Dean HD60 Large Vat
Gas Fryer Performance Tests

Application of ASTM Standard
Test Method F 1361-99

FSTC Report 5011.05.11

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Executive Summary

Dean's HD60 large-vat gas fryer features heat transfer tubes, which deliver heat into the frying medium via atmospheric burners. The frypot is made of stainless steel construction, an optional programmable cooking computer that controls the input to the fryer provides for a more consistent product. Figure ES-1 illustrates the HD60 fryer, as tested at the Food Service Technology Center (FSTC).

Figure ES-1.
Dean HD60 Fryer.

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 two food products: breaded frying chicken, and frozen shoestring potatoes. Heavy-load chicken tests used 48 pieces per load and light –load chicken tests used 8 pieces per load. The French-fry tests were conducted using three loading scenarios—heavy (5 lb), medium (2 ½ lb) and light (3/4 lb). The HD60 cooked a heavy-load of fried chicken in 16.2 minutes, producing 66.2 lb/h. Production capacity includes the cooking time and the time required for the frying medium to recover to 320°F (chicken tests).

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:

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[1] American Society for Testing and Materials. 2001. *Standard Test Method for the Performance of Large Open Vat Fryers.* ASTM Designation F 2144-01, in *Annual Book of ASTM Standards*, West Conshohocken, PA.

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

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)	125,000
Measured Energy Input Rate (Btu/h)	118,983
Preheat Time to 325°F (min)	8.54
Preheat Energy to 325°F (Btu)	16,362
Idle Energy Rate @ 325°F (1Btu/h)	10,242
Chicken Tests	
Heavy-Load Cooking-Energy Efficiency (%)[a]	37.0 ± 0.9
Light-Load Cooking-Energy Efficiency (%)[a]	18.3 ± 1.3
Production Capacity (lb/h)[a]	66.2 ± 1.5
French Fry Tests	
Heavy-Load Cooking-Energy Efficiency (%)[a]	52.2 ± 2.6
Medium-Load Cooking-Energy Efficiency (%)[a]	49.1 ± 2.2
Light-Load Cooking-Energy Efficiency (%)[a]	32.9 ± 1.2
Production Capacity (lb/h)[a]	107.1 ± 0.9

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

The HD60 gas fryer exhibited competitive cook times and a low idle rate. This translates to high production without sacrificing part-load performance.

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

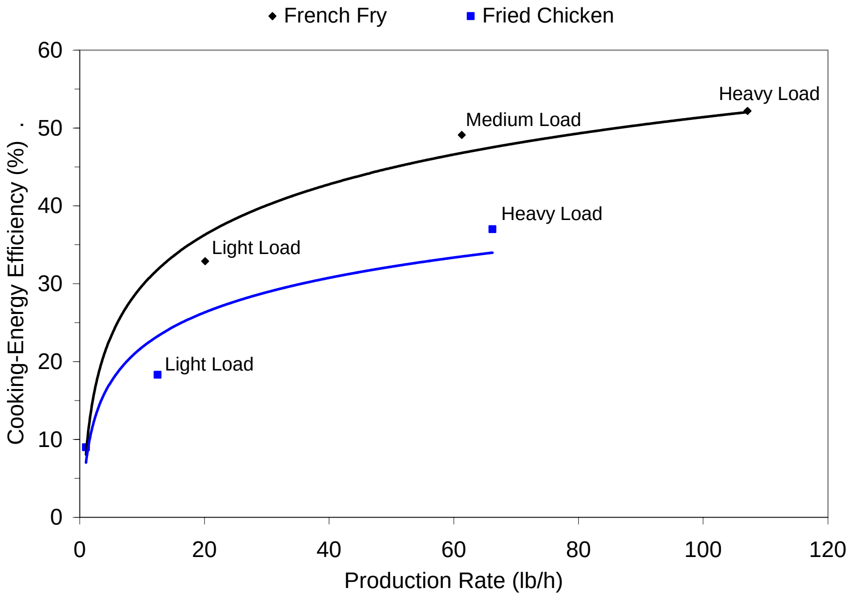


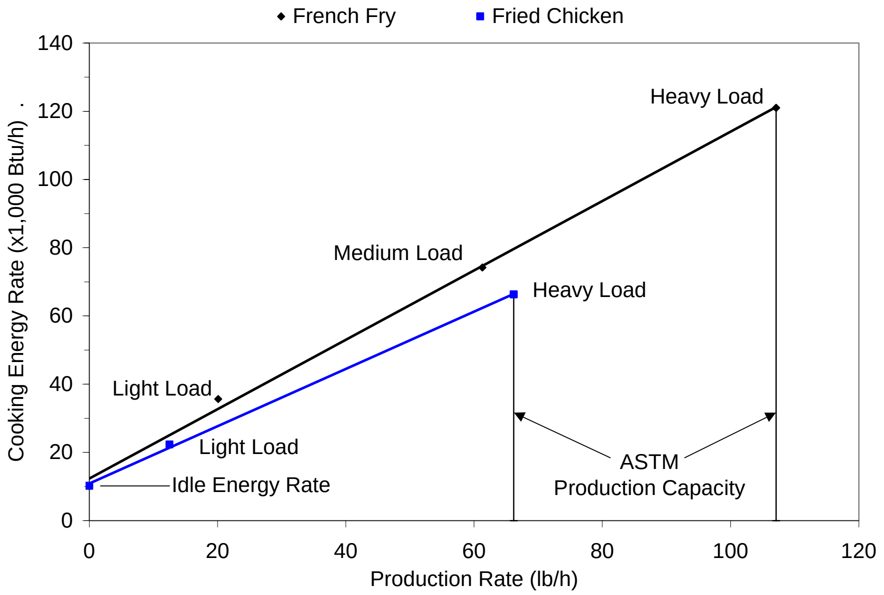
Figure ES-2.

Fryer part-load cooking-energy efficiency.

Note: French Fry: Light-load = ¾ pounds/load; Medium-load = 1½ pounds/load; Heavy-load = 3 pounds/load.
Fried Chicken: Light-load = 8 pieces/load; Heavy-load = 48 pieces/load.

Figure ES-3 illustrates the relationship between the fryer's average energy consumption rate and the production rate for the two food products. 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 of chicken are 19,300 Btu/h, 36,100 Btu/h, and 52,900 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 chicken over a ten hour day), the average energy consumption for the HD60 fryer would be 20,700 Btu/h.

Figure ES-3.
Fryer cooking energy consumption profile.



Note: French Fry: Light-load = ¾ pounds/load; Medium-load = 1½ pounds/load; Heavy-load = 3 pounds/load.
Fried Chicken: Light-load = 8 pieces/load; Heavy-load = 48 pieces/load.

The test results from the fried chicken tests 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.

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

Preheat Energy (kBtu/day)	16.3
Idle Energy (kBtu/day)	68.3
Cooking Energy (kBtu/day)	176.0
Annual Energy (kBtu/year)	90,094
Annual Cost ($/year)[a]	951

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

Executive Summary

Dean's HD60 fryer established itself as a versatile open deep fat gas 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. The heat transfer tubes in the frying medium allow for easy cleaning and low maintenance. Quick response times and rapid oil temperature recovery during cooking provide a food service operator with a workhorse fryer that can handle seriously high volume.

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.

Dean's HD60 gas fryer features five heat transfer tubes submerged in the frying oil with a stainless steel frypot, backsplash, and an optional programmable cooking computer. An integrated melt cycle prevents solid frying medium from scorching during preheat.

Introduction

This report presents the results of applying the ASTM test method[1] to the Dean HD60 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 HD60, 18-inch gas fryer at an input rating of 125,000 Btu/h, under the controlled conditions of the ASTM standard test method.[1] 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 chicken loading scenarios: heavy (48 piece load) and light (8 piece per load).
5. Document the cooking energy consumption and efficiency under three French fry loading scenarios at 350°F: heavy (5 pounds per load), medium (2 ½ pounds per load), and light (¾ pound per load).
6. Determine the production capacity and frying medium temperature recovery time for both food products during the heavy-load test.
7. Estimate the annual operating cost for the fryer using a standard cost model.

Appliance Description

Dean's HD60, 18-inch gas fryer has an input rating of 125,000 Btu/h. The fry pot is of a stainless steel construction and contains heat transfer tubes with atmospheric burners running from front to back, which provide a cooking platform within the fry vat (see Figure 1-1). An optional cooking computer allows for individualized programming for multiple food products. An integrated melt cycle prevents solid frying medium from scorching during preheat.

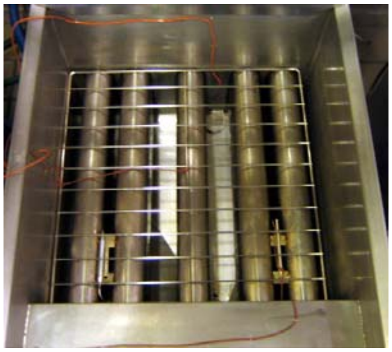


Figure 1-1.
Dean HD60 frypot.

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

Table 1-1. Appliance Specifications.

Manufacturer	Dean
Model	HD60
Generic Appliance Type	Large Vat Open Deep Fat Fryer
Rated Input	125,000 Btu/h
Frying Area	18" x 18.25" x 17"
Oil Capacity	80 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 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).

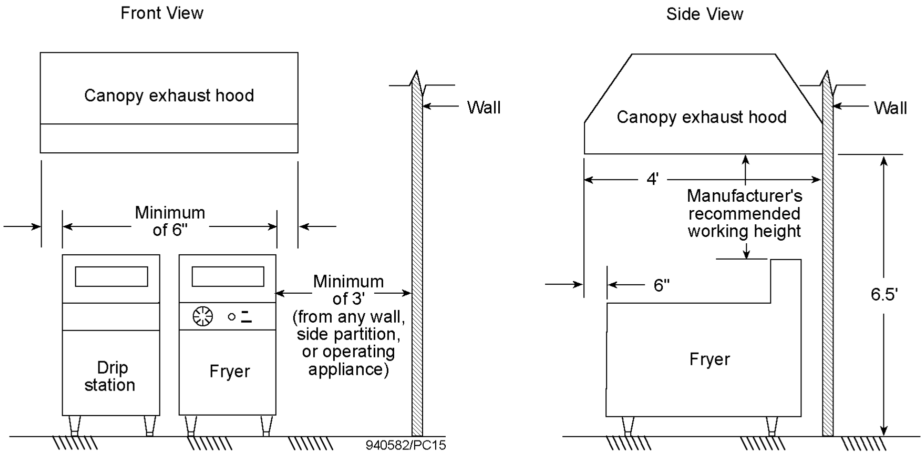
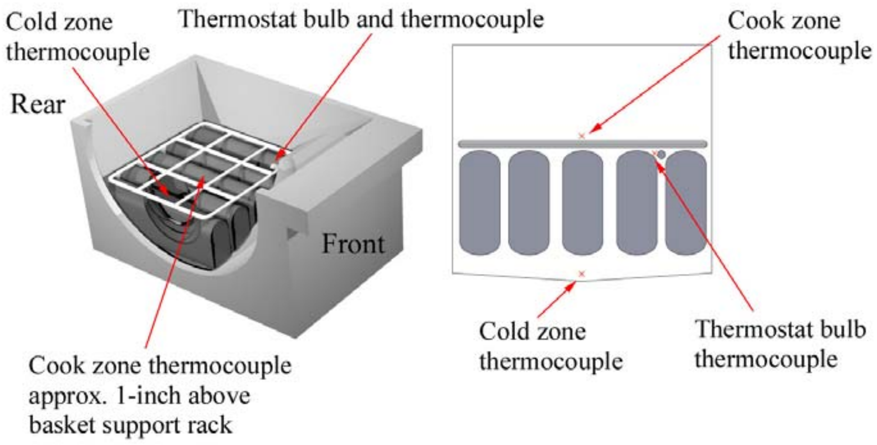


*Figure 2-1.
Equipment configuration.*

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.



Note: Graphic representation and not to scale

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 firing (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 fryer 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)	48
Light-Load (pieces)	8

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

Due to the 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: a minimum of three replicates of the heavy-load test and a minimum of 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 (F1361-99)[3]. Since the frypot could accommodate a larger load then specified in the test method, the heavy-load size was increased from three to five pounds of frozen French fries. Medium-loads were also increased in size to half the weight of the heavy-load, two and one-half 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 5-pound (heavy), 2 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 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.

The French fry tests were run in the following sequence: three replicates of the heavy-load test followed by three replicates of medium- and light-load tests. 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 118,983 Btu/h (a difference of 4.8% 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 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. Dean's cooking computer has an integrated melt cycle to prevent scorching of solid shortening, which was disabled for this test. Dean's HD60 fryer was ready to cook in 8.54 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 each fryer maintained the oil temperature at 325°F. The idle energy rate during this period was 10,242 Btu/h.

Results

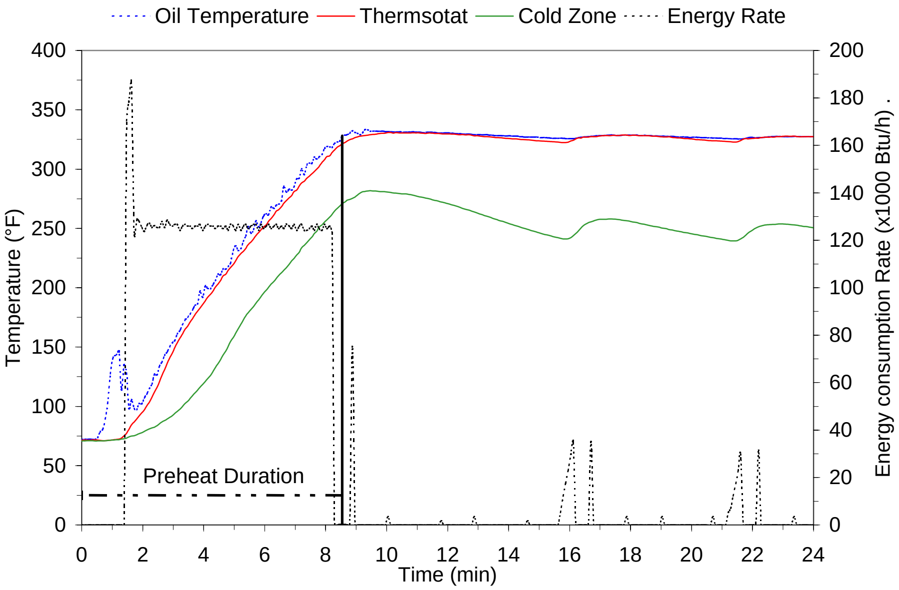


Figure 3-1.

Dean HD60 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)	125,000
Measured Energy Input Rate (Btu/h)	118,983
Percentage Difference (%)	4.81
Preheat	
Time to 325°F (min)	8.54
Preheat Energy (Btu)	16,362
Control Energy (Wh)	1.69
Preheat Rate to 325°F (°F/min)	29.6
Idle	
Energy Rate (Btu/h)	10,242
Control Energy Rate (W)	3.88

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 HD60 fryer was used to cook 48 pieces per load (12 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 chicken 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 these 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 tests were conducted using two fry baskets and the heavy-load cook time for the Dean fryer was 16.2 minutes.

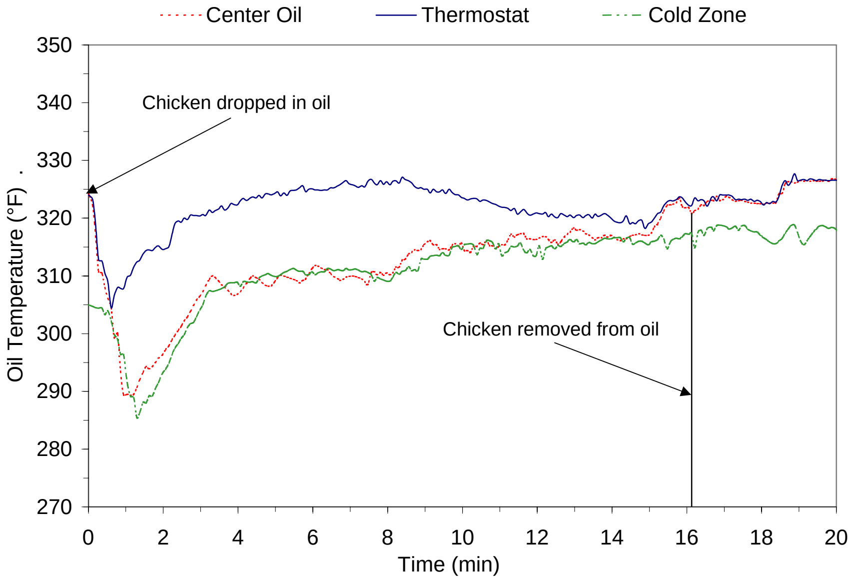


Figure 3-2.
Chicken cook cycle tempeature signature.

Light Load Tests

Light load chicken 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.

The light-load tests were conducted using a single fry basket and posted a 15.2 minute cook time.

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 37.0%, 36.2%, 37.6% and 37.1%, yielding a maximum uncertainty of 0.9%. The fryer, during light-load testing, demonstrated cooking-energy efficiencies of 19.3 %, 17.7%, 18.5% and 17.7%, with a maximum uncertainty of 1.3%. Production rates during heavy- and light-load testing were 66.2 lb/h and 12.5 lb/h, respectively.

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)	48	8
Cook Time (min)	16.2	15.2
Production Rate (lb/h)[a]	66.2 ± 1.5	12.5 ± 1.5
Energy to Food (Btu/lb)	336	328
Cooking Energy Rate (Btu/h)	60,037	22,332
Control Energy Rate (W)	7.67	7.91
Energy per Pound of Food Cooked (Btu/lb)	908	1,792
Cooking-Energy Efficiency (%)[a]	37.0 ± 0.9	18.3 ± 1.3

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

French Fry Tests

To provide additional information, the fryer was tested under three French-fry loading scenarios: heavy (5 pounds of fries per load), medium (2 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 French fry cooking tests were designed to reflect a fryer's maximum performance. The fryers were used to cook six 5-pound loads of frozen French fries—one load after the other in rapid succession, similar to a batch-cooking procedure. Figures 3-3 shows the average temperature of the frying medium during the heavy-load tests.

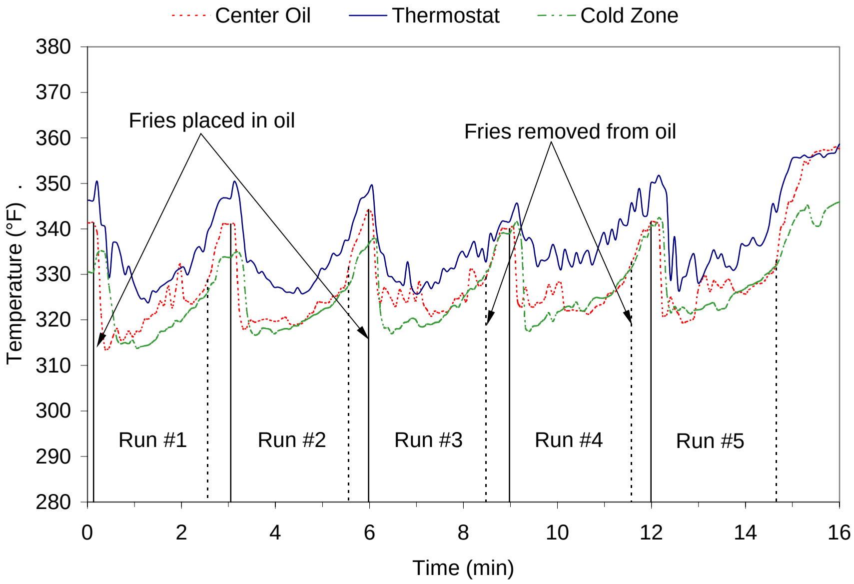


Figure 3-3.
Frying medium temperarture during a heavy-load test for the HD60 fryer.

The first load was used to stabilize the fryer, and the remaining five loads were used to calculate cooking-energy efficiency and production capacity, as seen in Figure 3-3. The heavy-load cook time for the fryer was 2.47 minutes with an average recovery time of 19.8 seconds. Figure 3-4 illustrates the temperature response of the Dean large vat fryer while cooking a 5-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).

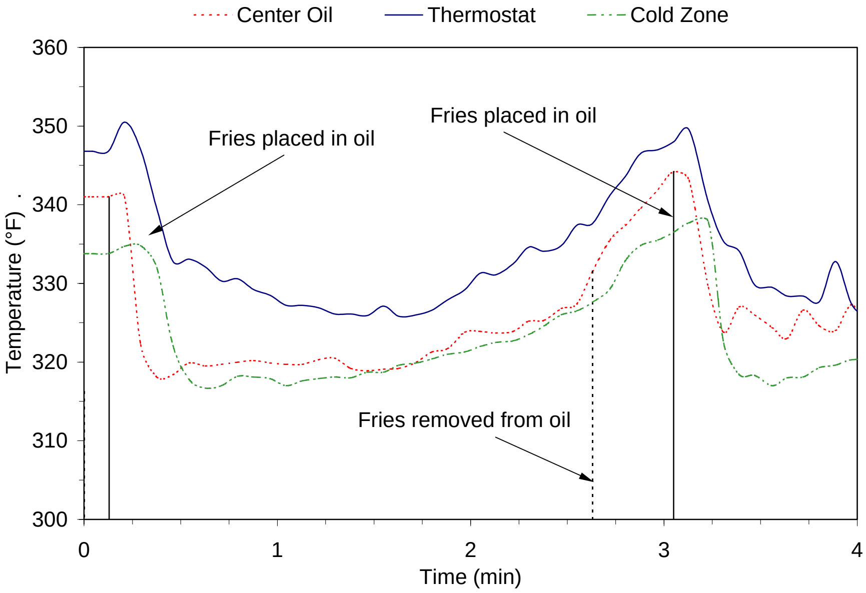


Figure 3-4.
Fryer cooking cycle temperature signature.

Medium- and Light-Load Tests

Medium- and light-load French fry 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 French fry tests were conducted using a single fry basket. The medium-load tests used 2½ pounds of fries per load and the light load tests used ¾ pounds of fries per load. Cook times were 2.30 minutes and 2.07 minutes respectively, with the fryer recovered and ready to cook another load.

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 51.3%, 51.9% and 53.3%, yielding a maximum uncertainty of 2.6%. The production capacity during testing was an impressive 107.1 pounds per hour of cooked French Fries. The medium- and light-load tests demonstrated cooking-energy efficiencies of 49.1% and 32.9%, while producing 61.3 lb/h and 19.3 20.1 lb/h, respectively.

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)	5.0	2 ½	¾
French Fry Cook Time (min)	2.47	2.30	2.07
Average Recovery Time (sec)	19.8	< 10	< 10
Production Rate (lb/h) [a]	107.1 ± 0.9	61.3 ± 2.0	20.1 ± 1.0
Energy to Food (Btu/lb)	590	594	81
Cooking Energy Rate (Btu/h)	121,042	74,178	35,598
Control Energy Rate (W)	19.8	8.81	5.95
Energy per Pound of Food Cooked (Btu/lb)	1,130	1,210	1,767
Cooking-Energy Efficiency (%)[a]	52.2 ± 2.6	49.1 ± 2.2	32.9 ± 1.2

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

Results Discussion

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 1/4-inch shoestring potatoes represent two extremes in cooking. The frozen fries have a large surface area to volume ratio, which promotes quick heat transfer to the interior of the food product. Breaded chicken is difficult to cook, due to the low surface area to volume ratio and a 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 when cooking two types of food product. 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.

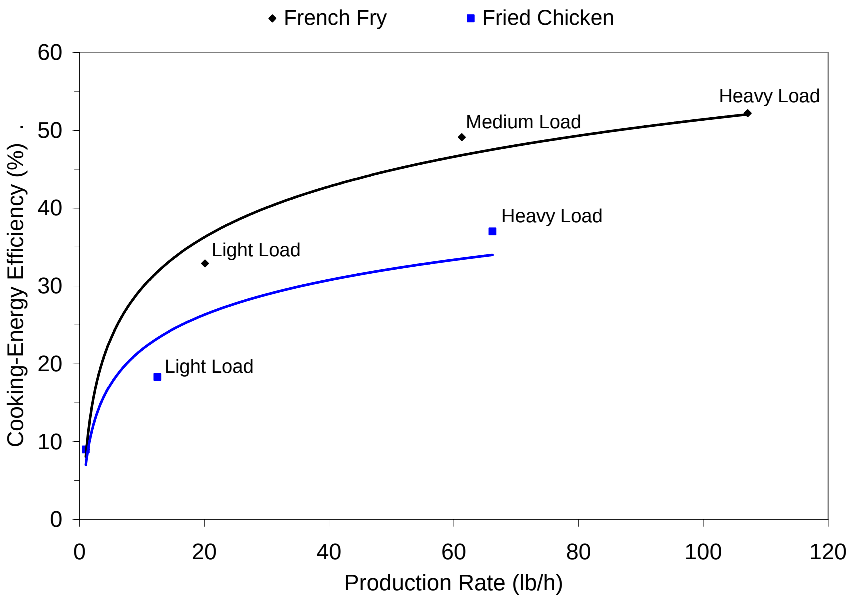


Figure 3-5.
Fryer part-load cooking-energy efficiency.

Note: French Fry: Light-load = ¾ pounds/load; Medium-load = 1½ pounds/load; Heavy-load = 3 pounds/load.
Fried Chicken: Light-load = 8 pieces/load; Heavy-load = 48 pieces/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 for the fryer in a real-world operation. Average energy consumption rates at 10, 30, and 50 pounds per hour of chicken were 19,300 Btu/h, 36,100 Btu/h, and 52,900 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 average energy consumption for the HD60 fryer would be 20,700 Bu/h.

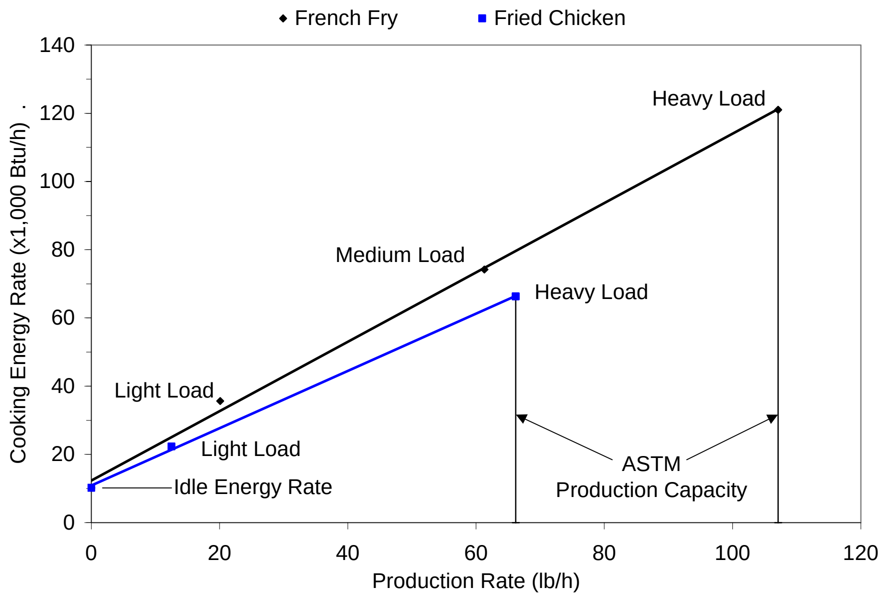


Figure 3-6.
Fryer cooking energy consumption profile.

Note: French Fry: Light-load = ¾ pounds/load; Medium-load = 1½ pounds/load; Heavy-load = 3 pounds/load.
Fried Chicken: Light-load = 8 pieces/load; Heavy-load = 48 pieces/load.

Energy Cost Model

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. Table 3-4 summarizes the estimated energy consumption and cost based on the model.

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

Preheat Energy (kBtu/day)	16.3
Idle Energy (kBtu/day)	68.3
Cooking Energy (kBtu/day)	176.0
Annual Energy (kBtu/year)	90,094
Annual Cost ($/year)[a]	951

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

4 Conclusions

Dean's DH-160 large-vat gas fryer exhibited strong performance while cooking both breaded chicken product and traditional French fries. During the heavy-load chicken tests, the fryer produced 66.2 lb/h while demonstrating a cooking-energy efficiency of 37.0%. During the French fry tests, the fryer produced an impressive 107.1 lb/h, while achieving a cooking-energy efficiency of 52.2%.

While the HD60 fryer showed strong performance under heavy-load testing, it posted solid part-load efficiencies as well. Since most food service establishments operate at an average of 15 pounds per hour over a typical day, partial load performance figures are more representative of real world application. During the light-load cooking tests, the efficiency was 18.3% for chicken and 32.9% for French fries.

During non-cooking periods, the fryer required 10,242 Btu/h to maintain a ready-to-cook state (325°F oil temperature). This low idle rate compares well to other large vat fryers, which typically exhibit idle rate of 15,000 to 20,000 Btu/h. Since fryers typically spend a good portion of the day in a ready-to-cook state, this translates to lower operating costs for the HD60.

The estimated operational cost of the HD60 large vat gas fryer is $951 per year. The model assumes the fryer is used to cook 15 lb 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 (standby) state.

The Dean HD60 fryer offers versatility without sacrificing performance. This fryer is well suited for institutions requiring high volume production.

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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 Dean HD60 fryer.

Table B-1. Appliance Specifications.

Manufacturer	Dean
Model	HD60
Generic Appliance Type	Large Vat Open Deep Fat Fryer
Rated Input	125,000 Btu/h
Frying Area	18" x 18.25" x 17"
Oil Capacity	80 lb
Controls	Programmable cooking computer
Construction	Stainless Steel

DEAN

Job No.______________________________
Item No.______________________________
Quantity______________________________

HD60G High Efficiency Decathlon Gas Fryers

HD60G gas fryer standard with 125,000 BTU (31,486 kcal/hr.) (37 kW) burners and 80 lbs. (39L) oil capacity (shown with optional computer, basket lifts and casters).

ISO 9001:2000

Large Capacity/High Production Plus High Efficiency

Designed for uses where close temperature regulation responds to a mix of large loads and delicate products

Maximize your profits and get superior results and higher production by providing precise temperature control, rapid recovery, and economical operation. With an oil capacity of 80 lbs., (39 liters) these units are ideal for everything from chicken and other breaded products to specialty foods and large size menu items requiring more frying area.

Make the most of your energy dollars with our exclusive Thermo-Tube design. The heating tubes are surrounded by oil and heat absorption is maximized with controlled flow tube diffusers. The energy is forced into the oil, with less going unused up the vent. You benefit with quick heat-up time, low idle costs, and low gas consumption per load of product cooked.

Enjoy rapid recovery - Dean's Thermatron solid state temperature control system, accurate to within plus or minus one degree, makes sure that your fryer responds to load demand as you add product.

Get superior results with the 125,000 BTU (31,486 kcal/hr) (37 kW) for frying large quantities fast.

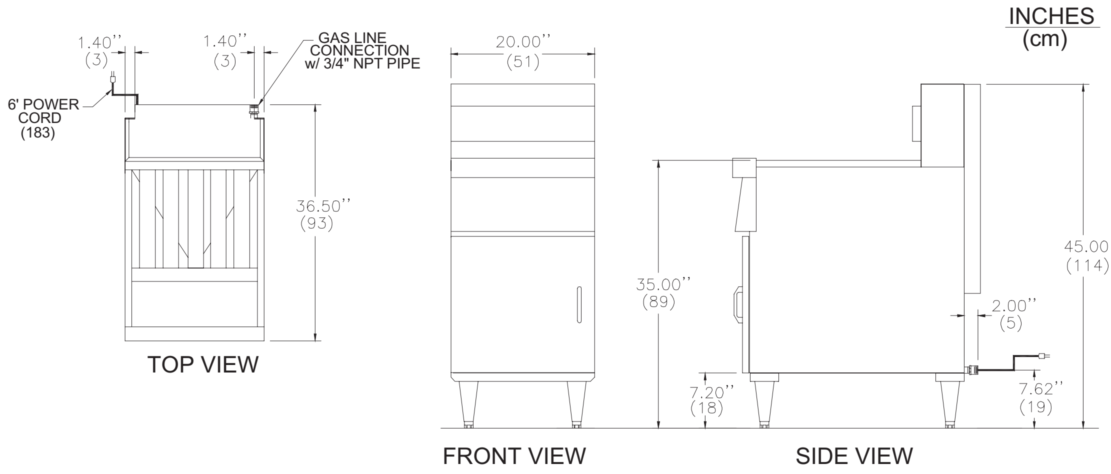
Build on our versatility **-** combine two or more units into a battery. Add optional filtration for safe and fast oil filtering; or specify a computer or basket lifts to help assure product consistency. Positive sloped bottom with 1.25" (3.175 cm) drain valve allows quick oil and sediment draining.

Enjoy lasting satisfaction - 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.

5489 Campus Drive, Shreveport, LA 71129, USA•Telephone: 318/865-1711•Toll Free: 800/221-4583•FAX:318/868-5987
http://dean.enodis.com

Bulletin No. 830-0090 Printed in U.S.A. 07/05

HD60G High Efficiency Decathlon Gas Fryers



SPECIFICATIONS

Min./Max. 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)		
80 lbs. (39 L)	20" (51)	36.50" (93)	45" (114)	35" (89)	1.25" (3.175)	18.75" (48)	5	18 x 18" (46 x 46)	85	255 lbs./28 (116/0,8)	**H** 55" (140)	**W** 29.5" (75)	**L** 43" (109)

POWER REQUIREMENTS

Natural or LP Gas Input Rating	Gas Connection	Electrical Requirement
125,000 BTU (31,486 kcal/hr.) (37 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 HD60G. Only 20" (51 cm) wide, 80# (39 liters) oil capacity, requiring 125,000 BTU (31,486 kcal/hr.) (37 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 6 1/8" x 8 3/4" x 17" (15 x 22 x 43 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 38" (97 cm) and overall height becomes 54.25" (138 cm)
☐ COMPU-FRY frying computer - add 1.0A
☐ See Dean Price List for optional accessories

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07/05

C Results Reporting Sheets

Manufacturer: Dean
Models: HD60
Date: June 2005

Test Fryer and Burner

Description of operational characteristics: Dean's HD60 gas fryer is rated at 125,000 Btu/h. The HD60 fryer features five heat transfer tubes to deliver heat into the frying medium. 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)	125,000
Measured (Btu/h)	118,983
Percent Difference between Measured and Rated (%)	4.81

Fry Vat Capacity.

Oil Capacity (lb)	82.8

Results Reporting Sheets

Thermostat Calibration

Thermostat Setting (°F)	325
Oil Temperature (°F)	321

Preheat Energy and Time

Starting Temperature (°F)	72.1
Energy Consumption (Btu)	16,362
Control Energy (Wh)	1.69
Duration (min)	8.54
Preheat Rate (°F/min)	29.6

Idle Energy Rate

Idle Energy Rate @ 325°F (Btu/h)	10,242
Control Energy Rate (W)	3.88

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

Load Size (pieces)	48
Cook Time (min)	16.2
Production Capacity (lb/h) [a]	66.2 ± 1.5
Energy to Food (Btu/lb)	336
Cooking Energy Rate (Btu/h)	60,037
Control Energy Rate (W)	7.67
Energy per Pound of Food Cooked (Btu/lb)	908
Cooking-Energy Efficiency (%)[a]	37.0 ± 0.9

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

Results Reporting Sheets

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

Load Size (lb)	8
Cook Time (min)	13.6
Production Rate (lb/h) [a]	12.5 ± 1.5
Energy to Food (Btu/lb)	328
Cooking Energy Rate (Btu/h)	22,332
Control Energy Rate (W)	7.79
Energy per Pound of Food Cooked (Btu/lb)	1,792
Cooking-Energy Efficiency (%)[a]	18.3 ± 1.3

[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)	5.0
French Fry Cook Time (min)	2.47
Average Recovery Time (sec)	19.8
Production Capacity (lb/h) [a]	107.1 ± 0.0
Energy to Food (Btu/lb)	590
Cooking Energy Rate (Btu/h)	121,042
Control Energy Rate (W)	19.8
Energy per Pound of Food Cooked (Btu/lb)	1,130
Cooking-Energy Efficiency (%)[a]	52.2 ± 2.6

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

Results Reporting Sheets

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

Load Size (lb)	2 ½
French Fry Cook Time (min)	2.30
Average Recovery Time (sec)	< 10
Production Rate (lb/h) [a]	61.3 ± 2.0
Energy to Food (Btu/lb)	594
Cooking Energy Rate (Btu/h)	74,178
Control Energy Rate (W)	8.81
Energy per Pound of Food Cooked (Btu/lb)	1,210
Cooking-Energy Efficiency (%)[a]	49.1 ± 2.2

[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)	2.07
Average Recovery Time (sec)	< 10
Production Rate (lb/h) [a]	20.1 ± 1.0
Energy to Food (Btu/lb)	581
Cooking Energy Rate (Btu/h)	35,598
Control Energy Rate (W)	5.95
Energy per Pound of Food Cooked (Btu/lb)	1,767
Cooking-Energy Efficiency (%)[a]	32.9 ± 1.2

[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	Repetition #4
Measured Values				
Electrical Energy Consumption (Wh)	2.05	2.12	2.06	2.08
Energy Consumption (Btu)	15,917	16,611	16,121	16,355
Total Test Time (min)	16.2	16.4	16.2	16.2
Weight Loss (%)	28.98	28.84	28.33	29.86
Initial Weight (lb)	17.460	18.387	17.851	17.965
Final Weight (lb)	12.401	13.085	12.793	12.600
Initial Moisture Content (%)	61.5	61.5	61.5	61.5
Final Moisture Content (%)	53.4	54.4	52.5	53.9
Initial Temperature (°F)	39	39	39	39
Final Temperature (°F)	198	193	197	196
Water Loss (lb)	4.11	4.19	4.26	4.26
Calculated Values				
Initial Weight of Water (lb)	10.738	11.308	10.978	11.048
Final Weight of Water (lb)	6.624	7.119	6.721	6.790
Sensible (Btu)	1,909	1,950	1,934	1,943
Latent – Heat of Vaporization (Btu)	3,990	4,063	4,130	4,130
Total Energy to Food (Btu)	5,899	6,012	6,064	6,073
Energy to Food (Btu/lb)	338	327	340	338
Total Energy to Fryer (Btu)	15,924	16,618	16,128	16,362
Energy to Fryer (Btu/lb)	912	904	903	911
Cooking-Energy Efficiency (%)	37.0	36.2	37.6	37.1
Cooking Energy Rate (Btu/h)	59,135	60,698	59,892	60,426
Control Energy Rate (W)	7.60	7.73	7.64	7.70
Production Rate (lb/h)	64.9	67.2	66.3	66.4

Cooking-Energy Efficiency Data

Table D-3. Light-Load Chicken Test Data

	Repetition #1	Repetition #2	Repetition #3	Repetition #4
Measured Values				
Electrical Energy Consumption (Wh)	1.85	1.87	2.08	2.08
Energy Consumption (Btu)	5,575	5,602	5,634	5,721
Total Test Time (min)	14.2	14.2	16.2	16.3
Weight Loss (%)	24.67	24.80	26.92	25.67
Initial Weight (lb)	3.181	3.105	3.165	3.136
Final Weight (lb)	2.396	2.335	2.313	2.331
Initial Moisture Content (%)	61.5	61.5	61.5	61.5
Final Moisture Content (%)	50.1	52.5	52.9	52.8
Initial Temperature (°F)	39	39	39	38
Final Temperature (°F)	198	192	198	196
Water Loss (lb)	0.75	0.68	0.72	0.70
Calculated Values				
Initial Weight of Water (lb)	1.956	1.910	1.946	1.928
Final Weight of Water (lb)	1.201	1.227	1.223	1.231
Sensible (Btu)	348	328	343	339
Latent – Heat of Vaporization (Btu)	732	663	702	676
Total Energy to Food (Btu)	1,080	990	1,045	1,015
Energy to Food (Btu/lb)	340	319	330	324
Total Energy to Fryer (Btu)	5,582	5,608	5,634	5,728
Energy to Fryer (Btu/lb)	1,755	1,806	1,780	1,827
Cooking-Energy Efficiency (%)	19.3	17.7	18.5	17.7
Cooking Energy Rate (Btu/h)	23,608	23,720	20,880	21,123
Control Energy Rate (W)	7.84	7.91	7.72	7.70
Production Rate (lb/h)	13.5	13.1	11.7	11.6

Table D-4. Heavy-Load Fry Test Data

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Electrical Energy Consumption (Wh)	2.90	2.89	2.90
Gas Energy Consumption (Btu)	28,292	28,292	28,146
Cook Time (min)	2.40	2.50	2.50
Total Test Time (min)	14.0	14.0	14.0
Weight Loss (%)	29.20	29.80	30.50
Initial Weight (lb)	25.000	25.000	25.000
Final Weight (lb)	17.711	17.560	17.378
Initial Moisture Content (%)	70.6	70.6	70.6
Final Moisture Content (%)	51.4	50.8	49.5
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	212	212	212
Calculated Values			
Initial Weight of Water (lb)	17.650	17.650	17.650
Final Weight of Water (lb)	9.103	8.920	8.602
Sensible (Btu)	3,684	3,684	3,684
Latent – Heat of Fusion (Btu)	2,542	2,542	2,542
Latent – Heat of Vaporization (Btu)	8,291	8,468	8,777
Total Energy to Food (Btu)	14,157	14,694	15,003
Energy to Food (Btu/lb)	581	588	600
Total Energy to Fryer (Btu)	28,302	28,302	28,156
Energy to Fryer (Btu/lb)	1,132	1,132	1,126
Cooking-Energy Efficiency (%)	51.3	51.9	53.3
Cooking Energy Rate (Btu/h)	121,251	121,251	120,626
Control Energy Rate (W)	12.4	12.4	12.4
Production Capacity (lb/h)	107.1	107.1	107.1
Average Recovery Time (sec)	24.0	18.0	18.0

Cooking-Energy Efficiency Data

Table D-5. Medium-Load Fry Test Data

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Electrical Energy Consumption (Wh)	1.80	1.79	1.80
Gas Energy Consumption (Btu)	15,674	14,924	8,441
Cook Time (min)	2.30	2.30	2.30
Total Test Time (min)	12.4	12.1	12.2
Weight Loss (%)	31.40	30.70	30.40
Initial Weight (lb)	12.500	12.500	12.500
Final Weight (lb)	8.578	8.657	8.705
Initial Moisture Content (%)	70.6	70.6	70.6
Final Moisture Content (%)	49.9	50.9	51.4
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	212	212	212
Calculated Values			
Initial Weight of Water (lb)	8.825	8.825	8.825
Final Weight of Water (lb)	4.280	4.406	4.474
Sensible (Btu)	1,842	1,842	1,842
Latent – Heat of Fusion (Btu)	1,271	1,271	1,271
Latent – Heat of Vaporization (Btu)	4,409	4,286	4,220
Total Energy to Food (Btu)	7,522	7,399	7,333
Energy to Food (Btu/lb)	602	592	587
Total Energy to Fryer (Btu)	15,680	14,930	14,786
Energy to Fryer (Btu/lb)	1,254	1,194	1,183
Cooking-Energy Efficiency (%)	48.0	49.6	49.6
Cooking Energy Rate (Btu/h)	75,842	74,003	72,689
Control Energy Rate (W)	8.71	8.88	8.85
Production Rate (lb/h)	60.5	62.0	61.5
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)	1.10	1.12	1.10
Gas Energy Consumption (Btu)	6,511	6,755	6,608
Cook Time (min)	2.00	2.10	2.10
Total Test Time (min)	10.9	11.3	11.3
Weight Loss (%)	29.50	29.70	30.10
Initial Weight (lb)	3.750	3.750	3.750
Final Weight (lb)	2.644	2.636	2.623
Initial Moisture Content (%)	70.6	70.6	70.6
Final Moisture Content (%)	52.8	51.7	51.0
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	212	212	212
Calculated Values			
Initial Weight of Water (lb)	2.648	2.648	2.648
Final Weight of Water (lb)	1.396	1.363	1.338
Sensible (Btu)	553	553	553
Latent – Heat of Fusion (Btu)	381	381	381
Latent – Heat of Vaporization (Btu)	1,214	1,246	1,271
Total Energy to Food (Btu)	2,148	2,180	2,205
Energy to Food (Btu/lb)	573	581	589
Total Energy to Fryer (Btu)	6,515	6,759	6,612
Energy to Fryer (Btu/lb)	1,737	1,802	1,763
Cooking-Energy Efficiency (%)	33.0	32.3	33.3
Cooking Energy Rate (Btu/h)	35,840	35,867	35,087
Control Energy Rate (W)	6.06	5.95	5.84
Production Rate (lb/h)	20.6	19.9	19.9
Average Recovery Time (sec)	< 10	< 10	< 10

Cooking-Energy Efficiency Data

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	37.0	19.3	64.9
Replicate #2	36.2	17.7	67.2
Replicate #3	37.6	18.5	66.3
Replicate #4	37.1	17.7	66.4
Average	37.0	18.3	66.2
Standard Deviation	0.59	0.80	0.97
Absolute Uncertainty	0.94	1.27	1.54
Percent Uncertainty	2.54	6.92	2.54

[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	51.3	48.0	33.0	107.1
Replicate #2	51.9	49.6	32.3	107.1
Replicate #3	53.3	49.6	33.3	107.1
Average	52.2	49.1	32.9	107.1
Standard Deviation	1.03	0.92	0.51	0.00
Absolute Uncertainty	2.55	2.28	1.26	0.00
Percent Uncertainty	4.89	4.64	3.83	0.00

[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- (48 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 energy 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)	8.54
Preheat Energy (Btu)	16,362
Idle Energy Rate (Btu/h)	10,242
Heavy-Load Cooking Energy Rate (Btu/h)	60,037
Light-Load Cooking Energy Rate (Btu/h)	22,332
Production Capacity (lb/h)	66.2
Light-Load Production Rate (lb/h)	12.5

***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 = 54 lb)
Percentage of Food Cooked Under Light-Load Conditions	30% (× 150 lb = 24 lb)

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

The total time cooking heavy-loads is as follows:

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

$$t_h = \frac{70\% \times 150\ lb}{66.\ lb/h},$$

$$t_h = 1.59\ h$$

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

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

$$E_{gas,h} = 60{,}037\ Btu/h \times 1.59\ h,$$

$$E_{gas,h} = 95{,}459\ Btu$$

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

The total time cooking light-loads is as follows:

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

$$t_l = \frac{30\% \times 150\ lb}{12.5\ lb/h},$$

$$t_l = 3.60\ h$$

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

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

$$E_{gas,l} = 22{,}332\ Btu/h \times 3.60\ h$$

$$E_{gas,l} = 80{,}395\ Btu$$

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

The total idle time is determined as follows:

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

$$t_i = 12.0\ h - 1.59\ h - 3.60\ h - \frac{1\ preheat \times 8.54\ min}{60\ min/h}$$

$$t_i = 6.67\ h$$

The idle energy consumption is then calculated as follows:

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

$$E_{gas,i} = 10{,}242\ Btu/h \times 6.67\ h$$

$$E_{gas,i} = 68{,}314\ Btu$$

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

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

$$E_{gas,daily} = 95{,}459 \text{ Btu} + 80{,}395 \text{ Btu} + 68{,}314 \text{ Btu} + 1 \times 16{,}362 \text{ Btu}$$

$$E_{gas,daily} = 260{,}530 \text{ Btu/day} = 2.605 \text{ therms/day}$$

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

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

$$Cost_{annual} = 2.605 \text{ therms/day} \times 1.00 \text{ \$/therm} \times 365 \text{ days/year}$$

$$Cost_{annual} = 951 \text{ \$/year}$$