production capacity of 71.6 pounds of French fries per hour, while demonstrating an impressive cooking-energy efficiency of 52.1%.

The insulated frypot also factored into competitive part-load performances. Medium-load tests posted an efficiency of 43.9% while producing 38.0 lbs/h. Light-load test demonstrated a solid cooking-energy efficiency of 35.9% at a production rate of 19.3 lbs/h. Since most food service establishments operate at an average of 15 pounds per hour over a typical day, these performance figures are more representative of real world usage.

The estimated operational cost of the HD50 gas fryer is \$798 per year. The model assumes the fryer is used to cook 100 pounds of French fries over a 12-hour day, 365 days a year. The model also assumes one preheat each day, with the remaining on-time being an idle (ready-to-cook) state.

Conclusions

Dean's HD50 gas fryer with the insulated frypot and high input offers a food service operator with a classic fryer design with energy efficient performance. High production capacity and rapid recovery times mean this fryer can handle high volume operations.

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/ft³) 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 ($75 \pm 5^\circ\text{F}$) 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 10°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 Dean HD50 fryer.

Table B-1. Appliance Specifications.

Manufacturer	Dean
Model	HD50
Generic Appliance Type	Open Deep Fat Fryer
Rated Input	100,000 Btu/h
Frying Area	14" x 13.75" x 17"
Oil Capacity	50 lb
Controls	Programmable cooking computer
Construction	Stainless Steel



Job No. _____

Item No. _____

Quantity _____

HD50G High Efficiency Decathlon Gas Fryers



HD50G gas fryer (100,000 BTU) (25,189 kcal/hr.) (29.3 kW) and 48 lbs. (24L) oil capacity (shown with optional casters).

Advanced High-Production Frying Plus Economy of Operation

Designed for uses where close temperature regulation is required for a mix of heavy loads and delicate products

Maximize your profits and get superior results with this high production fryer. The HD50G holds 48 lbs. (24 L) of oil. The full-size 14" x 14" (35 x 35 cm) frying area easily accommodates items from french fries to large size menu selections.

Make the most of your energy dollars with this Energy Star rated fryer, using our exclusive Thermo-Tube design. The heating tubes are surrounded by oil and heat absorption is maximized with controlled flow tube diffusers. You get quick heat-up, for faster, more powerful volume cooking during peak periods, with only 100,000 BTU/hr. (kcal 25,189/hr.) (29.3 kW).

Combine easy clean-up with long oil life - Dean's cool zone design minimizes wasteful oil deterioration by trapping debris under the cooking area. The sloped bottom and 1.25" (3.175 cm) drain valve allow quick oil and sediment draining.

Assure quick reaction time - Dean's thermatron solid state temperature control system, accurate to within plus or minus one degree, eliminates time lost in waiting between loads by providing accurate control of power for faster recovery.

Design a system to fit your needs - combine two or more units into a battery. Add optional basket lifts, computer, and filtration system for greater product consistency, plus safe and fast oil maintenance.

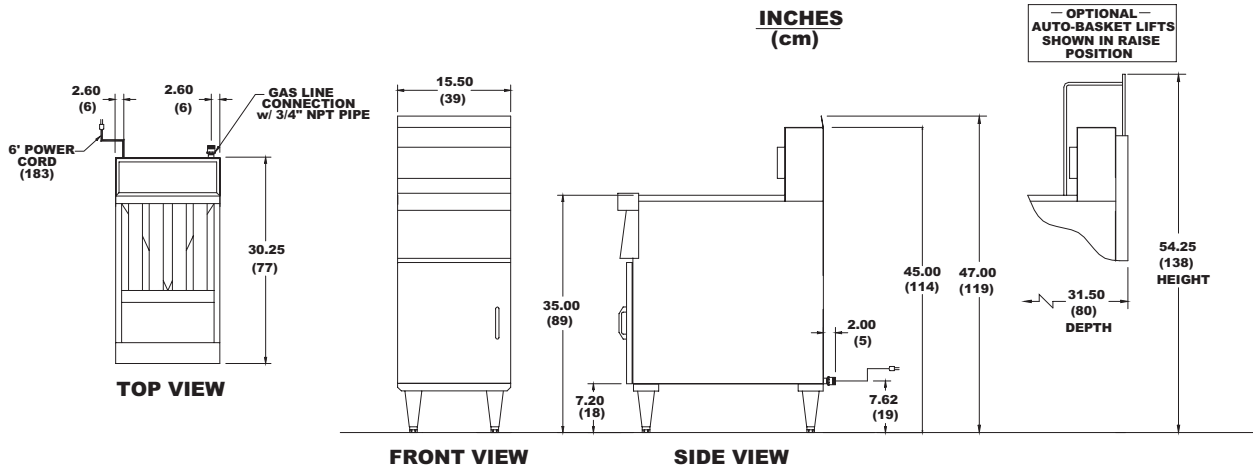
Invest in a product built to last - Dean fryers achieve long and dependable life through simplicity of design -- durable stainless steel diffusers and rugged burners keep maintenance to a minimum. Shipped standard with stainless steel frypot, front, door, and sides.



ISO 9001:2000



HD50G High Efficiency Decathlon Gas Fryers



SPECIFICATIONS

Oil Capacity	Size (cm)				Drain Valve (cm)	Drain Valve Height (cm)	No. of Tubes	Frying Area (cm)	Approximate Shipping Dimensions				
	Width	Depth	Overall Height	Work Height					Class	Shipping lbs./cu.ft. (kg/m ³)	Dimensions (cm)		
48 lbs. (24 L)	15.50" (39)	31.25" (79)	45" (114)	35" (89)	1.25" (3.175)	16.50" (42)	4	14 x 14" (35 x 35)	85	180 lbs./15 (82/0,42)	H 48.5" (123)	W 22" (56)	L 36" (91)

POWER REQUIREMENTS

Natural or LP Gas Input Rating	Gas Connection	Electrical Requirement
100,000 BTU (25,189 kcal/hr.) (29.3 kW)	3/4" N.P.T. regulator not required	120V/60~1Ø - 3.5A 230V/50~1Ø - 2A

SHORT FORM SPECIFICATION

Shall be DEAN free-standing cool zone deep fat fryer, Model HD50G. Only 15.5" (39 cm) wide, 48# (24 L) oil capacity, requiring 100,000 BTU (25,189 kcal/hr.) (29.3 kW) natural or LP gas input (3/4" N.P.T. connection) and Thermatron solid state temperature control requiring 120V/3.5 A.

DEAN, whose policy is one of constant improvement, reserves the right to amend specifications without prior notice.

STANDARD FEATURES

- Stainless steel frypot, front, door, and sides
- Stainless steel basket hanger and two fry baskets 5.50" x 6.50" x 12" (14 x 16 x 30 cm)
- Cool zone fry vessel construction
- Thermatron solid state temperature control system
- 6" (15 cm) adjustable steel legs
- Rack type basket support

ORDERING DATA

Please specify:
Natural or LP gas
Altitude -- if above 2000 ft. (610 m)

DO NOT CURB MOUNT

OPTIONS

- Casters
- Oil filtration system - see Super Cascade (UFF) or Cascade (SUFF) spec sheets for details and additional electrical requirements.
- Matching cabinet and dump station available with and without filtration.
- Electronic ignition
- Automatic melt cycle
- Boil-out mode
- Automatic basket lifts - adds 6.4 A; fryer depth becomes 31.75" (81 cm) and overall height becomes 54.25" (138 cm)
- COMPU-FRY frying computer - add 1.0A
- See Dean Price List for optional accessories



C Results Reporting Sheets

Manufacturer: Dean
Models: HD50
Date: December 2004

Test Fryer and Elements.

Description of operational characteristics: The HD150 gas fryer is rated at 100,000 Btu/h. The HD150GN fryer features tube atmospheric gas burners to deliver heat into the frying medium. Fry vats are of stainless steel construction with stainless steel front and side panels. The frypot has been insulated to reduce heat loss into the surrounding structure. An optional 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)	100,000
Measured (Btu/h)	95,650
Percent Difference between Measured and Rated (%)	4.35

Fry Vat Capacity.

Oil Capacity (lbs)	48.5
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Results Reporting Sheets

Preheat Energy and Time.

Starting Temperature (°F)	75.6
Energy Consumption (Btu)	11,117
Control Energy (Wh)	1.41
Duration (min)	7.58
Preheat Rate (°F/min)	36.1

Idle Energy Rate.

Idle Energy Rate (Btu/h)	8,386
Control Energy Rate (Wh)	3.09

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

Load Size (lb)	3.0
French Fry Cook Time (min)	2.30
Average Recovery Time (sec)	12.6
Production Capacity (lb/h) ^a	71.6 ± 0.9
Energy to Food (Btu/lb)	593
Cooking Energy Rate (Btu/h)	81,513
Control Energy Rate (W)	10.0
Energy per Pound of Food Cooked (Btu/lb)	1,139
Cooking-Energy Efficiency (%) ^a	52.1 ± 2.4

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

Results Reporting Sheets

Medium-Load Cooking-Energy Efficiency and Cooking Energy Rate.

Load Size (lb)	1 ½
French Fry Cook Time (min)	2.20
Average Recovery Time (sec)	< 10
Production Rate (lb/h) ^a	38.0 ± 1.3
Energy to Food (Btu/lb)	580
Cooking Energy Rate (Btu/h)	50,212
Control Energy Rate (W)	7.13
Energy per Pound of Food Cooked (Btu/lb)	1,321
Cooking-Energy Efficiency (%) ^a	43.9 ± 1.4

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

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

Load Size (lb)	¾
French Fry Cook Time (min)	2.17
Average Recovery Time (sec)	< 10
Production Rate (lb/h) ^a	19.3 ± 0.3
Energy to Food (Btu/lb)	579
Cooking Energy Rate (Btu/h)	31,074
Control Energy Rate (W)	5.31
Energy per Pound of Food Cooked (Btu/lb)	1,612
Cooking-Energy Efficiency (%) ^a	35.9 ± 1.5

^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
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 Fry Test Data.

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Electrical Energy Consumption (Wh)	2.10	2.11	2.10
Gas Energy Consumption (Btu)	17,299	17,008	16,911
Cook Time (min)	2.30	2.30	2.30
Total Test Time (min)	12.6	12.6	12.5
Weight Loss (%)	30.40	30.30	30.30
Initial Weight (lb)	15.000	15.000	15.000
Final Weight (lb)	10.445	10.450	10.451
Initial Moisture Content (%)	69.1	69.1	69.1
Final Moisture Content (%)	48.4	48.4	47.1
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	212	212	212
Calculated Values			
Initial Weight of Water (lb)	10.365	10.365	10.365
Final Weight of Water (lb)	5.055	5.058	4.922
Sensible (Btu)	2,210	2,210	2,210
Latent – Heat of Fusion (Btu)	1,493	1,493	1,493
Latent – Heat of Vaporization (Btu)	5,151	5,148	5,280
Total Energy to Food (Btu)	8,854	8,851	8,983
Energy to Food (Btu/lb)	590	590	597
Total Energy to Fryer (Btu)	17,306	17,015	16,918
Energy to Fryer (Btu/lb)	1,154	1,134	1,128
Cooking-Energy Efficiency (%)	51.2	52.0	53.1
Cooking Energy Rate (Btu/h)	82,376	80,990	81,173
Control Energy Rate (W)	10.0	10.1	10.1
Production Rate (lb/h)	71.4	71.4	72.0
Average Recovery Time (sec)	13.2	13.2	12.0

Cooking-Energy Efficiency Data

Table D-3. Medium-Load Fry Test Data.

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Electrical Energy Consumption (Wh)	1.40	1.42	1.40
Gas Energy Consumption (Btu)	10,016	9,919	9,772
Cook Time (min)	2.20	2.20	2.20
Total Test Time (min)	12.0	11.7	11.8
Weight Loss (%)	30.60	30.20	30.50
Initial Weight (lb)	7.500	7.500	7.500
Final Weight (lb)	5.208	5.236	5.216
Initial Moisture Content (%)	69.1	69.1	69.1
Final Moisture Content (%)	50.5	49.1	50.5
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	212	212	212
Calculated Values			
Initial Weight of Water (lb)	5.183	5.183	5.183
Final Weight of Water (lb)	2.630	2.571	2.672
Sensible (Btu)	1,105	1,105	1,105
Latent – Heat of Fusion (Btu)	746	746	746
Latent – Heat of Vaporization (Btu)	2,476	2,534	2,473
Total Energy to Food (Btu)	4,327	4,385	4,324
Energy to Food (Btu/lb)	577	585	577
Total Energy to Fryer (Btu)	10,021	9,924	9,777
Energy to Fryer (Btu/lb)	1,336	1,323	1,304
Cooking-Energy Efficiency (%)	43.2	44.2	44.2
Cooking Energy Rate (Btu/h)	50,080	50,867	49,688
Control Energy Rate (W)	7.00	7.28	7.12
Production Rate (lb/h)	37.5	38.5	38.1
Average Recovery Time (sec)	< 10	< 10	< 10

Cooking-Energy Efficiency Data

Table D-4. Light Load Fry Test Data.

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Electrical Energy Consumption (Wh)	1.00	1.10	1.00
Gas Energy Consumption (Btu)	5,912	6,205	6,010
Cook Time (min)	2.10	2.20	2.20
Total Test Time (min)	11.6	11.7	11.7
Weight Loss (%)	29.50	29.80	29.90
Initial Weight (lb)	3.750	3.750	3.750
Final Weight (lb)	2.644	2.631	2.628
Initial Moisture Content (%)	69.1	69.1	69.1
Final Moisture Content (%)	50.3	49.1	49.6
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	212	212	212
Calculated Values			
Initial Weight of Water (lb)	2.591	2.591	2.591
Final Weight of Water (lb)	1.329	1.292	1.304
Sensible (Btu)	553	553	553
Latent – Heat of Fusion (Btu)	373	373	373
Latent – Heat of Vaporization (Btu)	1,223	1,260	1,249
Total Energy to Food (Btu)	2,149	2,186	2,175
Energy to Food (Btu/lb)	573	583	580
Total Energy to Fryer (Btu)	5,915	6,209	6,103
Energy to Fryer (Btu/lb)	1,577	1,656	1,603
Cooking-Energy Efficiency (%)	36.3	35.2	36.2
Cooking Energy Rate (Btu/h)	30,579	31,821	31,811
Control Energy Rate (W)	5.17	5.64	5.13
Production Rate (lb/h)	19.4	19.2	19.2
Average Recovery Time (sec)	10.2	< 10	< 10

Cooking-Energy Efficiency Data

Table D-5. Cooking-Energy Efficiency and Production Capacity Statistics.

	Cooking-Energy Efficiency (%) ^a			Production Capacity
	Heavy-Load	Medium-Load	Light-Load	(lbs/h) ^a
Replicate #1	51.2	43.2	36.3	71.4
Replicate #2	52.0	44.2	35.2	71.4
Replicate #3	53.1	44.2	36.2	72.0
Average	52.1	43.9	35.9	71.6
Standard Deviation	0.95	0.58	0.61	0.35
Absolute Uncertainty	2.36	1.44	1.51	0.87
Percent Uncertainty	4.53	3.28	4.21	1.22

^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-, medium-, and light-loads).

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- (two 1½-lb baskets), medium- (one 1½-lb basket), and light- (one ¾-lb basket) loads. For example, a fryer operating for 12 hours a day with one preheat cooked 100 pounds of food: 36% of the food was cooked under heavy-load conditions, 48% was cooked under medium-load conditions, and 16% was cooked under light-load conditions. Calculate the energy due to cooking at heavy-, medium-, 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)	7.58
Preheat Energy (Btu)	11,117
Idle Energy Rate (Btu/h)	8,386
Heavy-Load Cooking Energy Rate (Btu/h)	81,513
Medium-Load Cooking Energy Rate (Btu/h)	50,121
Light-Load Cooking Energy Rate (Btu/h)	31,074
Production Capacity (lb/h)	71.6
Medium-Load Production Rate (lb/h)	38.0
Light-Load Production Rate (lb/h)	19.3

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	100 lb
Percentage of Food Cooked Under Heavy-Load Conditions	36% (× 100 lb = 36 lb)
Percentage of Food Cooked Under Medium-Load Conditions	48% (× 100 lb = 48 lb)
Percentage of Food Cooked Under Light-Load Conditions	16% (× 100 lb = 16 lb)

Step 2—Calculate the total heavy-load energy.

The total time cooking heavy-loads is as follows:

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

$$t_h = \frac{36\% \times 100 \text{ lb}}{71.6 \text{ lb/h}},$$

$$t_h = 0.50 \text{ h}$$

Energy Cost Model

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

$$\begin{aligned}E_{gas,h} &= q_{gas,h} \times t_h \\E_{gas,h} &= 81,513 \text{ Btu/h} \times 0.50 \text{ h}, \\E_{gas,h} &= 40,757 \text{ Btu}\end{aligned}$$

Step 3—Calculate the total medium-load energy.

The total time cooking medium-loads is as follows:

$$\begin{aligned}t_m &= \frac{\% m \times W}{PR_m}, \\t_m &= \frac{48\% \times 100 \text{ lb}}{38.0 \text{ lb/h}}, \\t_m &= 1.26 \text{ h}\end{aligned}$$

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

$$\begin{aligned}E_{gas,m} &= q_{gas,m} \times t_m \\E_{gas,m} &= 50,121 \text{ Btu/h} \times 1.26 \text{ h}, \\E_{gas,m} &= 63,152 \text{ Btu}\end{aligned}$$

Step 4—Calculate the total light-load energy.

The total time cooking light-loads is as follows:

$$\begin{aligned}t_l &= \frac{\% l \times W}{PR_l}, \\t_l &= \frac{16\% \times 100 \text{ lb}}{19.3 \text{ lb/h}}, \\t_l &= 0.83 \text{ h}\end{aligned}$$

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

$$\begin{aligned}E_{gas,l} &= q_{gas,l} \times t_l \\E_{gas,l} &= 31,074 \text{ Btu/h} \times 0.83 \text{ h} \\E_{gas,l} &= 25,791 \text{ Btu}\end{aligned}$$

Energy Cost Model

Step 5—Calculate the total idle time and energy consumption.

The total idle time is determined as follows:

$$t_i = t_{on} - t_h - t_m - t_l - \frac{n_p \times t_p}{60},$$
$$t_i = 12.0 \text{ h} - 0.50 \text{ h} - 1.26 \text{ h} - 0.83 \text{ h} - \frac{1 \text{ preheat} \times 7.58 \text{ min}}{60 \text{ min/h}}$$
$$t_i = 9.28 \text{ h}$$

The idle energy consumption is then calculated as follows:

$$E_{gas,i} = q_{gas,i} \times t_i,$$
$$E_{gas,i} = 8,386 \text{ Btu/h} \times 9.28 \text{ h}$$
$$E_{gas,i} = 77,822 \text{ Btu}$$

Step 6—The total daily energy consumption is calculated as follows:

$$E_{gas,daily} = E_{gas,h} + E_{gas,m} + E_{gas,l} + E_{gas,i} + n_p \times E_{gas,p}$$
$$E_{gas,daily} = 40,757 \text{ Btu} + 63,152 \text{ Btu} + 25,791 \text{ Btu} + 77,822 \text{ Btu} + 1 \times 11,117 \text{ Btu}$$
$$E_{gas,daily} = 218,639 \text{ Btu/day} = 2.186 \text{ therms/day}$$

Step 7—The annual energy cost is calculated as follows:

$$Cost_{annual} = E_{gas,daily} \times R_{gas} \times Days$$
$$Cost_{annual} = 2.186 \text{ therms/day} \times 1.00 \text{ \$/therm} \times 365 \text{ days/year}$$
$$Cost_{annual} = 798 \text{ \$/year}$$