

Vulcan High Capacity Fryer Performance Testing

FSTC Report 5011.00.88

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Executive Summary

The three Vulcan fryers tested are powered by atmospheric burners each rated at 30,000 Btu/h. The TK 65 and GRD 65 contain five burners. The GRD 85 also contains five burners with longer heat transfer tubes and a 30% larger cooking area. The TK series fryer uses a mechanical thermostat, and the GRD series fryers use a solid state thermostat and control package with an integrated melt cycle for solid shortening. Figure ES-1 illustrates Vulcan TK and GRD series fryers tested at the Food Service Technology Center (FSTC). The melt cycle has an override that allows for a shorter preheat when using a liquid shortening.

Food Service Technology Center (FSTC) engineers tested the fryers using a modified version of the American Society for Testing and Materials' (ASTM) Standard Test Method for the Performance of Pressure and Kettle Fryers.¹ Fryer performance is characterized by preheat time and energy consumption, idle energy consumption rate, cooking energy efficiency, and production capacity.

Cooking performance was determined by cooking breaded 8-piece cut 2 ¾ frying chicken under three load scenarios: heavy—64 pieces (GRD 85) or 48 pieces (TK 65 and GRD 65), medium—32 pieces (GRD 85) or 24 pieces (TK 65 and GRD 65), and light—8 pieces for all three fryers. The cook time for the TK 65 fryer heavy load test was 20.35 minutes. While the GRD 65 and 85 series fryers had heavy load cook times of 20.46 and 19.34 respectively. Production capacity is based on heavy load tests. Additional cooking performance was determined by cooking frozen French fries under two different loading scenarios (heavy—5 pounds per load and light—¾ pound per

¹ American Society for Testing and Materials. 1999. *Standard Test Method for the Performance of Pressure Fryers*. ASTM Designation F 1964-99, in *Annual Book of ASTM Standards*, Philadelphia.

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load). Production capacity includes the cooking time and the time required for the frying medium to recover to 340°F (recovery time).

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

Cooking energy efficiency is a measure of how much of the energy that an appliance consumes is actually delivered to the food product during the cooking process. Cooking energy efficiency is therefore defined by the following relationship:

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

Figure ES-1.
Vulcan TK and GRD series
Gas fryers.



TK Series



GRD Series

Executive Summary

Table ES-1. Summary of Fryer Performance.

	<i>TK 65</i>	<i>GRD 65</i>	<i>GRD 85</i>
Rated Energy Input Rate (Btu/h)	150,000	150,000	150,000
Measured Energy Input Rate (Btu/h)	154,426	154,555	146,627
Preheat Time to 325°F (min)	8.6	8.8	10.7
Preheat Energy to 325°F (Btu)	21,469	20,446	26,889
Idle Energy Rate @ 325°F (Btu/h)	14,875	18,298	19,273
Cooking Energy Efficiency:			
Heavy-Load (%) ^a	30.6 ± 2.4	29.5 ± 0.3	35.7 ± 0.8
Medium-Load (%) ^a	21.2 ± 1.9	21.5 ± 1.3	27.0 ± 1.2
Light-Load (%) ^a	12.3 ± 0.6	11.2 ± 0.7	12.4 ± 0.9
Production Capacity (lb/h) ^b	54.0 ± 3.1	53.3 ± 1.3	75.7 ± 5.3

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

^bBased on the heavy-load cooking test

The larger fry vat size of the GRD 85 demonstrated higher production capacity and cooking energy efficiency values over the smaller vat fryers of the TK 65 and GRD 65. Table ES-2 compares the load sizes for all three fryers. The increase in oil volume for the GRD 85 lengthened the preheat time, but was negligible compared to the 40% gain in production capacity.

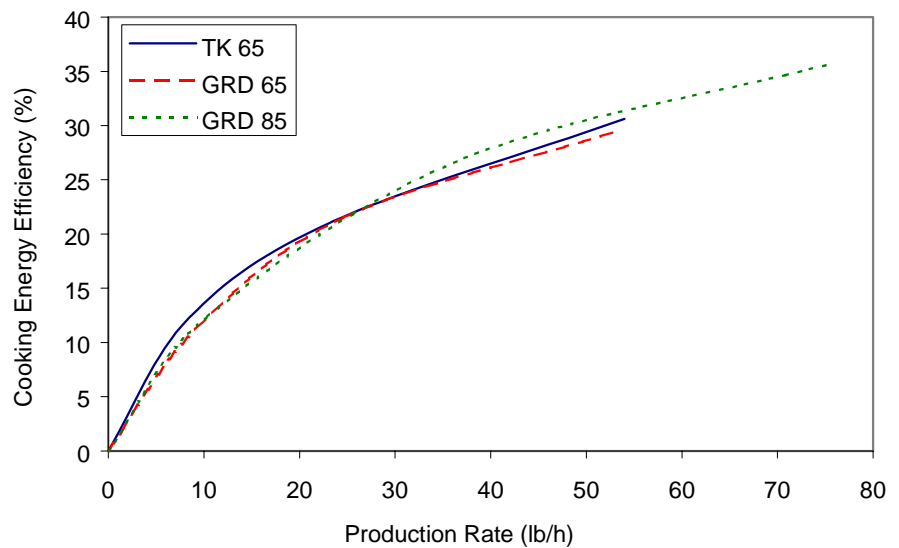
Table ES-2. Chicken Load Size.

	<i>TK 65</i>	<i>GRD 65</i>	<i>GRD 85</i>
Light Load	8 Pieces	8 Pieces	8 Pieces
Medium Load	24 Pieces	24 Pieces	32 Pieces
Heavy Load	48 Pieces	48 Pieces	64 Pieces

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Figure ES-2 illustrates the relationship between cooking energy efficiency and production rate for the three fryers. Figure ES-3 illustrates the relationship between the fryer's average energy consumption rates and the production rates. 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 for the TK 65 fryer are 26,567 Btu/h, 42,855 Btu/h, and 59,143 Btu/h respectively. Table ES-3 summarizes the estimated energy consumption at 10, 30, and 50 lbs/h for all three fryers.

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



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Figure ES-3.
Fryer cooking energy consumption profile.

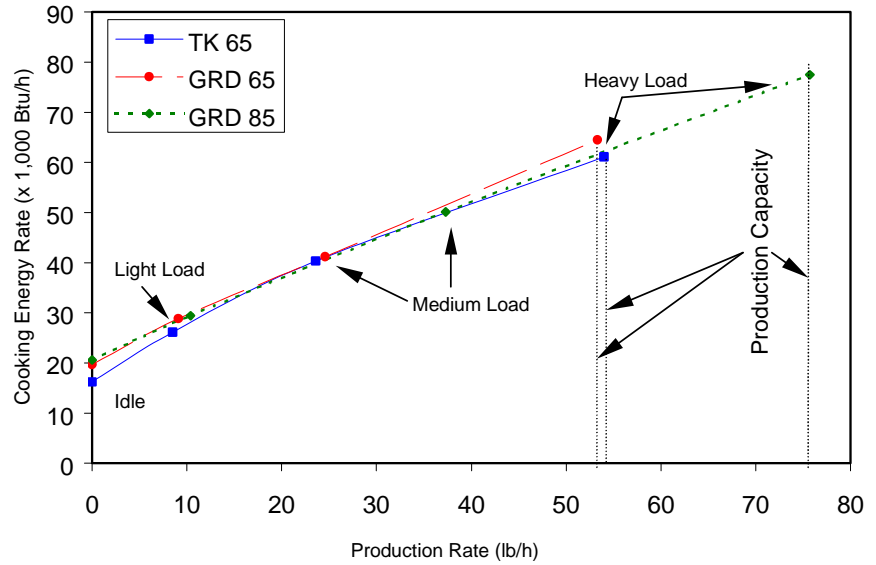


Table ES-3. Chicken Energy Consumption Estimations.

<i>Production Rate</i>	<i>TK 65</i>	<i>GRD 65</i>	<i>GRD 85</i>
10 lbs/h	26,567 Btu/h	28,786 Btu/h	28,790 Btu/h
30 lbs/h	42,855 Btu/h	45,406 Btu/h	43,762 Btu/h
50 lbs/h	59,143 Btu/h	63,026 Btu/h	58,734 Btu/h

The FSTC conducted additional French fry testing on Vulcan’s large vat fryers. The testing included two load sizes: heavy (5-pound loads) and light (3/4-pound loads). The high input fryers showed large production capacities with efficiencies on par with their lower input companions tested at the FSTC. The FSTC applied the Performance of Open Deep Fat Fryers ASTM to Vulcan’s lower input 14-inch gas fryers. Information can be found in the report *Vulcan 14-inch Fryer Performance Testing 5011.00.87*. Table ES-4 summarizes the heavy-load test results.

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Table ES-4. French Fry Heavy Load Test Results.

	<i>TK 65</i>	<i>GRD 65</i>	<i>GRD 85</i>
Production Capacity (lb/h) ^a	101.4 ± 0.9	101.4 ± 2.7	105.9 ± 2.1
Energy Consumption (Btu/lb)	1,456	1,320	1,337
Cooking Energy Rate (Btu/h)	145,300	133,828	141,566
Cooking Energy Efficiency (%) ^a	39 ± 1.4	43.5 ± 0.7	42.7 ± 2.2

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

Vulcan's large vat, high input, fryer line is well suited for high-volume institutions. The GRD 85, with its larger fry vat, really shows its stripes under heavy load conditions. The GRD 65 and TK 65 fryer both had respectable production capacities, but the increase in vat size on the GRD 85 fryer demonstrated its ability to cook higher quantities of food per hour. All three fryers also performed quite well under partial load conditions. The French fry test proved their versatility, with production capacities over 100 lb/hr and cooking energy efficiencies around 40%. It is this versatility without sacrificing fryer performance that will attract the attention of food service operators.

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.

With today's food service operators becoming more sophisticated in their choice of equipment, the demand for objective performance data has increased. Since Pacific Gas and Electric Company is a dual-fuel utility, the food service industry felt that it would produce unbiased data for gas and electric appliances. Pacific Gas and Electric Company would benefit by passing this performance data on to its customers, helping them to select energy efficient equipment. With support from the Electric Power Research Institute (EPRI), the Gas Research Institute (GRI), and the National Restaurant Association, Pacific Gas and Electric Company has been involved in developing test methods for commercial cooking equipment for over ten years at its Food Service Technology Center (FSTC) in San Ramon, California.

In 1999, FSTC researchers developed a uniform test procedure to evaluate the performance of gas and electric pressure and kettle fryers. This test method was submitted to the American Society for Testing and Materials' (ASTM) committee F26 on Food Service Equipment, and in July 1999, it was accepted as a standard test method (Designation F 1964-99).¹ This test method was modified to apply to large vat open, deep fat fryers. Fryer performance is characterized by preheat time and energy consumption, idle energy consumption rate, pilot energy consumption rate, cooking energy efficiency and production capacity.

Vulcan-Hart is considered one of the leading manufacturers of food service equipment, offering a wide variety of gas fryers. Through the use of "high

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thermal-efficiency, tube fired heating system” they offer a food service operator quality food production and cost savings. Vulcan approached the FSTC to test their full line of gas fryers under the tightly controlled conditions of the modified ASTM test method.

Vulcan’s high capacity fryer line was composed of three fryers. The TK 65 is powered by five atmospheric burners—each rated at 30,000 Btu/h— and a mechanically controlled thermostat. The GRD 65 also has five burners, but is controlled by a solid state thermostat and a control package with an integrated melt cycle. The GRD 85 was the same design as the GRD 65, but had a 4-inch longer frypot.

Vulcan Hart approached the FSTC to test their full line of gas fryers. This report is the second of a two-part study on Vulcan Hart’s gas fryer line. The first part *Vulcan 14-inch Fryer Performance Testing 5011.00.87*. 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 Vulcan’s line of high capacity gas fryers, under the controlled conditions of the modified ASTM standard test method. The modified ASTM standard test method is a combination of the Standard Test Method for Performance of Pressure and Kettle Fryers and the Standard Test Method for Performance of Open Deep Fat Fryers. 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.

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4. Document the cooking energy consumption and efficiency under three fry loading scenarios: heavy (48 piece load), medium (24 piece load) and light (8 pound per load).
5. Determine the production capacity during the heavy-load test.
6. Document the cooking energy consumption and efficiency under two French fry loading scenarios: heavy (5 pounds per load and light (3/4 pound per load).
7. Determine the French fry production capacity and frying medium temperature recovery time during the heavy –load French fry test.

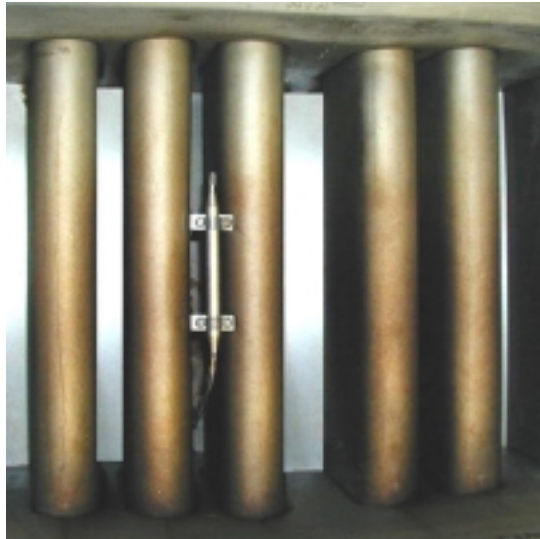
Appliance Description

Vulcan’s high capacity gas fryers are offered with one power rating but different frypot sizes. The 65 series fryers have 150,000 Btu/h of available input with a frypot size of 19 ½” x 14”. The 85 series fryer also has 150,000 Btu/h of input, but a larger frypot size of 19 ½” x 18 ¼” increases the length of the heat transfer tubes by 4 ¼ inches. The flue gasses are routed from the front of the fryer through heat transfer tubes to the back of the frypot (see Figure 1-1 and Figure 1-2). All three fryers, as tested, were constructed of stainless steel front and painted steel sides. The frypots were made from 14-gauge cold rolled steel. Optional stainless steel frypots are also available. The TK-series fryer is controlled by a mechanical thermostat, with a high-limit shut off. The GRD-series fryers incorporate a solid state thermostat and control package with a solid shortening melt cycle and a high-limit shot off.

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

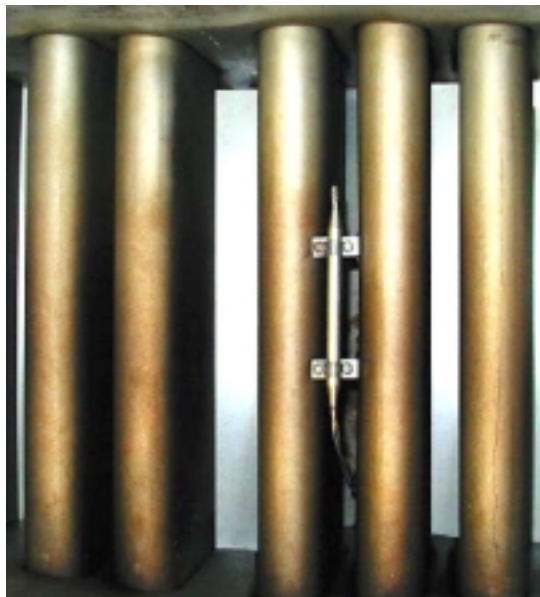
Introduction

*Figure 1-1.
Vulcan TK & GRD 65
heat transfer tubes.*



*150,000 Btu Fryers
19 1/2" X 14"*

*Figure 1-2.
Vulcan GRD 85 heat
transfer tubes.*



*150,000 Btu Fryers
19 1/2" X 18 1/4"*

Introduction

Table 1-1. Appliance Specifications.

Model: Vulcan TK 65	
Rated Input	150,000 (Btu/h)
Oil Capacity	70 (lbs)
Frying Area	19-½ " x 14"
Construction	Stainless steel front and top, painted sides and cold rolled steel fry tank
Controls	Mechanical thermostat
Generic Appliance Type	Open Deep Fat Fryer

Model: Vulcan GRD 65	
Rated Input	150,000 (Btu/h)
Oil Capacity	70 (lbs)
Frying Area	19-½ " x 14"
Construction	Stainless steel front and top, painted sides and cold rolled steel fry tank
Controls	Solid state thermostat with melt cycle
Generic Appliance Type	Open Deep Fat Fryer

Model: Vulcan GRD 85	
Rated Input	150,000 (Btu/h)
Oil Capacity	90 (lbs)
Frying Area	19-½ " x 18-¼ "
Construction	Stainless steel front and top, painted sides and cold rolled steel fry tank
Controls	Solid state thermostat with melt cycle
Generic Appliance Type	Open Deep Fat Fryer

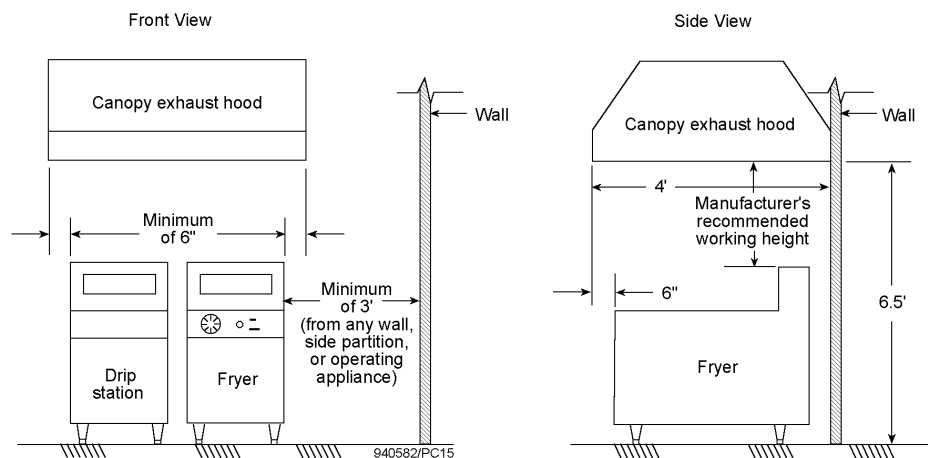
2 Methods

Setup and Instrumentation

FSTC researchers installed the fryers 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 were 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. Additionally, four thermocouples were welded onto the heat transfer tubes, one in each of the four quadrants of the frypot, and a single thermocouple monitored flue temperature. 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

Figure 2-1.
Equipment configuration.



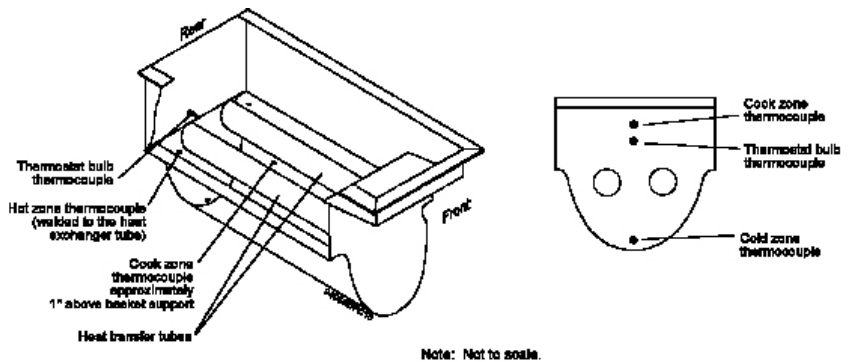
Methods

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.

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 chemical laboratory used a gas chromatograph 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.*



Methods

Measured Energy Input Rate

Rated energy input rate is the maximum or peak rate at which the fryer consumes energy—as specified on the fryer’s nameplate. Measured energy input rate is the maximum or peak rate of energy consumption, which is recorded during a period when the burners are operating (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 fryers were tested with 8-piece cut, 2 ¾-pound, individually quick frozen frying chicken which had been thawed, breaded, and stabilized in a refrigerator at 38 °F. Researchers tested the fryers using nominal heavy, medium 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 $27 \pm 2\%$. This ensured fully-cooked chicken with no redness in the center.

Table 2-1. Chicken Load Size.

	<i>TK 65</i>	<i>GRD 65</i>	<i>GRD 85</i>
Light Load	8 pieces	8 pieces	8 pieces
Medium Load	24 pieces	24 pieces	32 pieces
Heavy Load	48 pieces	48 pieces	64 pieces

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

Methods

Due to logistics in removing one load of cooked chicken and placing another load into the fryer, a minimum preparation time of 10 minutes was incorporated into the cooking procedure. This ensures that the cooking tests are uniformly applied from laboratory to laboratory. Fryer recovery was then based on the frying medium reaching a threshold temperature of 325°F (measured at the center of the cook zone).

The Chicken tests were run in the following sequence: three replicates of the heavy-load test, three replicates of the medium-load test, and three replicates of the light-load test. This procedure ensured that the reported cooking energy efficiency and production capacity results had an uncertainty of less than $\pm 10\%$. 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 three fryers, researchers applied the French fry test from the ASTM Test Method for Open Deep Fat Fryers (F1361-99). Since the frypots could accommodate a larger load than specified in the test method, the heavy-load size was increased from three to five pounds of frozen French fries

Simplot[®] brand ¼-inch blue ribbon product, par-cooked, frozen shoestring potatoes were used for these 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), 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 tempera-

Methods

ture 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 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 the light-load test. 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 each fryer was operating within its specified parameters. The measured energy input rates are listed in Table 3-1.

Table 3-1. Energy Input Rates.

	<i>TK 65</i>	<i>GRD 65</i>	<i>GRD 85</i>
Name Plate (Btu/h)	150,000	150,000	150,000
Measured (Btu/h)	154,426	154,555	146,627
Percentage Difference	2.95 %	3.04 %	2.25 %

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, 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. The TK 65 and GRD 65 fryers were ready to cook in about 9 minutes. The GRD 85 fryer preheated in about 11 minutes. The addition of the solid

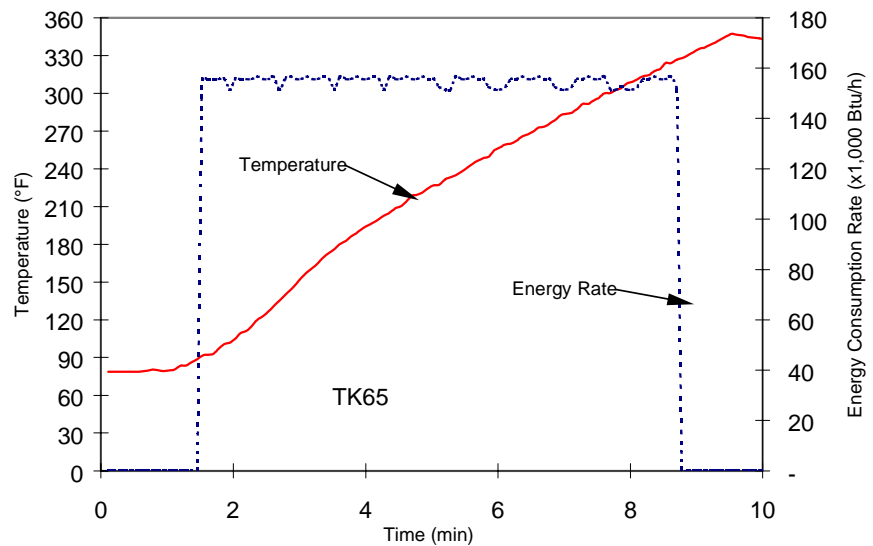
Results

state thermostat in the GRD 65 reduced the preheat energy by 5% by minimizing temperature overshoot. Figures 3-1 thru Figure 3-3 show the preheat characteristics for all three fryers.

Idle Energy Rate

Once the frying medium reached 325°F, the fryers were 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 325°F. The idle energy rate during this period for the TK 65 fryer was 14,875 Btu/h, the idle rate for the GRD 65 fryer was 18,298 Btu/h, and the idle rate for the GRD 85 fryer was 19,273 Btu/h.

*Figure 3-1.
TK 65 preheat
characteristics.*



Results

Figure 3-2.
GRD 65 preheat characteristics.

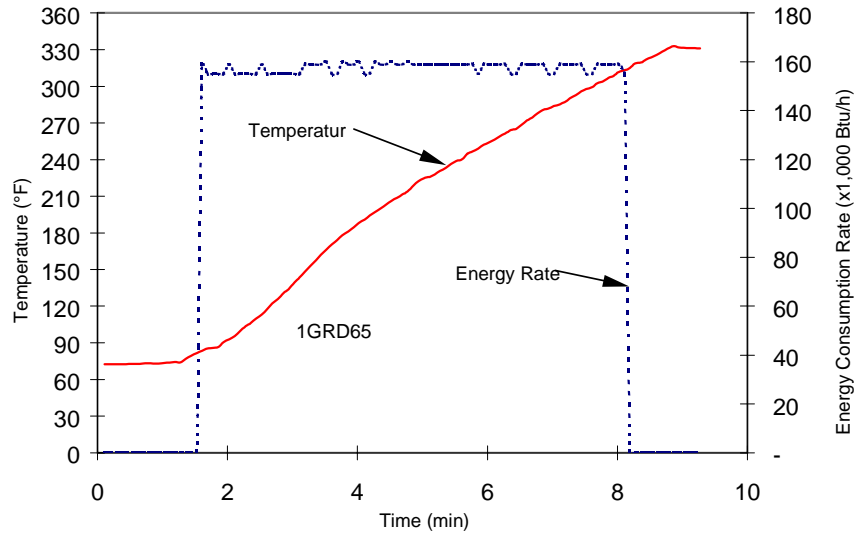
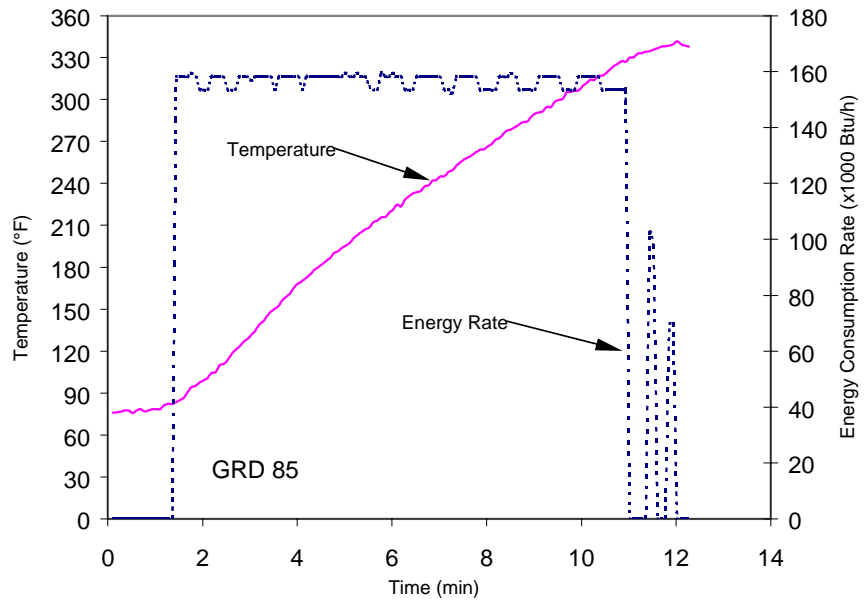


Figure 3-3.
GRD 85 preheat characteristics.



Results

Test Results

Input, preheat, and idle test results are summarized in Table 3-2.

Table 3-2. Input, Preheat, and Idle Test Results.

	<i>TK 65</i>	<i>GRD 65</i>	<i>GRD 85</i>
Rated Energy Input Rate (Btu/h)	150,000	150,000	150,000
Measured Energy Input Rate (Btu/h)	154,426	154,555	146,627
Preheat			
Time to 325°F (min)	8.6	8.8	10.7
Energy (Btu)	21,469	20,446	26,889
Rate to 325°F (°F/min)	26.1	28.4	23.3
Idle Energy Rate @ 325°F (Btu/h)	14,875	18,298	19,273

Chicken Tests

The fryers were 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 TK 65 and GRD 65 fryers were used to cook 48 pieces per load (12 of each type of piece—breast, wings, legs and thighs); the GRD 85 fryer was used to cook 64 pieces per load (16 of each type of piece). Medium-loads comprised one half the number or pieces used in the heavy load tests. Light-load tests used 8 pieces per load for all three fryers. Researchers monitored chicken cooking time and weight loss, frying medium temperature, and fryer energy consumption during these tests.

Heavy-Load Tests

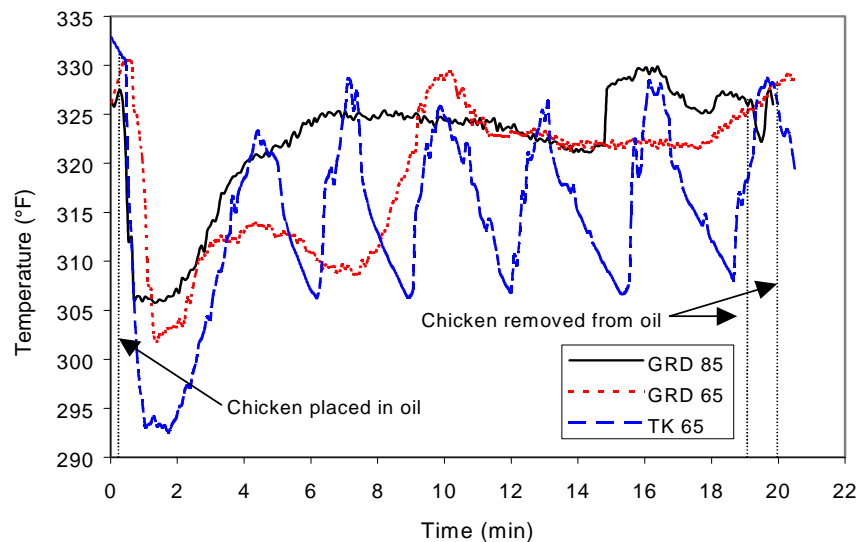
The heavy-load cooking tests were designed to reflect a fryer's maximum performance. The fryer was used to cook three or more heavy loads of

Results

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 3-4 compares the temperature signatures for each fryer under a heavy-load test.

The heavy-load cook time for the TK 65 fryer was 20.35 minutes. The GRD 65 had a heavy-load cook time of 20.46 minutes and the GRD 85's heavy-load cook time was 19.34 minutes. Production capacity includes the cook time and a 30 second reload time.

*Figure 3-4.
Chicken cook cycle
temperature signature.*



Results

Medium and Light Load Tests

Medium and light load tests represent the fryer's performance under non-peak conditions. Since a fryer is often used to cook single-basket loads during slow periods, these part-load efficiencies can be used to estimate a fryer's performance in an actual operations.

Both the medium and light-load tests were conducted using a single fry basket. Cooking energy efficiencies for the TK65 fryer at 23.6 (medium) 8.5 (light) pounds per hour were 21.2% and 12.3% respectively.

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.

Cooking energy efficiency results for the ASTM heavy-load tests for the TK 65 fryer were 29.6, 30.9%, and 31.4%, yielding a maximum uncertainty of 2.4% in the test results. The GRD 65 fryer had cooking energy efficiency results of 29.7%, 29.6%, 29.2%, and 29.3%, yielding a maximum uncertainty of 0.3% in the tests results. The cooking energy efficiency results for the GRD 85 fryer were 36.0%, 35.4%, 35.7%, yielding a maximum uncertainty in the test results of 0.8%. Table 3-4 summarizes the results for the heavy, medium and light-load tests.

Results

Table 3-4. Chicken Cooking Test Results.

	<i>TK 65</i>	<i>GRD 65</i>	<i>GRD 85</i>
Heavy Load			
Load Size (pieces)	48	48	64
Cook Time (min)	20.35	20.46	19.34
Production Capacity (lb/h)	54.0 ± 3.1	53.3 ± 1.3	75.7 ± 5.3
Energy Consumption (Btu/lb)	1,131	1,211	1,023
Cooking Energy Rate (Btu/h)	61,109	64,505	77,504
Cooking Energy Efficiency (%)	30.6 ± 2.4	29.5 ± 0.3	35.7 ± 0.8
Medium Load			
Load Size (pieces)	24	24	32
Cook Time (min)	22.65	21.91	19.21
Production Rate (lb/h)	23.6 ± 1.2	24.6 ± 1.1	37.3 ± 0.6
Energy Consumption (Btu/lb)	1,707	1,714	1,345
Cooking Energy Rate (Btu/h)	40,296	42,182	50,113
Cooking Energy Efficiency (%)	21.2 ± 1.9	21.5 ± 1.3	27.0 ± 1.2
Light Load			
Load Size (lb)	8	8	8
Cook Time (min)	21.30	20.46	17.63
Production Rate (lb/h)	8.5 ± 0.7	9.1 ± 0.3	10.4 ± 0.5
Energy Consumption (Btu/lb)	3,067	3,154	2,817
Cooking Energy Rate (Btu/h)	26,162	28,837	29,396
Cooking Energy Efficiency (%)	12.3 ± 0.6	11.2 ± 0.7	12.4 ± 0.9

Figure 3-5 illustrates the relationship between cooking energy efficiency and production rate for the three fryers. Fryer production rate is a function of both the chicken cook time and the reloading time. Appendix D contains a synopsis of test data for each replicate of the cooking tests.

Results

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

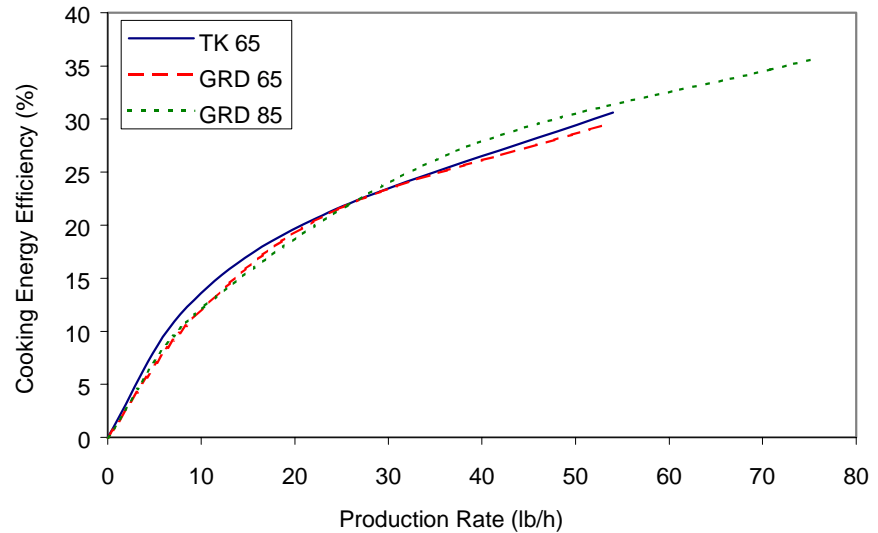


Figure 3-6 illustrates the relationship between the fryer's average energy consumption rate and the production rate for frying chicken. This graph can be used as a tool to estimate the daily energy consumption for the fryer in a real-world operation. Average energy consumption rates at 10, 30, and 50 pounds per hour are presented in Table 3-5. For example, the TK 65 fryer had estimated energy consumption rates of 26,567 Btu/h, 42,855 Btu/h, and 59,143 Btu/h at 10, 30, and 50 pounds per hour, 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 daily energy consumption rate for this fryer would be 30,639 Btu/h.

Results

Figure 3-6.
Fryer cooking energy consumption profile.

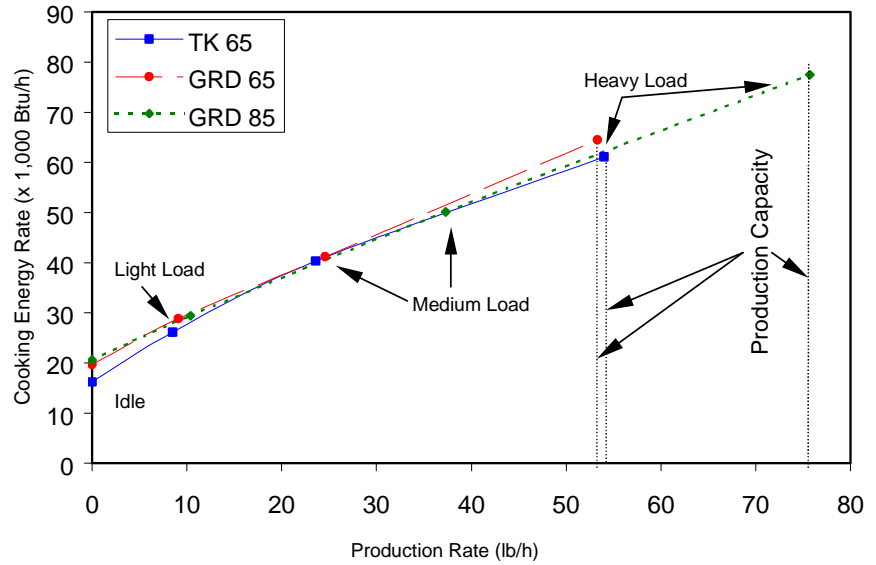


Table 3-5. Part-Load Energy Consumption Estimations.

<i>Production Rate</i>	<i>TK 65</i>	<i>GRD 65</i>	<i>GRD 85</i>
10 lbs/h	26,567 Btu/h	28,786 Btu/h	28,790 Btu/h
30 lbs/h	42,855 Btu/h	45,406 Btu/h	43,762 Btu/h
50 lbs/h	59,143 Btu/h	63,026 Btu/h	58,734 Btu/h

French Fry Tests

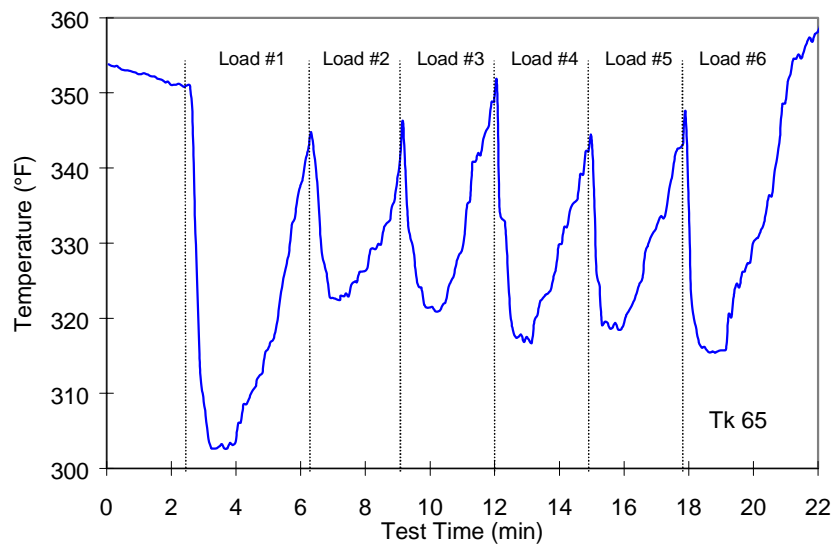
The fryers were tested used to cook frozen ¼-inch shoestring potatoes under two loading scenarios: heavy (5 pounds of fries per load) and light (¾ pound of fries per load). The fries used for the cooking tests consisted of approximately 6% fat and 66% moisture, as specified by the ASTM procedure. Researchers monitored French fry cook time and weight loss, frying medium recovery time, and fryer energy consumption during these tests.

Results

Heavy-Load Tests

The heavy-load cooking tests were designed to reflect a fryer's maximum performance. The fryer was 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 3-7 thru 3-9 show the average temperature of the frying medium during the heavy-load French fry tests. The first load was used to stabilize the fryer, the remaining five loads were used to calculate cooking energy efficiency and production capacity. The average frying medium temperature during these tests were 329°F for the TK 65 fryer, 326°F for the GRD 65 fryer, and 334°F for GRD 85 fryer.

*Figure 3-7.
Frying medium temperature
during a heavy-load test for
the TK 65 fryer.*



Results

Figure 3-8.
Frying medium temperature during a heavy-load test for the GRD 65 fryer.

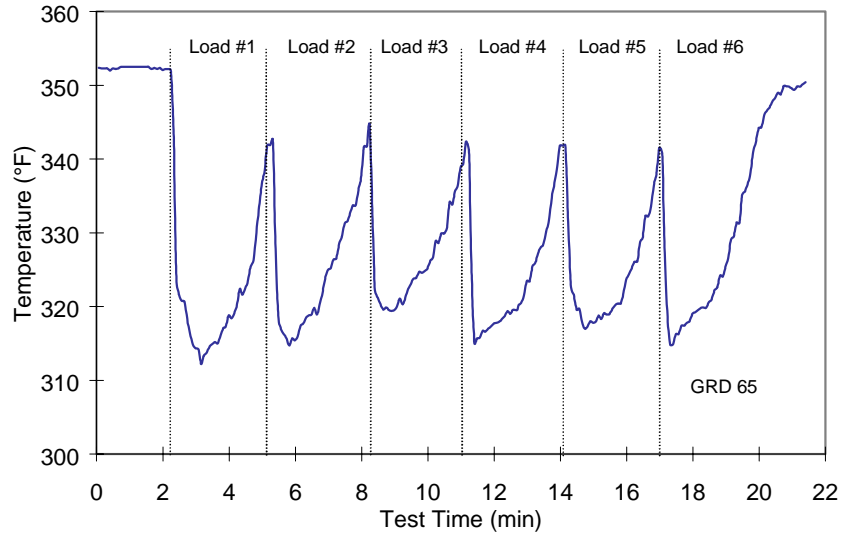
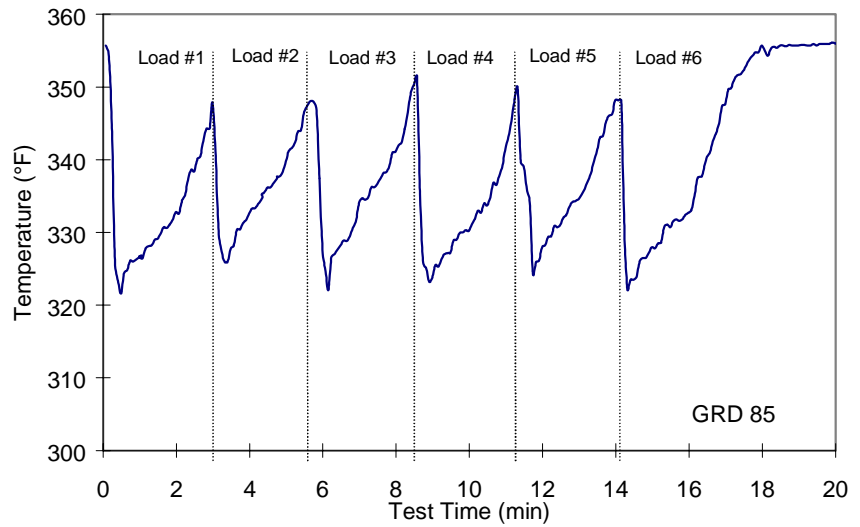


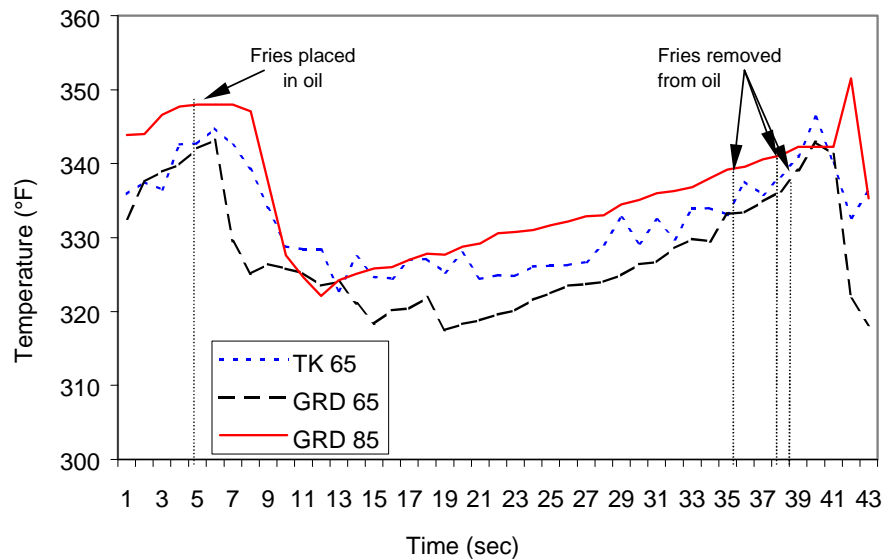
Figure 3-9.
Frying medium temperature during a heavy-load test for the GRD 85 fryer.



Results

The heavy-load French fry cook time for the TK 65 was 2.72 minutes, with a recovery time of 0.23 minutes. The GRD 65 had a cook time of 2.64 minutes and an average recovery time of 0.32 minutes. The GRD 85 cooked 5 pounds of fries in 2.62 minutes and required 0.21 minutes to recover to 340°F. Figure 3-10 compares the temperature response of the three fryers while cooking a 5-pound load of frozen French fries. French fry production capacity is a function of both the cook time and the recovery time.

*Figure 3-10.
Fryer cooking cycle
temperature signature.*



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.

Results

Heavy load French fry cooking energy efficiency results for the TK 65 fryer were 39.3%, 39.2%, and 38.3%, yielding a maximum uncertainty of 1.4% in the test results. The GRD 65 fryer had French fry cooking energy efficiency results of 43.6%, 43.1%, 43.6%, yielding a maximum uncertainty of 0.7%. The GRD 85 fryer exhibited French fry cooking energy efficiencies of 41.7%, 42.9%, 43.5%, resulting in a maximum uncertainty of 2.2%. Table 3-6 summarizes the results of the heavy and light-load test results.

Table 3-6. French Fry Cooking Test Results.

	<i>TK 65</i>	<i>GRD 65</i>	<i>GRD 85</i>
Heavy Load			
Load Size (lb)	5.00	5.00	5.00
French Fry Cook Time (min)	2.72	2.64	2.62
Average Recovery Time (min)	0.23	0.32	0.21
Production Rate (lb/h)	101.4 ± 0.9	101.4 ± 2.7	105.9 ± 2.1
Energy Consumption (Btu/lb)	1,456	1,320	1,337
Cooking Energy Rate (Btu/h)	145,195	133,828	141,566
Cooking Energy Efficiency (%)	39.0 ± 1.4	43.5 ± 0.7	42.7 ± 2.2
Light Load			
Load Size (pounds)	¾	¾	¾
French Fry Cook Time (min)	2.28	2.33	2.05
Average Recovery Time (min)	0.19	0.17	0.18
Production Rate (lb/h)	18.2 ± 0.1	18.0 ± 0.4	20.2 ± 0.1
Energy Consumption (Btu/lb)	2,428	2,718	2,423
Cooking Energy Rate (Btu/h)	44,010	49,000	48,930
Cooking Energy Efficiency (%)	23.8 ± 1.5	20.9 ± 1.2	23.2 ± 1.2

4 Conclusion

Vulcan's high input fryers the TK 65, GRD 65 and GRD 85 demonstrated a versatility that smaller vat fryers can't offer. These fryers lend themselves well to cooking large quantities of breaded food product such as chicken and fish. When Vulcan asked the FSTC to test their full line of fryers, cooking fried chicken in these large vat fryers based on a slightly modified version of the ASTM test method for pressure fryers was our first thought. The fryer's large fry vats were capable of cooking significant amounts of chicken, not otherwise possible in Vulcan's smaller counterparts. In fact, these fryers were capable of producing 54 lbs/hr of chicken in the TK 65 series fryer, 53 lbs/hr in the GRD 65, and 75 lbs/hr in the GRD 85 fryer.

The GRD 85 fryer had an impressive heavy load size of 64 pieces. Coupled with a cook time of 19.34 minutes it produced a lot of chicken in a short period of time. The GRD 85's larger fry vat contributed to 19% higher cooking energy efficiency (35.7% vs. 30%) than the slightly smaller GRD 65 and TK 65 fryers. The high input of these fryers really shows its prowess with heavy loads. The medium and light-loads were impressive as well. They produce results on par or better than other pressure fryers.⁹

Due to the classic open deep fat fryer design, these fryers can be used in a traditional fashion. The FSTC conducted heavy and light load test on Vulcan's high input fryers. Based on the size of the fry vat the heavy load was changed to 5 pounds. All three fryers had impressive production capacities of over 100 lbs/hr with cooking energy efficiencies around 40%. The heavy load conditions did not have a drastic impact on the cook times. The TK 65 with its mechanical thermostat had a slightly longer cook time than the GRD 65 fryer and GRD85 fryer with their solid state thermostat; all three fryers showed good recovery times. The FSTC also tested Vulcan's lower input 14-inch fryers. The high capacity compared favorably with the lower input

Conclusions

fryers. The large vat fryers exhibited cooking energy efficiencies equal or greater than their smaller 14-inch counterparts, and consistently higher production capacities.

Granted, the test fryers have more than twice the input of conventional pressure fryers and kettle fryers, but these large vat fryers offer versatility without sacrificing performance. These fryers are well suited for institutions requiring high volume production.

5 References

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9. Food Service Technology Center. Delicatessen Appliance Performance Testing. Report 5016.95.23 prepared for Pacific Gas and Electric Company Products and Services Department. San Francisco. Pacific Gas and Electric Company.

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.

Glossary

Idle Energy Rate (kW or Btu/h)

Idle Energy Input Rate

Idle Rate

The rate of appliance energy consumption while it is “idling” or “holding” at 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.

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

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.

Glossary

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 “preheat” 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.

B Appliance Specifications

Appendix B includes the product literature for the Vulcan fryers.

MODEL TK65 FLOOR MODEL GAS FRYER



TK65



SPECIFICATIONS:

65 - 70 lb. capacity floor model gas fryer, Vulcan-Hart Model No. TK65. Stainless steel front and sides; 6¹/₄" adjustable nickel plated, noncorrosive legs. Stainless steel fry tank with 5 heat exchanger tubes and "V" shaped cold zone. 1" full port ball type drain valve. Twin fry baskets with plastic coated handles. 150,000 BTU/hr. input. Millivolt control system adjusts from 200° to 400°F. Hi-limit shut-off. Combination gas shut-off valve, pressure regulator and pilot ignition system. Overall dimensions: 21"w x 29³/₄"d x 47¹/₈"h. Working height 36¹/₄".

CSA design certified. NSF listed.

SPECIFY TYPE OF GAS AND FINISH WHEN ORDERING.

SPECIFY ALTITUDE WHEN ABOVE 3,000 FT.

STANDARD FEATURES

- Stainless steel front and sides; 6¹/₄" adjustable nickel plated, noncorrosive legs.
- Stainless steel fry tank, 65 - 70 lb. capacity. Includes limited 10 year tank warranty.
- 1" full port ball type drain valve.
- Twin fry baskets with plastic coated handles.
- 150,000 BTU/hr. input.
- Five heat exchanger tubes positioned for easy cleaning.
- Millivolt control system adjusts from 200° to 400°F.
- Hi-limit shut-off.
- Combination gas shut-off valve, pressure regulator and pilot ignition system.
- 1/2" rear gas connection.
- One year limited parts and labor warranty.

OPTIONS

- Set of 4 casters (2 locking).
- Orifice change for altitudes above 3,000 ft. (no charge). Please specify altitude.
- Second year extended limited parts and labor warranty.

ACCESSORIES

- Stainless steel tank cover.
- Grease protector strips.
- Single large basket - 18³/₄"w x 13¹/₄"d x 5¹/₂"h.
- Set of twin baskets - 9¹/₄"w x 13¹/₄"d x 6"h.
- Set of tri-baskets - 5¹/₂"w x 11d" x 4¹/₂"h.
- 19" x 13¹/₂" fish grid.
- Stainless steel crumb scoop.
- Skimmer, 6" square with plastic coated handle.
- Stainless steel batter tray frame.
- Tank brush.
- Flexible gas hose with quick disconnect and restraining device. Consult price book for available sizes.



MODEL TK65

FLOOR MODEL GAS FRYER

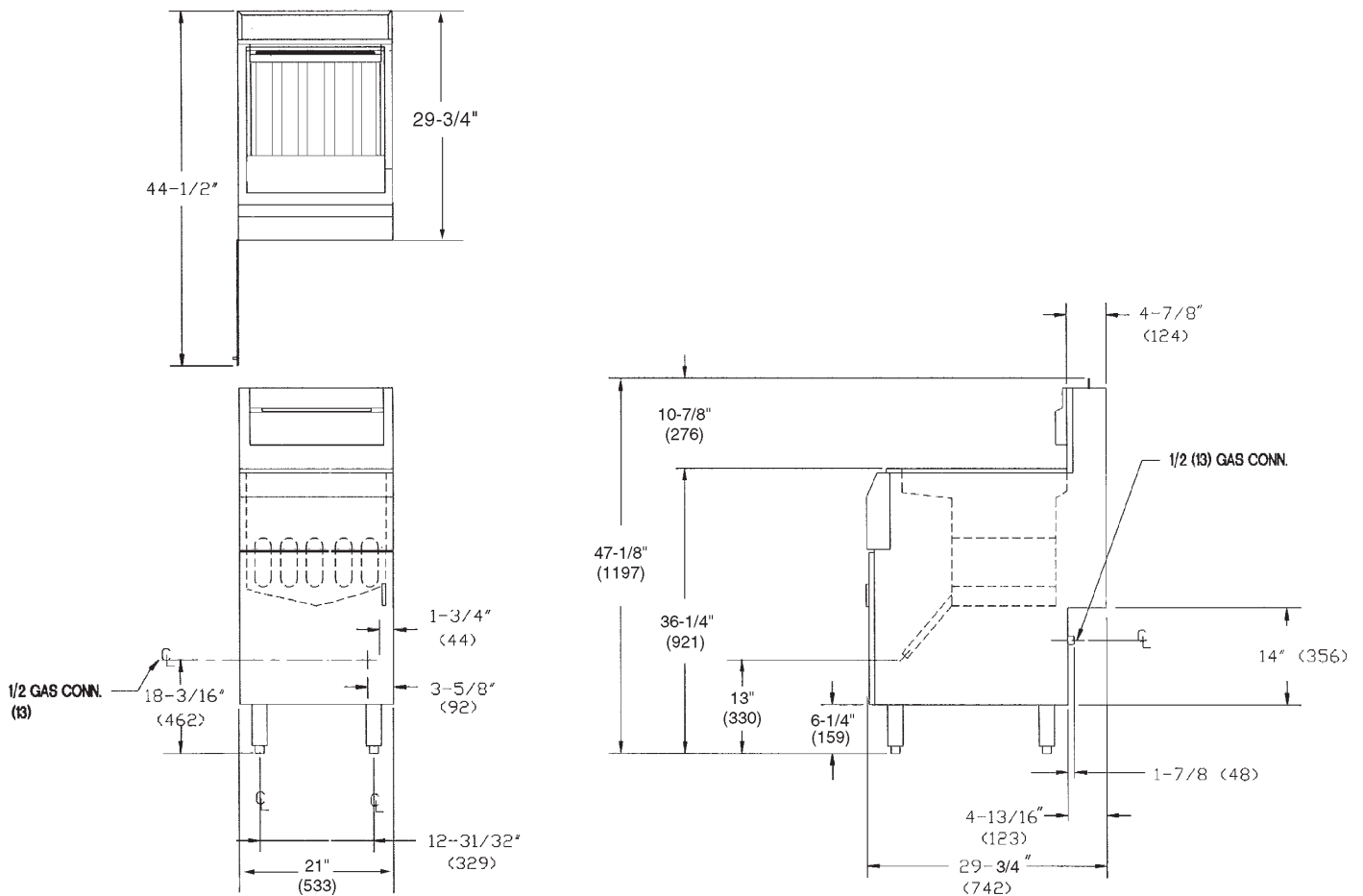
IMPORTANT

1. A combination valve with pressure regulator is provided with this unit.
 Natural Gas 4.0" (102 mm) W.C.
 Propane Gas 10.0" (254 mm) W.C.
2. An adequate ventilation system is required for Commercial Cooking Equipment. Information may be obtained by writing to the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269. When writing refer to NFPA No. 96.

3. All models require a 6" (152 mm) clearance at both sides and rear adjacent to combustible construction.
4. All models require a 16" (407 mm) minimum clearance to adjacent open top burner units.
5. This appliance is manufactured for commercial installation only and is not intended for home use.

SERVICE CONNECTIONS:

1/2" (13 mm) gas connection.



MODEL	WIDTH	DEPTH	OVERALL HEIGHT	WORKING HEIGHT	TANK SIZE	BTU/HR.	FRY COMP. CAPACITY	FRYING CAPACITY	APPROX. SHP.WT.
TK65	21"	29 ³ / ₄ "	47 ¹ / ₈ "	36 ¹ / ₄ "	19 ¹ / ₂ " x 14"	150,000	65-70 lbs.	115 lbs. 1/4" frozen fries/hr.	275 lbs.

NOTE: In line with its policy to continually improve its products, Vulcan-Hart Company reserves the right to change materials and specifications without notice.

GR65 SERIES FLOOR MODEL GAS FRYER



Model GRS65



SPECIFICATIONS:

65 - 70 lb. capacity floor model gas fryer, Vulcan-Hart Model No. (GRS65) (GRD65) (GRC65). Stainless steel front top, sides and door. 6¼" adjustable nickel plated, noncorrosive legs. Stainless steel fry tank with five heat exchanger tubes and a "V" shaped cold zone. 1" full port ball type drain valve. Twin fry baskets with plastic coated handles. 150,000 BTU/hr. input. (Millivolt) (Solid state) (Programmable computer) control system. Overall dimensions: 21"w x 29¾"d x 47⅝"h. Working height 36¼".

CSA design certified. NSF listed.

SPECIFY TYPE OF GAS AND FINISH WHEN ORDERING.

SPECIFY ALTITUDE WHEN ABOVE 3,000 FT.

GRS65: Millivolt thermostat control adjusts from 200° to 400°F.

GRD65: Solid state temperature control adjusts from 200° to 375°F. Fat melt cycle. Power "ON", "HEATING" and "HI-LIMIT" indicators.

GRC65: Computer control with digital 12 character display. Completely programmable with product and custom operator message system. Fat melt cycle. Energy saving idle mode automatically cuts back temperature when fryer is not in use. Adjusts from 320° to 375°F (161° to 190°C).

STANDARD FEATURES

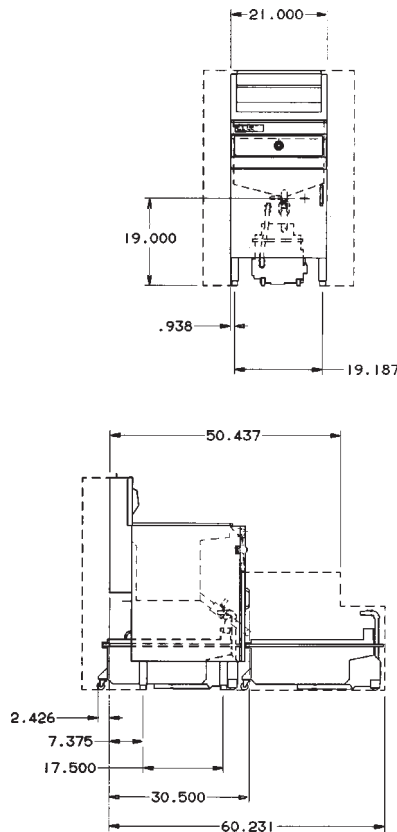
- Stainless steel fry tank, 65 - 70 lb. capacity. Includes limited 10 year tank warranty.
- 1" full port ball type drain valve.
- Stainless steel front top, sides and door.
- 6¼" adjustable nickel plated, noncorrosive legs.
- Twin fry baskets with plastic coated handles.
- 150,000 BTU/hr. input.
- Five heat exchanger tubes positioned for easy cleaning.
- Hi-limit shut-off.
- Combination gas shut-off valve, pressure regulator and pilot ignition system.
- One year limited parts and labor warranty.

OPTIONS

- Electronic ignition (GRD & GRC models).
- Automatic basket lifts (casters required for AGA certification) (GRD & GRC models) (adds 2¾" to overall depth).
- Filter ready for use with MF85 mobile filter for single fryers.
- Battery construction available up to 6 units wide.
- KleenScreen filtration system for batteries from 2-6 fryers.
- Set of 4 casters (2 locking).
- Orifice change for altitudes above 3,000 ft. (no charge). Please specify altitude.
- Second year extended limited parts and labor warranty.

ACCESSORIES

- Stainless steel tank cover.
- Grease protector strips.
- Single large basket - 18 $\frac{3}{4}$ "w x 13 $\frac{1}{4}$ "d x 5 $\frac{1}{2}$ "h.
- Set of twin baskets - 9 $\frac{1}{4}$ "w x 13 $\frac{1}{4}$ "d x 6"h.
- Set of tri-baskets - 5 $\frac{1}{2}$ "w x 11"d x 4 $\frac{1}{2}$ "h.
- 19" x 13 $\frac{1}{2}$ " fish grid.
- Stainless steel crumb scoop.
- Skimmer, 6" square with plastic coated handle.
- Stainless steel batter tray frame.
- Tank brush.
- Flexible gas hose with quick disconnect and restraining device. Consult price book for available sizes.

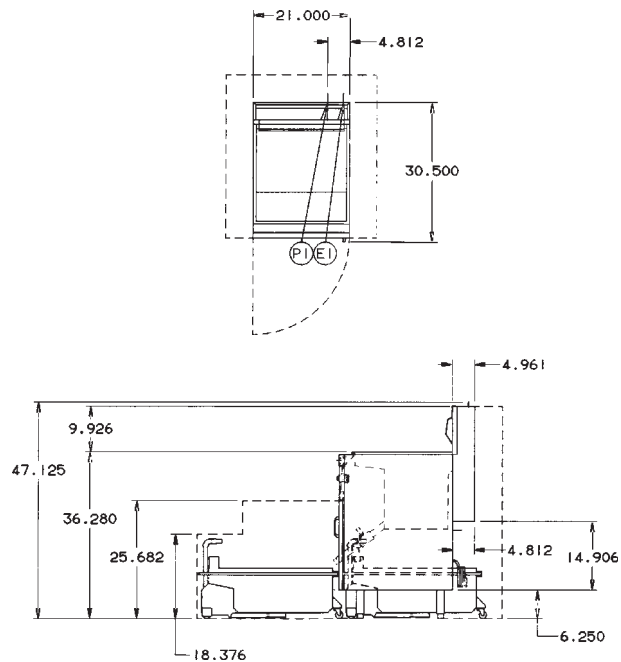


IMPORTANT

1. A combination valve with pressure regulator is provided with this unit.
Natural Gas 4.0" (102 mm) W.C.
Propane Gas 10.0" (254 mm) W.C.
2. An adequate ventilation system is required for Commercial Cooking Equipment. Information may be obtained by writing to the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269. When writing refer to NFPA No. 96.
3. All models require a 6" (152 mm) clearance at both sides and rear adjacent to combustible construction.
4. All models require a 16" (407 mm) minimum clearance to adjacent open top burner units.
5. This appliance is manufactured for commercial installation only and is not intended for home use.

SERVICE CONNECTIONS:

- (P1) 1/2" (13 mm) rear gas connection (single units).
1 1/4" (32 mm) rear manifold (batteries).
- (E1) 115 volt cord & plug supplied on GRD and GRC fryers, filter ready fryers and GRS fryers with fat melt and electronic ignition options.



MODEL	WIDTH	DEPTH	OVERALL HEIGHT	WORKING HEIGHT	TANK SIZE	BTU/HR.	FRY COMP. CAPACITY	APPROX. SHP.WT.
GRS65 GRD65 GRC65	21"	29 $\frac{3}{4}$ "	47 $\frac{5}{8}$ "	36 $\frac{1}{4}$ "	19 $\frac{1}{2}$ " x 14"	150,000	65 - 70 lbs.	275 lbs.

NOTE: In line with its policy to continually improve its products, Vulcan-Hart Company reserves the right to change materials and specifications without notice.

GR85 SERIES FLOOR MODEL GAS FRYER



Model GRS85



SPECIFICATIONS:

70 - 85 lb. capacity floor model gas fryer, Vulcan-Hart Model No. (GRS85) (GRD85) (GRC85). Stainless steel front top, sides and door. 6¼" adjustable nickel plated, noncorrosive legs. Stainless steel fry tank with five heat exchanger tubes and a "V" shaped cold zone. 1¼" full port ball type drain valve. Twin fry baskets with plastic coated handles. 150,000 BTU/hr. input. (Millivolt) (Solid state) (Programmable computer) control system. Overall dimensions: 21"w x 34¾"d x 47⅝"h. Working height 36¼".

CSA design certified. NSF listed.

SPECIFY TYPE OF GAS AND FINISH WHEN ORDERING.

SPECIFY ALTITUDE WHEN ABOVE 3,000 FT.

GRS85: Millivolt thermostat control adjusts from 200° to 400°F.

GRD85: Solid state temperature control adjusts from 200° to 375°F. Fat melt cycle. Power "ON", "HEATING" and "HI-LIMIT" indicators.

GRC85: Computer control with digital 12 character display. Completely programmable with product and custom operator message system. Fat melt cycle. Energy saving idle mode automatically cuts back temperature when fryer is not in use. Adjusts from 320° to 375°F (161° to 190°C).

STANDARD FEATURES

- Stainless steel fry tank, 70 - 85 lb. capacity. Includes limited 10 year tank warranty.
- 1¼" full port ball type drain valve.
- Stainless steel front top, sides and door.
- 6¼" adjustable nickel plated, noncorrosive legs.
- Twin fry baskets with plastic coated handles.
- 150,000 BTU/hr. input.
- Five heat exchanger tubes positioned for easy cleaning.
- Hi-limit shut-off.
- Combination gas shut-off valve, pressure regulator and pilot ignition system.
- One year limited parts and labor warranty.

OPTIONS

- Electronic ignition (GRD & GRC models).
- Automatic basket lifts (casters required for AGA certification) (GRD & GRC models) (adds 2¾" to overall depth).
- Filter ready for use with MF85 mobile filter for single fryers.
- Battery construction available up to 6 units wide.
- KleenScreen filtration system for batteries from 2-6 fryers.
- Set of 4 casters (2 locking).
- Orifice change for altitudes above 3,000 ft. (no charge). Please specify altitude.
- Second year extended limited parts and labor warranty.

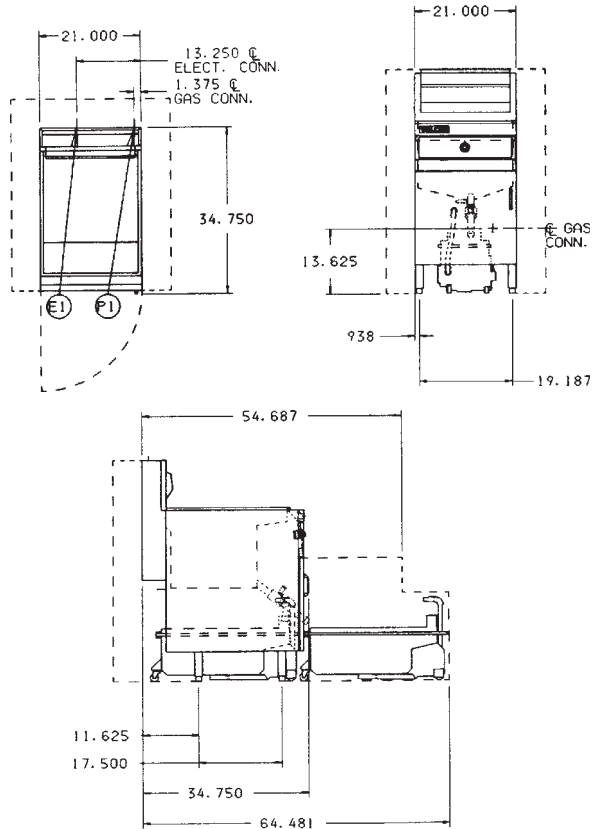


GR85 SERIES

FLOOR MODEL GAS FRYER

ACCESSORIES

- Stainless steel tank cover.
- Grease protector strips.
- Single large basket - 18 $\frac{3}{4}$ "w x 17 $\frac{1}{4}$ "d x 6"h.
- Set of twin baskets - 9 $\frac{1}{4}$ "w x 17 $\frac{1}{4}$ "d x 6"h.
- Set of tri-baskets - 5"w x 16 $\frac{13}{32}$ "d x 5 $\frac{5}{16}$ "h.
- 19" x 17 $\frac{3}{4}$ " fish grid.
- Stainless steel crumb scoop.
- Skimmer, 6" square with plastic coated handle.
- Stainless steel batter tray frame.
- Tank brush.
- Flexible gas hose with quick disconnect and restraining device. Consult price book for available sizes.



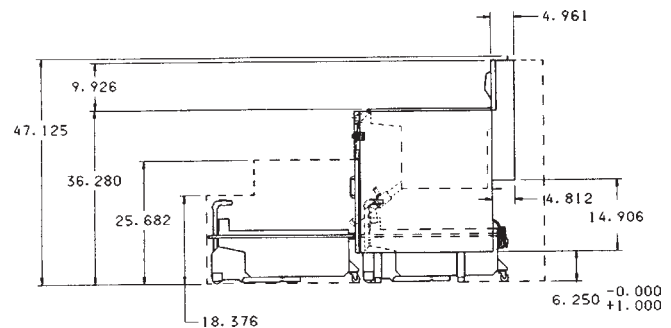
NOTES: ALL DIMENSIONS ARE REFERENCE DIMENSIONS.

IMPORTANT

1. A combination valve with pressure regulator is provided with this unit.
Natural Gas 4.0" (102 mm) W.C.
Propane Gas 10.0" (254 mm) W.C.
2. An adequate ventilation system is required for Commercial Cooking Equipment. Information may be obtained by writing to the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269. When writing refer to NFPA No. 96.
3. All models require a 6" (152 mm) clearance at both sides and rear adjacent to combustible construction.
4. All models require a 16" (407 mm) minimum clearance to adjacent open top burner units.
5. This appliance is manufactured for commercial installation only and is not intended for home use.

SERVICE CONNECTIONS:

- (P1)** 1/2" (13 mm) rear gas connection (single units).
1/4" (32 mm) rear manifold (batteries).
- (E1)** 115 volt cord & plug supplied on GRD and GRC fryers, filter ready fryers and GRS fryers with fat melt and electronic ignition options.



MODEL	WIDTH	DEPTH	OVERALL HEIGHT	WORKING HEIGHT	TANK SIZE	BTU/HR.	FRY COMP. CAPACITY	APPROX. SHP.WT.
GRS85 GRD85 GRC85	21"	34 $\frac{3}{4}$ "	47 $\frac{5}{8}$ "	36 $\frac{1}{4}$ "	19 $\frac{1}{2}$ " x 18 $\frac{1}{4}$ "	150,000	70 - 85 lbs.	300 lbs.

NOTE: In line with its policy to continually improve its products, Vulcan-Hart Company reserves the right to change materials and specifications without notice.

VULCAN-HART COMPANY, P.O. BOX 696, LOUISVILLE, KY 40201, TEL. 1-800-814-2028
502-778-2791 QUOTE & ORDER FAX: 1-800-444-0602

C Reporting Sheets

Manufacturer: Vulcan
Model: TK 65, GRD 65, and GRD 85
Date: November 2000

Section 11.1 Test

Description of operational characteristics: The TK 65, GRD 65, and GRD 85 fryers are powered by five atmospheric burners, each rated at 30,000 Btu/h. The TK 65 fryer is controlled by a mechanical thermostat, while both the GRD 65 and 85 fryers use solid state thermostats with a control package. Both the GRD 65 and 85 fryers include a melt cycle for solid shortening, with a manual override that allows for a shorter preheat when using a liquid shortening. All three fryers have a 19" frypot, but the GRD 85 fryer has a 4" deeper tank area giving it a larger shortening capacity.

Section 11.2 Apparatus

Check if testing apparatus conformed to specifications in section 6.

Deviations: None.

Section 11.4. Energy Input Rate.

	TK 65	GRD 65	GRD 85
Gas Heating Value (Btu/scf)	1016	1018	1020
Name Plate (Btu/h)	150,000	150,000	150,000
Measured (Btu/h)	154,430	154,560	146,270
Percentage Difference (%)	3.0	3.0	2.5

Results Reporting Sheets

Section 11.5 Thermostat Calibration

	TK 65	GRD 65	GRD 85
Thermostat Setting (°F)	325	325	325
Oil Temperature (°F)	326	326	326

Section 11.6 Preheat Energy and Time

	TK 65	GRD 65	GRD 85
Gas Heating Value (Btu/scf)	1018	1019	1019
Starting Temperature (°F)	74	75	76
Energy Consumption (Btu)	21,469	20,446	26,889
Duration (min)	9.6	8.8	10.7
Preheat Rate (°F/min)	26.1	28.4	23.3

Section 11.7 Idle Energy Rate

	TK 65	GRD 65	GRD 85
Gas Heating Value (Btu/scf)	1018	1019	1018
Idle Energy Rate @ 325 °F (Btu/h)	14,875	18,298	19,273

Results Reporting Sheets

Section 11.8 Heavy Load Cooking Energy Efficiency and Cooking Energy Rate

	TK 65	GRD 65	GRD 85
Gas Heating Value (Btu/scf)	1018	1018	1018
Load Size (pieces)	48	48	64
Cook Time (min)	20.35	20.46	19.34
Production Rate (lb/h)	54.0 ± 3.1	53.3 ± 1.31	75.7 ± 5.3
Energy Consumption (Btu/lb)	346	357	365
Cooking Energy Rate (Btu/h)	61,109	64,506	77,504
Energy per Pound of Food Cooked (Btu/lb)	1,131	1,211	1,023
Cooking Energy Efficiency (%)	30.6 ± 2.4	29.5 ± 0.3	35.7 ± 0.8

Section 11.9 Medium Load Cooking Energy Efficiency and Cooking Energy Rate

	TK 65	GRD 65	GRD 85
Gas Heating Value (Btu/scf)	1010	1010	1018
Load Size (pieces)	24	24	32
Cook Time (min)	22.65	21.91	19.21
Production Rate (lb/h)	23.6 ± 1.2	24.6 ± 1.1	37.3 ± 0.6
Energy Consumption (Btu/lb)	361	368	362
Cooking Energy Rate (Btu/h)	40,296	42,182	50,113
Energy per Pound of Food Cooked (Btu/lb)	1,707	1,714	1,345
Cooking Energy Efficiency (%)	21.2 ± 1.9	21.5 ± 1.3	27.0 ± 1.2

Results Reporting Sheets

Section 11.10 Light Load Cooking Energy Efficiency and Cooking Energy Rate

	TK 65	GRD 65	GRD 85
Gas Heating Value (Btu/scf)	1010	1010	1018
Load Size (pieces)	8	8	8
Cook Time (min)	21.30	20.46	17.63
Production Rate (lb/h)	8.5 ± 0.7	9.1 ± 0.3	10.4 ± 0.5
Energy Consumption (Btu/lb)	376	354	350
Cooking Energy Rate (Btu/h)	26,162	28,837	29,396
Energy per Pound of Food Cooked (Btu/lb)	3,067	3,154	2,817
Cooking Energy Efficiency (%)	12.3 ± 0.6	11.2 ± 0.7	12.4 ± 0.9

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. TK 65 Heavy-Load Chicken Test Data.

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Total Energy (Btu)	21,019	21,019	20,152
Total Test Time (min)	20.5	20.3	20.3
Weight Loss (%)	25.48	25.17	25.58
Initial Weight (lb)	18.094	18.750	18.144
Final Weight (lb)	13.484	14.030	13.502
Initial Moisture Content (%)	61.5	61.5	61.5
Final Moisture Content (%)	50.7	50.0	49.6
Initial Temperature (°F)	37	37	37
Final Temperature (°F)	202	200	200
Water Loss (lb)	4.29	4.52	4.46
Calculated Values			
Initial Weight of Water (lb)	11.126	11.530	11.157
Final Weight of Water (lb)	6.834	7.012	6.695
Sensible (Btu)	2,054	2,103	2,009
Latent - Heat of Vaporization (Btu)	4,163	4,382	4,329
Total Energy to Food (Btu)	6,217	6,485	6,338
Energy to Food (Btu/lb)	344	346	349
Total Energy to Fryer (Btu)	21,019	21,019	20,152
Energy to Fryer (Btu/lb)	1,162	1,121	1,111
Cooking Energy Efficiency (%)	29.6	30.9	31.4
Cooking Energy Rate (Btu/h)	61,641	63,126	59,562
Production Rate (lb/h)	53.1	55.4	53.6

Cooking Energy Efficiency Data

Table D-3. TK 65 Medium-Load Chicken Test Data.

	Repetition #1	Repetition #2	Repetition #3	Repetition #4
Measured Values				
Total Energy (Btu)	15,301	15,108	15,686	14,723
Total Test Time (min)	22.2	23.1	22.7	22.6
Weight Loss (%)	25.39	28.17	26.12	28.73
Initial Weight (lb)	9.135	9.046	8.755	8.706
Final Weight (lb)	6.816	6.497	6.469	6.205
Initial Moisture Content (%)	61.5	61.5	61.5	61.5
Final Moisture Content (%)	49.1	49.3	49.8	48.1
Initial Temperature (°F)	37	37	37	37
Final Temperature (°F)	202	200	200	200
Water Loss (lb)	2.27	2.36	2.16	2.37
Calculated Values				
Initial Weight of Water (lb)	5.617	5.562	5.384	5.354
Final Weight of Water (lb)	3.348	3.203	3.222	2.985
Sensible (Btu)	1,037	1,015	969	970
Latent - Heat of Vaporization (Btu)	2,201	2,288	2,097	2,298
Total Energy to Food (Btu)	3,238	3,303	3,066	3,267
Energy to Food (Btu/lb)	354	365	350	375
Total Energy to Fryer (Btu)	15,301	15,108	15,686	14,723
Energy to Fryer (Btu/lb)	1,675	1,670	1,792	1,691
Cooking Energy Efficiency (%)	21.2	21.9	19.5	22.2
Cooking Energy Rate (Btu/h)	41,445	39,276	41,441	39,019
Production Rate (lb/h)	24.7	23.5	23.1	23.1

Cooking Energy Efficiency Data

Table D-4. TK 65 Light-Load Chicken Test Data.

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Total Energy (Btu)	9,314	9,219	9,314
Total Test Time (min)	20.6	21.6	21.6
Weight Loss (%)	26.64	27.77	26.34
Initial Weight (lb)	3.041	3.001	3.038
Final Weight (lb)	2.231	2.168	2.238
Initial Moisture Content (%)	62.7	62.7	62.7
Final Moisture Content (%)	49.5	47.8	48.4
Initial Temperature (°F)	37	37	37
Final Temperature (°F)	202	200	200
Water Loss (lb)	0.80	0.85	0.82
Calculated Values			
Initial Weight of Water (lb)	1.907	1.882	1.905
Final Weight of Water (lb)	1.104	1.037	1.083
Sensible (Btu)	345	337	336
Latent - Heat of Vaporization (Btu)	779	820	797
Total Energy to Food (Btu)	1,124	1,157	1,134
Energy to Food (Btu/lb)	370	386	373
Total Energy to Fryer (Btu)	9,314	9,219	9,314
Energy to Fryer (Btu/lb)	3,063	3,072	3,066
Cooking Energy Efficiency (%)	12.1	12.5	12.2
Cooking Energy Rate (Btu/h)	27,076	25,573	25,836
Production Rate (lb/h)	8.8	8.3	8.4

Cooking Energy Efficiency Data

Table D-5. GRD 65 Heavy-Load Chicken Test Data.

	Repetition #1	Repetition #2	Repetition #3	Repetition #4
Measured Values				
Total Energy (Btu)	21,770	21,619	22,488	22,079
Total Test Time (min)	20.6	20.3	20.2	20.6
Weight Loss (%)	27.61	27.36	28.42	26.55
Initial Weight (lb)	18.180	17.783	18.330	18.340
Final Weight (lb)	13.160	12.917	13.120	13.470
Initial Moisture Content (%)	61.5	61.5	61.5	61.5
Final Moisture Content (%)	50.5	49.6	50.2	49.8
Initial Temperature (°F)	37	37	37	37
Final Temperature (°F)	202	200	200	200
Water Loss (lb)	4.54	4.53	4.68	4.57
Calculated Values				
Initial Weight of Water (lb)	11.179	10.935	11.272	11.288
Final Weight of Water (lb)	6.643	6.401	6.588	6.711
Sensible (Btu)	2,064	1,995	2,030	2,043
Latent - Heat of Vaporization (Btu)	4,400	4,399	4,543	4,430
Total Energy to Food (Btu)	6,464	6,393	6,573	6,472
Energy to Food (Btu/lb)	356	360	359	353
Total Energy to Fryer (Btu)	21,770	21,619	22,484	22,079
Energy to Fryer (Btu/lb)	1,197	1,216	1,227	1,204
Cooking Energy Efficiency (%)	29.7	29.6	29.2	29.3
Cooking Energy Rate (Btu/h)	63,286	63,836	66,718	64,183
Production Rate (lb/h)	52.8	52.5	54.4	53.3

Cooking Energy Efficiency Data

Table D-6. GRD 65 Medium-Load Chicken Test Data.

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Total Energy (Btu)	15,087	15,758	15,374
Total Test Time (min)	21.9	22.2	21.7
Weight Loss (%)	26.76	28.17	28.90
Initial Weight (lb)	9.094	8.911	8.968
Final Weight (lb)	6.660	6.400	6.376
Initial Moisture Content (%)	61.5	61.5	61.5
Final Moisture Content (%)	49.0	48.7	48.5
Initial Temperature (°F)	37	37	37
Final Temperature (°F)	202	200	200
Water Loss (lb)	2.33	2.36	2.42
Calculated Values			
Initial Weight of Water (lb)	5.592	5.479	5.514
Final Weight of Water (lb)	3.266	3.118	3.094
Sensible (Btu)	1,032	999	993
Latent - Heat of Vaporization (Btu)	2,257	2,290	2,348
Total Energy to Food (Btu)	3,289	3,289	3,341
Energy to Food (Btu/lb)	362	369	373
Total Energy to Fryer (Btu)	15,087	15,758	15,374
Energy to Fryer (Btu/lb)	1,659	1,768	1,714
Cooking Energy Efficiency (%)	21.8	20.9	21.7
Cooking Energy Rate (Btu/h)	41,352	42,666	42,527
Production Rate (lb/h)	24.9	24.1	24.8

Cooking Energy Efficiency Data

Table D-7. GRD 65 Light-Load Chicken Test Data.

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Total Energy (Btu)	9,605	9,799	10,090
Total Test Time (min)	20.1	20.2	21.1
Weight Loss (%)	25.80	26.08	26.98
Initial Weight (lb)	3.097	3.075	3.179
Final Weight (lb)	2.298	2.273	2.321
Initial Moisture Content (%)	61.5	61.5	61.5
Final Moisture Content (%)	49.2	50.3	49.4
Initial Temperature (°F)	37	37	37
Final Temperature (°F)	202	200	200
Water Loss (lb)	0.77	0.75	0.81
Calculated Values			
Initial Weight of Water (lb)	1.904	1.891	1.955
Final Weight of Water (lb)	1.130	1.144	1.146
Sensible (Btu)	351	345	352
Latent - Heat of Vaporization (Btu)	751	725	785
Total Energy to Food (Btu)	1,102	1,069	1,136
Energy to Food (Btu/lb)	356	348	358
Total Energy to Fryer (Btu)	9,605	9,799	10,090
Energy to Fryer (Btu/lb)	3,102	3,187	3,174
Cooking Energy Efficiency (%)	11.5	10.9	11.3
Cooking Energy Rate (Btu/h)	28,714	29,077	28,719
Production Rate (lb/h)	9.3	9.1	9.0

Cooking Energy Efficiency Data

Table D-8. GRD 85 Heavy-Load Chicken Test Data.

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Total Energy (Btu)	24,406	24,598	25,943
Total Test Time (min)	19.4	19.3	19.4
Weight Loss (%)	29.76	29.61	28.99
Initial Weight (lb)	24.145	23.867	25.230
Final Weight (lb)	16.960	16.801	17.915
Initial Moisture Content (%)	61.5	61.5	61.5
Final Moisture Content (%)	50.7	50.4	49.4
Initial Temperature (°F)	37	37	37
Final Temperature (°F)	202	200	200
Water Loss (lb)	6.24	6.22	6.66
Calculated Values			
Initial Weight of Water (lb)	14.847	14.677	15.515
Final Weight of Water (lb)	8.606	8.461	8.854
Sensible (Btu)	2,741	2,677	2,794
Latent - Heat of Vaporization (Btu)	6,054	6,029	6,461
Total Energy to Food (Btu)	8,794	8,706	9,255
Energy to Food (Btu/lb)	364	365	367
Total Energy to Fryer (Btu)	24,406	24,598	25,943
Energy to Fryer (Btu/lb)	1,011	1,031	1,028
Cooking Energy Efficiency (%)	36.0	35.4	35.7
Cooking Energy Rate (Btu/h)	75,560	76,550	80,403
Production Rate (lb/h)	74.8	74.3	78.2

Cooking Energy Efficiency Data

Table D-9. GRD 85 Medium-Load Chicken Test Data.

	Repetition #1	Repetition #2	Repetition #3	Repetition #4
Measured Values				
Total Energy (Btu)	16,070	15,974	16,263	15,878
Total Test Time (min)	19.2	19.2	19.2	19.2
Weight Loss (%)	27.24	28.00	27.61	29.92
Initial Weight (lb)	11.808	11.927	11.909	12.091
Final Weight (lb)	8.592	8.587	8.621	8.474
Initial Moisture Content (%)	61.5	61.5	61.5	61.5
Final Moisture Content (%)	49.2	50.4	49.3	49.8
Initial Temperature (°F)	37	37	37	37
Final Temperature (°F)	202	200	200	201
Water Loss (lb)	3.03	3.01	3.08	3.21
Calculated Values				
Initial Weight of Water (lb)	7.261	7.334	7.323	7.435
Final Weight of Water (lb)	4.230	4.327	4.246	4.222
Sensible (Btu)	1,340	1,338	1,319	1,347
Latent - Heat of Vaporization (Btu)	2,940	2,917	2,985	3,117
Total Energy to Food (Btu)	4,280	4,255	4,303	4,464
Energy to Food (Btu/lb)	362	357	361	369
Total Energy to Fryer (Btu)	16,070	15,974	16,263	15,878
Energy to Fryer (Btu/lb)	1,361	1,339	1,366	1,313
Cooking Energy Efficiency (%)	26.6	26.6	26.5	28.1
Cooking Energy Rate (Btu/h)	50,168	49,894	50,822	49,567
Production Rate (lb/h)	36.9	37.3	37.2	37.7

Cooking Energy Efficiency Data

Table D-10. GRD 85 Light-Load Chicken Test Data.

	Repetition #1	Repetition #2	Repetition #3	Repetition #4
Measured Values				
Total Energy (Btu)	8,443	8,831	8,779	8,458
Total Test Time (min)	17.1	17.2	18.1	18.2
Weight Loss (%)	26.56	25.14	25.19	23.98
Initial Weight (lb)	3.031	3.009	3.186	3.030
Final Weight (lb)	2.226	2.252	2.383	2.304
Initial Moisture Content (%)	61.5	61.5	61.5	61.5
Final Moisture Content (%)	48.4	50.1	49.2	49.8
Initial Temperature (°F)	37	37	37	37
Final Temperature (°F)	202	200	200	201
Water Loss (lb)	0.79	0.72	0.79	0.72
Calculated Values				
Initial Weight of Water (lb)	1.864	1.850	1.959	1.863
Final Weight of Water (lb)	1.078	1.129	1.172	1.147
Sensible (Btu)	344	337	353	337
Latent - Heat of Vaporization (Btu)	762	700	763	695
Total Energy to Food (Btu)	1,106	1,037	1,116	1,033
Energy to Food (Btu/lb)	365	345	350	341
Total Energy to Fryer (Btu)	8,443	8,831	8,779	8,458
Energy to Fryer (Btu/lb)	2,786	2,935	2,756	2,791
Cooking Energy Efficiency (%)	13.1	11.7	12.7	12.2
Cooking Energy Rate (Btu/h)	29,692	30,877	29,165	27,851
Production Rate (lb/h)	10.7	10.5	10.6	10.0

Cooking Energy Efficiency Data

Table D-11. TK 65 Heavy-Load Fry Test Data.

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Total Energy (Btu)	35,428	35,676	36,412
Cook Time (min)	2.72	2.72	2.72
Total Test Time (min)	14.8	14.8	14.7
Weight Loss (%)	29.56	29.69	29.91
Initial Weight (lb)	25.000	25.000	25.000
Final Weight (lb)	17.611	17.578	17.523
Initial Fat Content (%)	6.1	6.1	6.1
Initial Moisture Content (%)	64.3	64.3	64.3
Final Moisture Content (%)	44.8	44.5	45.0
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	212	212	212
Calculated Values			
Initial Weight of Water (lb)	16.074	16.074	16.074
Final Weight of Water (lb)	7.891	7.831	7.877
Sensible (Btu)	3,684	3,684	3,684
Latent - Heat of Fusion (Btu)	2,315	2,315	2,315
Latent - Heat of Vaporization (Btu)	7,938	7,996	7,951
Total Energy to Food (Btu)	13,936	13,994	13,949
Energy to Food (Btu/lb)	557	560	558
Total Energy to Fryer (Btu)	35,428	35,676	36,412
Energy to Fryer (Btu/lb)	1,417	1,427	1,456
Cooking Energy Efficiency (%)	39.3	39.2	38.3
Cooking Energy Rate (Btu/h)	143,335	144,342	148,216
Production Rate (lb/h)	101.1	101.1	101.8
Average Recovery Time (sec)	0.25	0.25	0.23

Cooking Energy Efficiency Data

Table D-12. TK 65 Light Load Fry Test Data.

	Repetition #1	Repetition #2	Repetition #3	Repetition #4
Measured Values				
Total Energy (Btu)	8,529	8,919	9,684	9,104
Cook Time (min)	2.28	2.28	2.28	2.28
Total Test Time (min)	12.4	12.3	12.4	12.3
Weight Loss (%)	30.31	30.33	30.87	30.83
Initial Weight (lb)	3.750	3.750	3.750	3.750
Final Weight (lb)	2.614	2.613	2.593	2.594
Initial Fat Content (%)	6.1	6.1	6.1	6.1
Initial Moisture Content (%)	64.3	64.3	64.3	64.3
Final Moisture Content (%)	44.5	43.5	42.3	42.3
Initial Temperature (°F)	0	0	0	0
Final Temperature (°F)	212	212	212	212
Calculated Values				
Initial Weight of Water (lb)	2.411	2.411	2.411	2.411
Final Weight of Water (lb)	1.164	1.138	1.096	1.097
Sensible (Btu)	553	553	553	553
Latent - Heat of Fusion (Btu)	347	347	347	347
Latent - Heat of Vaporization (Btu)	1,210	1,235	1,275	1,275
Total Energy to Food (Btu)	2,110	2,135	2,175	2,174
Energy to Food (Btu/lb)	563	569	580	580
Total Energy to Fryer (Btu)	8,529	8,919	9,684	9,104
Energy to Fryer (Btu/lb)	2,274	2,378	2,583	2,428
Cooking Energy Efficiency (%)	24.7	23.9	22.5	23.9
Cooking Energy Rate (Btu/h)	41,335	43,365	47,050	44,304
Production Rate (lb/h)	18.2	18.2	18.2	18.2
Average Recovery Time (sec)	0.19	0.19	0.19	0.19

Cooking Energy Efficiency Data

Table D-13. GRD 65 Heavy Load Fry Test Data.

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Total Energy (Btu)	32,701	33,303	33,025
Cook Time (min)	2.63	2.65	2.65
Total Test Time (min)	14.6	14.9	14.9
Weight Loss (%)	29.49	29.46	29.87
Initial Weight (lb)	25.000	25.000	25.000
Final Weight (lb)	17.627	17.636	17.532
Initial Fat Content (%)	6.1	6.1	6.1
Initial Moisture Content (%)	66.0	66.0	66.0
Final Moisture Content (%)	45.6	45.1	45.0
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	212	212	212
Calculated Values			
Initial Weight of Water (lb)	16.504	16.504	16.504
Final Weight of Water (lb)	8.044	7.948	7.893
Sensible (Btu)	3,684	3,684	3,684
Latent - Heat of Fusion (Btu)	2,377	2,377	2,377
Latent - Heat of Vaporization (Btu)	8,206	8,299	8,352
Total Energy to Food (Btu)	14,266	14,359	14,412
Energy to Food (Btu/lb)	571	574	576
Total Energy to Fryer (Btu)	32,701	33,303	33,025
Energy to Fryer (Btu/lb)	1,308	1,332	1,320
Cooking Energy Efficiency (%)	43.6	43.1	43.6
Cooking Energy Rate (Btu/h)	134,205	134,560	132,718
Production Rate (lb/h)	102.6	101.0	100.5
Average Recovery Time (sec)	0.29	0.323	0.34

Cooking Energy Efficiency Data

Table D-14. GRD 65 Light Load Fry Test Data.

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Total Energy (Btu)	10,046	10,416	10,121
Cook Time (min)	2.33	2.33	2.33
Total Test Time (min)	12.6	12.4	12.5
Weight Loss (%)	30.28	30.05	30.17
Initial Weight (lb)	3.750	3.750	3.750
Final Weight (lb)	2.615	2.623	2.619
Initial Fat Content (%)	6.1	6.1	6.1
Initial Moisture Content (%)	64.3	64.3	64.3
Final Moisture Content (%)	44.5	43.5	42.3
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	212	212	212
Calculated Values			
Initial Weight of Water (lb)	2.411	2.411	2.411
Final Weight of Water (lb)	1.164	1.142	1.107
Sensible (Btu)	553	553	553
Latent - Heat of Fusion (Btu)	347	347	347
Latent - Heat of Vaporization (Btu)	1,210	1,231	1,265
Total Energy to Food (Btu)	2,109	2,130	2,164
Energy to Food (Btu/lb)	562	568	577
Total Energy to Fryer (Btu)	10,046	10,416	10,121
Energy to Fryer (Btu/lb)	2,679	2,778	2,699
Cooking Energy Efficiency (%)	21.0	20.5	21.4
Cooking Energy Rate (Btu/h)	47,915	50,604	48,502
Production Rate (lb/h)	17.9	18.2	18.0
Average Recovery Time (sec)	0.19	0.14	0.17

Cooking Energy Efficiency Data

Table D-15. GRD 85 Heavy Load Fry Test Data.

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Total Energy (Btu)	34,234	33,253	32,762
Cook Time (min)	2.62	2.62	2.62
Total Test Time (min)	14.1	14.3	14.1
Weight Loss (%)	30.09	30.10	30.33
Initial Weight (lb)	25.000	25.000	25.000
Final Weight (lb)	17.479	17.475	17.418
Initial Fat Content (%)	6.1	6.1	6.1
Initial Moisture Content (%)	64.3	64.3	64.3
Final Moisture Content (%)	43.2	43.2	43.5
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	212	212	212
Calculated Values			
Initial Weight of Water (lb)	16.074	16.074	16.074
Final Weight of Water (lb)	7.545	7.546	7.582
Sensible (Btu)	3,684	3,684	3,684
Latent - Heat of Fusion (Btu)	2,315	2,315	2,315
Latent - Heat of Vaporization (Btu)	8,274	8,272	8,237
Total Energy to Food (Btu)	14,272	17,271	14,236
Energy to Food (Btu/lb)	571	571	569
Total Energy to Fryer (Btu)	34,234	33,253	32,762
Energy to Fryer (Btu/lb)	1,369	1,330	1,310
Cooking Energy Efficiency (%)	41.7	42.9	43.5
Cooking Energy Rate (Btu/h)	145,367	139,620	139,710
Production Rate (lb/h)	106.2	105.0	106.6
Average Recovery Time (sec)	0.21	0.24	0.19

Cooking Energy Efficiency Data

Table D-16. GRD 85 Light Load Fry Test Data.

	Repetition #1	Repetition #2	Repetition #3
Measured Values			
Total Energy (Btu)	9,090	9,285	8,879
Cook Time (min)	2.05	2.05	2.05
Total Test Time (min)	11.2	11.2	11.2
Weight Loss (%)	29.45	30.29	29.50
Initial Weight (lb)	3.750	3.750	3.750
Final Weight (lb)	2.646	2.614	2.644
Initial Fat Content (%)	6.1	6.1	6.1
Initial Moisture Content (%)	64.3	64.3	64.3
Final Moisture Content (%)	44.5	44.3	44.1
Initial Temperature (°F)	0	0	0
Final Temperature (°F)	212	212	212
Calculated Values			
Initial Weight of Water (lb)	2.411	2.411	2.411
Final Weight of Water (lb)	1.177	1.159	1.166
Sensible (Btu)	553	553	553
Latent - Heat of Fusion (Btu)	347	347	347
Latent - Heat of Vaporization (Btu)	1,197	1,215	1,208
Total Energy to Food (Btu)	2,097	2,115	2,108
Energy to Food (Btu/lb)	559	564	562
Total Energy to Fryer (Btu)	9,090	9,285	8,879
Energy to Fryer (Btu/lb)	2,424	2,476	2,368
Cooking Energy Efficiency (%)	23.1	22.8	23.7
Cooking Energy Rate (Btu/h)	48,913	50,099	47,781
Production Rate (lb/h)	20.2	20.2	20.2
Average Recovery Time (sec)	0.18	0.17	0.18

Cooking Energy Efficiency Data

Table D-17. TK 65 Chicken Cooking Energy Efficiency and Production Capacity Statistics.

	Cooking Energy Efficiency			Production Capacity
	Heavy Load	Medium Load	Light Load	
Replicate #1	29.6	21.2	12.1	53.1
Replicate #2	30.9	21.9	12.5	55.4
Replicate #3	31.4	19.5	12.2	53.6
Replicate #4	—	22.2	—	—
Average	30.6	21.2	12.3	54.0
Standard Deviation	1.0	1.2	0.3	1.2
Absolute Uncertainty	2.4	1.9	0.6	3.1
Percent Uncertainty	7.7	8.8	5.1	5.6

Table D-18. GRD 65 Chicken Cooking Energy Efficiency and Production Capacity Statistics.

	Cooking Energy Efficiency			Production Capacity
	Heavy Load	Medium Load	Light Load	
Replicate #1	29.7	21.8	11.5	52.8
Replicate #2	29.6	20.9	10.9	52.5
Replicate #3	29.2	21.7	11.3	54.4
Replicate #4	29.3	—	—	53.3
Average	29.5	21.5	11.2	53.3
Standard Deviation	0.2	0.5	0.3	0.8
Absolute Uncertainty	0.3	1.3	0.7	1.3
Percent Uncertainty	1.2	6.0	6.3	2.4

Cooking Energy Efficiency Data

Table D-19. GRD 85 Chicken Cooking Energy Efficiency and Production Capacity Statistics.

	Cooking Energy Efficiency			Production Capacity
	Heavy Load	Medium Load	Light Load	
Replicate #1	36.0	26.6	13.1	74.8
Replicate #2	35.4	26.6	11.7	74.3
Replicate #3	35.7	26.5	12.7	78.2
Replicate #4	—	28.1	12.2	—
Average	35.7	27.0	12.4	75.7
Standard Deviation	0.3	0.8	0.6	2.1
Absolute Uncertainty	0.8	1.2	0.9	5.3
Percent Uncertainty	2.2	4.6	7.6	7.0

Table D-20. TK 65 French Fry Cooking Energy Efficiency and Production Capacity Statistics.

	Cooking Energy Efficiency		Production Capacity
	Heavy Load	Light Load	
Replicate #1	39.3	24.7	101.1
Replicate #2	39.2	23.9	101.1
Replicate #3	38.3	22.5	101.8
Replicate #4	—	23.9	—
Average	39.0	23.8	101.4
Standard Deviation	0.6	0.9	0.4
Absolute Uncertainty	1.4	1.5	0.9
Percent Uncertainty	3.6	6.3	0.9

Cooking Energy Efficiency Data

Table D-21. GRD 65 Cooking Energy Efficiency and Production Capacity Statistics.

	Cooking Energy Efficiency		Production Capacity
	Heavy Load	Light Load	
Replicate #1	43.6	21.0	102.6
Replicate #2	43.1	20.5	101.0
Replicate #3	43.6	21.4	100.5
Replicate #4	—	—	—
Average	43.5	20.9	101.4
Standard Deviation	0.3	0.5	1.1
Absolute Uncertainty	0.7	1.2	2.7
Percent Uncertainty	1.7	5.5	2.7

Table D-22. GRD 85 Cooking Energy Efficiency and Production Capacity Statistics.

	Cooking Energy Efficiency		Production Capacity
	Heavy Load	Light Load	
Replicate #1	41.7	23.1	106.2
Replicate #2	42.9	22.8	105.0
Replicate #3	43.5	23.7	1066
Replicate #4	—	—	—
Average	39.0	23.2	105.9
Standard Deviation	0.6	0.5	0.8
Absolute Uncertainty	1.4	1.2	2.1
Percent Uncertainty	3.6	5.3	2.0