Standard Test Method for Performance of Pressure Fryers[1]

This standard is issued under the fixed designation F1964; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method evaluates the energy consumption and cooking performance of pressure and kettle fryers. The food service operator can use this evaluation to select a fryer and understand its energy efficiency and production capacity.

1.2 This test method is applicable to floor model natural gas and electric pressure fryers.

1.3 The fryer can be evaluated with respect to the following:

1.3.1 Energy input rate (10.2),

1.3.2 Preheat energy and time (10.4),

1.3.3 Idle energy rate (10.5),

1.3.4 Pilot energy rate (10.6, if applicable),

1.3.5 Cooking energy rate and efficiency (10.9), and

1.3.6 Production capacity (10.9).

1.4 The values stated in inch-pound units are to be regarded as standard. The SI units given in parentheses are for information only.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ANSI Standard:*[2]

ANSI Z83.11 Gas Food Service Equipment

2.2 *AOAC Standard:*[3]

AOAC Official Action 950.46 Air Drying to Determine Moisture Content of Meat and Meat Products

2.3 *ASHRAE Standard:*[4]

ASHRAE 2-1986 (RA90) Engineering Analysis of Experimental Data

3. Terminology

3.1 *Definitions:*

3.1.1 *pressure fryer, n*—an appliance with a deep kettle containing oil or fat and covered by a heavy, gasketed lid with a pressure valve; the appliance kettle operates between 10 and 12 psig.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cold zone, n*—the volume in the fryer below the heating elements or heat exchanger surface designed to remain cooler than the cook zone.

3.2.2 *cooking energy, n*—total energy consumed by the fryer as it is used to cook breaded chicken product under heavy- and light-load conditions.

3.2.3 *cooking energy efficiency, n*—quantity of energy imparted to the chicken during the cooking process expressed as a percentage of the quantity of energy input to the fryer during the heavy tests.

3.2.4 *cooking energy rate, n*—average rate of energy consumed by the fryer while cooking a heavy load of chicken.

3.2.5 *cook zone, n*—the volume of oil in which food is cooked.

3.2.6 *energy input rate, n*—peak rate at which a fryer consumes energy (Btu/h or kW), typically reflected during preheat.

3.2.7 *idle energy rate, n*—average rate of energy consumed (Btu/h or kW) by the fryer while holding or idling the frying medium at the thermostat(s) set point.

3.2.8 *pilot energy rate, n*—average rate of energy consumption (Btu/h) by a fryer's continuous pilot (if applicable).

3.2.9 *preheat energy, n*—amount of energy consumed (Btu or kWh) by the fryer while preheating the frying medium from ambient room temperature to the calibrated thermostat(s) set point.

[1] This test method is under the jurisdiction of ASTM Committee F26 on Food Service Equipment and is the direct responsibility of Subcommittee F26.06 on Productivity and Energy Protocol.

Current edition approved June 1, 2011. Published August 2011. Originally approved in 1999. Last previous edition approved in 2005 as F1964 – 99 (2005). DOI: 10.1520/F1964-11.

[2] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

[3] Available from the Association of Official Analytical Chemists, 1111 N. 19th Street, Arlington, VA 22209.

[4] Available from American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), 1791 Tullie Circle, NE, Atlanta, GA 30329.

3.2.10 *preheat rate, n*—the average rate (°F/min) at which the frying medium temperature is heated from ambient temperature to the fryer's calibrated thermostat(s) set point.

3.2.11 *preheat time, n*—time required for the frying medium to preheat from ambient room temperature to the calibrated thermostat(s) set point.

3.2.12 *production capacity, n*—maximum rate (lb/h) at which a fryer can bring the specified food product to a specified cooked condition.

3.2.13 *uncertainty, n*—measure of systematic and precision errors in specified instrumentation or measure of repeatability of a reported test result.

4. Summary of Test Method

4.1 The fryer under test is connected to the appropriate, metered energy source. The measured energy input rate is determined and checked against the rated input before continuing with testing.

4.2 The frying medium temperature in the cook zone is monitored at a location chosen to represent the average temperature of the frying medium while the fryer is idled at 325°F. Fryer temperature calibration to 325°F is achieved at the location representing the average temperature of the frying medium.

4.3 The preheat energy and time and idle energy rate are determined while the fryer is operating with the thermostat(s) set at a calibrated 325°F. The rate of pilot energy consumption also is determined, when applicable, to the fryer under test.

4.4 Energy consumption and time are monitored while the fryer is used to cook breaded chicken. Cooking energy efficiency, cooking energy rate, and production capacity are determined for heavy-load cooking tests.

5. Significance and Use

5.1 The energy input rate test is used to confirm that the fryer under test is operating in accordance with its nameplate rating.

5.2 Fryer temperature calibration is used to ensure that the fryer being tested is operating at the specified temperature. Temperature calibration also can be used to evaluate and calibrate the thermostat control dial.

5.3 Preheat energy and time can be used by food service operators to manage their restaurants' energy demands, and to estimate the amount of time required for preheating a fryer.

5.4 Idle energy rate and pilot energy rate can be used to estimate energy consumption during noncooking periods.

5.5 Preheat energy, idle energy rate, pilot energy rate, and heavy-load cooking energy rates can be used to estimate the fryer's energy consumption in an actual food service operation.

5.6 Cooking energy efficiency is a direct measurement of fryer efficiency at different loading scenarios. This information can be used by food service operators in the selection of fryers, as well as for the management of a restaurants' energy demands.

5.7 Production capacity is used by food service operators to choose a fryer that matches their food output requirements.

6. Apparatus

6.1 *Analytical Balance Scale,* for measuring weights up to 25 lb, with a resolution of 0.01 lb and an uncertainty of 0.01 lb.

6.2 *Barometer,* for measuring absolute atmospheric pressure, to be used for adjustment of measured gas volume to standard conditions. The barometer shall have a resolution of 0.2 in. Hg and an uncertainty of 0.2 in. Hg.

6.3 *Canopy Exhaust Hood,* 4 ft in depth, wall-mounted with the lower edge of the hood 6 ft, 6 in. from the floor and with the capacity to operate at a nominal exhaust ventilation rate of 300 cfm per linear foot of active hood length. This hood shall extend a minimum of 6 in. past both sides and the front of the cooking appliance and shall not incorporate side curtains or partitions. Makeup air shall be delivered through the face registers or from the space, or both.

6.4 *Convection Drying Oven,* with temperature controlled at 215 to 220°F, used to determine moisture content of both the raw and cooked food product.

6.5 *Data Acquisition System,* for measuring energy and temperatures, capable of multiple temperature displays updating at least every 2 s.

6.6 *Fry Basket,* chrome-plated steel construction, supplied by the manufacturer of the fryer under test. At least two baskets are required to test each pressure fryer according to this standard.

6.7 *Gas Meter,* for measuring the gas consumption of a fryer, shall be a positive displacement type with a resolution of at least 0.01 ft^3 and a maximum uncertainty no greater than 1 % of the measured value for any demand greater than 2.2 ft^3/h. If the meter is used for measuring the gas consumed by the pilot lights, it shall have a resolution of at least 0.01 ft^3 and a maximum uncertainty no greater than 2 % of the measured value.

6.8 *Pressure Gage,* for monitoring gas pressure, with a range from 0 to 15 in. H_2O, a resolution of 0.5 in. H_2O, and a maximum uncertainty of 1 % of the measured value.

6.9 *Stopwatch,* with a 1-s resolution.

6.10 *Temperature Sensor,* for measuring natural gas temperature in the range from 50 to 100°F with an uncertainty of ±1°F.

6.11 *Thermocouple(s),* Teflon™–insulated, 24 gage, Type T or Type K thermocouples capable of immersion with a range from 50 to 400°F and an uncertainty of ±1°F.

6.12 *Thermocouple Probe(s),* "fast response" Type T or Type K thermocouple probe, 1⁄16 in. or smaller diameter, with a 3–s response time, capable of immersion with a range from 30 to 250°F and an uncertainty of ±1°F.

6.13 *Watt-Hour Meter,* for measuring the electrical energy consumption of a fryer, shall have a resolution of at least 10 W/h and a maximum uncertainty no greater than 1.5 % of the measured value for any demand greater than 100 W. For any demand less than 100 W, the meter shall have a resolution of at least 10 W/h and a maximum uncertainty no greater than 10 %.

7. Reagents and Materials

7.1 *Enriched Flour*—Order a sufficient quantity of all-purpose, enriched white flour to conduct the heavy load tests.

7.2 *Chicken*—Order sufficient quantity of frozen, 5-oz, whole meat, boneless, skinless chicken breasts to conduct the cooking tests.

7.3 *Cooling Racks*—Stainless steel construction, measuring 18 by 26 in., by 1-in. high, to be used for draining chicken.

7.4 *Bucket*—Food grade, 5-gal bucket for coating the chicken pieces in a dipping solution.

7.5 *Breading Bin, or Food Storage Box*—made from food-grade plastic, measuring 18 by 26 by 9 in. for coating the chicken pieces in flour breading.

7.6 *Frying Medium*—Shall be 100 % pure vegetable oil. New frying medium shall be used for each fryer tested in accordance with this test method. The new frying medium that has been added to the fryer for the first time shall be heated to 325°F at least once before any test is conducted.

NOTE 1—Generic all-vegetable oil (soybean oil) has been shown to be an acceptable product for testing.

7.7 *Sheet Pans*—Measuring 18 by 26 by 1 in., for use in holding the chicken.

7.8 *Tongs*—Heavy-duty, 15-in. tongs for holding hot pieces of chicken.

8. Sampling of Test Units

8.1 *Fryer*—A representative production model shall be selected for performance testing.

9. Preparation of Apparatus

9.1 Install the appliance in accordance with the manufacturer's instructions under a 4-ft deep canopy exhaust hood mounted against the wall with the lower edge of the hood 6 ft, 6 in. from the floor. Position the fryer with the front edge of frying medium inset 6 in. from the front edge of the hood at the manufacturer's recommended working height. The length of the exhaust hood and active filter area shall extend a minimum of 6 in. past the vertical plane of both sides of the fryer. In addition, both sides of the fryer shall be a minimum of 3 ft from any side wall, side partition, or other operating appliance. A drip station positioned next to the fryer is recommended. The exhaust ventilation rate shall be based on 300 cfm per linear foot of hood length. The associated heating or cooling system shall be capable of maintaining an ambient temperature of 75 ± 5°F within the testing environment when the exhaust system is operating.

9.2 Connect the fryer to a calibrated energy test meter. For gas installations, a pressure regulator shall be installed downstream from the meter to maintain a constant pressure of gas for all tests. Both the pressure and temperature of the gas supplied to a fryer, as well as the barometric pressure, shall be recorded during each test so that the measured gas flow can be corrected to standard conditions. For electric installations, a voltage regulator may be required to maintain a constant "nameplate" voltage during tests if the voltage supply is not within ±2.5 % of the manufacturer's nameplate voltage.

9.3 For a gas fryer, adjust (during maximum energy input) the gas supply pressure downstream from the fryer's pressure regulator to within ±2.5 % of the operating manifold pressure specified by the manufacturer. Make adjustments to the fryer following the manufacturer's recommendations for optimizing combustion. Proper combustion may be verified by measuring air-free carbon monoxide (CO) in accordance with ANSI Z83.11.

9.4 For an electric fryer, confirm (while the fryer elements are energized) that the supply voltage is within ±2.5 % of the operating voltage specified by the manufacturer. Record the test voltage for each test.

NOTE 2—This test method is intended to evaluate the performance of a fryer at its rated gas pressure or electric voltage. If an electric fryer is rated dual voltage (that is, designed to operate at either 208 or 240 V with no change in components), the voltage selected by the manufacturer or tester, or both, shall be reported. If a fryer is designed to operate at two voltages without a change in the resistance of the heating elements, the performance of the fryer (for example, preheat time) may differ at the two voltages.

9.5 Make fryer ready for use in accordance with the manufacturer's instructions. Clean fryer by "boiling" with the manufacturer's recommended cleaner and water and then rinsing the inside of the fry pot thoroughly.

9.6 To prepare the fryer for temperature calibration, attach an immersion-type thermocouple in the fry pot before beginning any tests. The thermocouple used to calibrate the fryer shall be located within 1 in. of the tip of the thermostat probe. If it is not possible to locate a thermocouple near the thermostat probe, position the thermocouple at the rear of the fry pot, 2 in. below the oil fill line and ½ in. from rear wall of the fry pot.

10. Procedure

10.1 *General:*

10.1.1 For gas fryers, record the following for each test run:

10.1.1.1 Higher heating value,

10.1.1.2 Standard gas pressure and temperature used to correct measured gas volume to standard conditions,

10.1.1.3 Measured gas temperature,

10.1.1.4 Measured gas pressure,

10.1.1.5 Barometric pressure,

10.1.1.6 Ambient temperature, and

10.1.1.7 Energy input rate during or immediately prior to test.

NOTE 3—Use of a calorimeter or gas chromatograph in accordance with accepted laboratory procedures is the preferred method for determining the higher heating value of gas supplied to the fryer under test. It is recommended that all testing be performed with gas having a higher heating value of 1000 to 1075 Btu/ft^3.

10.1.2 For gas fryers, add electric energy consumption to gas energy for all tests, with the exception of the energy input rate test (see 10.2).

10.1.3 For electric fryers, record the following for each test run:

10.1.3.1 Voltage while elements are energized,

10.1.3.2 Ambient temperature, and

10.1.3.3 Energy input rate during or immediately prior to test run.

10.1.4 For each test run, confirm that the peak input rate is within ±5 % of the rated nameplate input. If the difference is greater than 5 %, terminate testing and contact the manufacturer. The manufacturer may make appropriate changes or adjustments to the fryer.

10.2 *Energy Input Rate:*

10.2.1 Load fryer with water to the indicated fill line and turn the fryer on with the temperature controls set to the maximum setting possible.

10.2.2 For gas fryers, operate the unit for a period of 15 min, then monitor the time required for the fryer to consume 5 ft^3 of gas. Adjustments to input rate may be made by adjusting gas manifold pressure.

10.2.3 For electric fryers, monitor the energy consumption for 15 min with the controls set to achieve maximum input. If the unit begins cycling during the 15–min interval, record the time and energy consumed for the time from when the unit was first turned on until it begins cycling.

10.2.4 Confirm that the measured input rate or power (Btu/h for a gas fryer or kW for an electric fryer) is within 5 % of the rated nameplate input or power (it is the intent of this test method to evaluate the performance of a fryer at its rated energy input rate). If the difference is greater than 5 %, terminate testing and contact the manufacturer. The manufacturer may make appropriate changes or adjustments to the fryer or supply another fryer for testing.

10.3 *Calibration:*

10.3.1 Ensure that the frying medium is loaded to the indicated fryer fill line. Preheat to 325°F and allow the fryer to stabilize for 30 min before beginning temperature calibration.

10.3.2 The frying medium temperature shall be measured by attaching a calibrated immersion-type thermocouple in the cook zone as detailed in 9.6. The median temperature recorded over three complete thermostat cycles at this point shall be considered as the average temperature for the frying medium.

10.3.3 Where required, adjust the fryer temperature control(s) to calibrate the fryer at an average frying medium temperature of 325 ± 5°F. Record the frying medium temperature over three cycles and average the temperatures over the three cycles to verify that the average measured temperature at the frying medium sensor location is 325 ± 5°F.

10.4 *Preheat Energy and Time:*

10.4.1 Ensure that the frying medium is loaded to the indicated fryer fill line. Record the frying medium temperature and ambient kitchen temperature at the start of the test. The frying medium temperature shall be 75 ± 5°F at the start of the test.

10.4.2 With the fry pot uncovered, turn the fryer on with the temperature controls set to attain a temperature within the frying medium of a calibrated 325°F. The fryer shall remain uncovered throughout this preheat test.

10.4.3 Begin monitoring energy consumption, time, and temperature as soon as the fryer is turned on. For a gas fryer, the preheat time shall include any delay between the time the unit is turned on and the burners actually ignite. Preheat is judged complete when the temperature at the monitored location reaches 325°F.

10.5 *Idle Energy Rate:*

10.5.1 Ensure that the frying medium is loaded to the indicated fryer fill line.

10.5.2 Preheat to 325°F and allow the frying medium to stabilize at 325°F for at least 30 min after the last thermostat has commenced cycling at the thermostat set point.

10.5.3 Monitor the elapsed time, temperature, and energy consumption of the fryer while it is operated under this idle condition for a minimum of 2 h. The fryer shall remain uncovered throughout this idle test.

10.6 *Pilot-Energy Consumption (Gas Models with Standing Pilots):*

10.6.1 Where applicable, set the gas valve controlling the gas supply to the appliance at the pilot position. Otherwise set the temperature controls to the off position.

10.6.2 Light and adjust pilots in accordance with the manufacturer's instructions.

10.6.3 Record gas reading, electric energy consumed, and time before and after a minimum of 8 h of pilot operation.

10.7 *Test Product Preparation:*

10.7.1 Prepare enough chicken for a minimum of 4 test runs of the heavy-load tests. The heavy-load size is determined by the manufacturer's stated capacity for the fryer, based on eight chicken breasts for every head of chicken that the fryer can cook at one time (see Table 1).

10.7.2 The chicken may be thawed by immersing it in cold running water. Place the chicken in a single layer onto a drip rack on a sheet pan and cover with plastic wrap. Place the covered chicken in the refrigerator and allow it to stabilize at 38 to 40°F.

NOTE 4—Unless the chicken has been continuously held below 40°F, it may be unsafe and should not be eaten.

10.7.3 Separate the chicken into individual load batches, based on eight pieces for head of chicken that the fryer can cook at one time. The weight of the uncooked chicken breasts shall be 2.4 ± 0.1 lb per each group of eight chicken breasts. If it is not possible to find eight chicken breasts that weigh 2.4 ± 0.1 lb, then add or remove no more than one chicken breast to the group until the target weight is met.

10.7.4 Monitor the internal temperature of a sample piece of chicken with a thermocouple probe. Its internal temperature must reach 38 to 40°F before the chicken can be removed from the refrigerator and breaded. If necessary, adjust the refrigerator temperature to achieve this required internal temperature.

TABLE 1 Sample Heavy-Load Sizes Based on Nominal Oil Capacity

Fryer Nominal Chicken Capacity	Heavy-Load Size, Number of Pieces	Heavy-Load Weight
2-head	16 ± 1	5.0 ± 0.5 lb
4-head	32 ± 2	10.0 ± 0.5 lb
6-head	48 ± 3	15.0 ± 0.5 lb
8-head	64 ± 4	20.0 ± 0.5 lb

NOTE 5—If the chicken is not cooked within 24 h, it should be covered with plastic wrap. Thawed chicken should not be stored in the refrigerator for more than one week.

10.7.5 Randomly select 4 raw pieces of chicken for moisture content determination in accordance with recognized laboratory procedures (AOAC Official Action 950.46). Place the sample in a self-sealing bag in the freezer unless the moisture content test is run immediately. This will be used for determining the energy of vaporization component of the cooking energy efficiency equation.

10.8 *Cook Time Determination:*

NOTE 6—This is a trial-and-error procedure and may take several iterations to obtain the correct cook time.

10.8.1 Ensure that the frying medium is loaded to the indicated fryer fill line. Confirm that the frying medium temperature is 325 ± 5°F as calibrated in 10.3. Allow the fryer to stabilize for 30 min at 325°F, then briefly submerge the frying basket or rack(s) into the oil, remove, and allow the basket(s) or rack(s) to drip over the fryer.

NOTE 7—Submerging the frying baskets or racks provides a coating of oil that inhibits food sticking to the containers and facilitates removal of the cooked food product. This procedure should be followed at the beginning of every cook-time determination test.

10.8.2 After the 30–min stabilization, vigorously stir the cold zone with a long spoon or equivalent until the temperature at the bottom of the cold zone is within 10°F of the temperature at the center of the cook zone (fryers with cold zones). Allow the fryer to stabilize for 15 ± 5 min after stirring the cold zone.

NOTE 8—While it is recognized that stirring the cold zone is not practiced in industry, it is included in this test method because stirring provides a simple way to eliminate the variations in cold-zone temperature that could cause a significant fluctuation in the measured cooking-energy efficiency. To make the cooking-energy efficiency test repeatable, the cold zone must be at the same temperature when beginning each test. This is accomplished with minimal time and effort through manual stirring.

10.8.3 Prepare the dipping solution by cooling tap water with ice to achieve a water temperature between 45°F and 50°F. Pour the solution in a food grade bucket.

10.8.4 Pour enough flour to fill the breading bin half-way. Allow to stabilize at room temperature.

10.8.5 Remove the chicken pieces from the refrigerator and immerse briefly in the dipping solution. Remove the chicken pieces from the solution and allow to drip briefly over the dipping container. Transfer the dipped pieces of chicken to the breading bin. Ensure that each piece is evenly coated on all sides. The breaded chicken shall weigh 2.5 ± 0.1 lb for every group of 8 pieces. The total load weight shall meet the specifications in Table 1. Record the total initial weight of the chicken load.

10.8.6 Insert high gauge thermocouples into the thickest parts of two of the chicken breasts for each fryer head and wrap them around the chicken piece to prevent the thermocouple from coming out during cooking. The average chicken temperature shall be 50 ± 5°F at the start of the cooking test, before being loaded into the fryer.

10.8.7 Estimate a cook time for a heavy-load of chicken. Set the timer on the fryer to this estimated cook time (fryers with timers).

10.8.8 Load the chicken into the fryer as follows:

10.8.8.1 For fryers with frying racks, place the breaded chicken pieces onto the fry rack(s). When the fryer has cycled off, immediately load the racks into the fryer per the manufacturer's instructions. Start monitoring time and fryer energy consumption when the racks are loaded into the fryer.

10.8.8.2 For fryers with open fry baskets, lower the empty basket into the oil. When the fryer has cycled off, immediately start methodically dropping the pieces into the oil on even intervals. Start monitoring time and fryer energy consumption when the first chicken pieces are loaded into the fryer. Loading time shall be no more than 15 s for each head of chicken (for example, 60 s for a 4-head fryer). Immediately after loading, vigorously stir the chicken pieces for 5 s to minimize product clumping.

10.8.9 Close and latch the lid per manufacturer's instructions. If necessary, tighten the lid spindle (or handle) to properly secure and seal the lid.

10.8.10 Activate the fryer's cook timer.

NOTE 9—Many pressure fryers require the timer to be activated before it will allow pressure to build in the cooking container.

10.8.11 Monitor the temperature of the chicken during cooking. When the temperature of the coldest piece approaches 165°F, then cancel the cooking cycle and commence depressurizing the cooking vessel.

10.8.12 Wait for the cooking container to depressurize before attempting to open the lid.

NOTE 10—If the actual cook time has elapsed before the time set on the fryer's cook timer, it may be necessary to override the fryer's cook timer in order to commence depressurization of the cooking vessel. Depressurization times may vary from fryer to fryer.

10.8.13 Lift the basket and allow to drain over the fryer for approximately 15 s. Pour the contents of the basket onto a sheet pan.

10.8.14 Measure and record the temperature of two randomly selected pieces per head of chicken by inserting a fast response thermocouple probe into a thick (meaty) portion of each piece. The additional temperatures shall be recorded within 5 min of removing the chicken from the cooking oil. The minimum chicken breast temperature shall be greater than 165°F. If the internal temperature of any piece is lower than 165°F, then the increase cook time and repeat 10.8.3 – 10.8.13.

10.8.15 Weigh and record the weight of the cooked load. The weight loss shall be 27 ± 2 %.

10.8.16 Clean the fry basket(s) or rack(s) of debris between loads, making sure to remove any food that may be stuck on the inside of the basket.

10.8.17 If the percent weight loss is not 27 ± 2 %, repeat 10.8.3 – 10.8.16, adjusting the total cooking time to attain the 27 ± 2 % weight loss. Subsequent loads may be inserted into the fryer when the oil temperature has returned to 325 ± 5°F.

10.8.18 Record the final cooking time as the total time the chicken pieces are submerged in the cooking oil. Use the cooking time for the cooking energy efficiency determination and production capacity tests (see 10.9).

10.9 *Cooking-Energy Efficiency and Production Capacity for Heavy-Load Cooking Tests:*

10.9.1 The cooking energy efficiency and production capacity tests are to be run a minimum of three times. Additional test runs may be necessary to obtain the required precision for the reported test results (see Annex A1). The minimum three test runs for each loading scenario shall be run on the same day.

10.9.2 Each replicate of the cooking-energy efficiency and production capacity test will consist of five individual loads, run one after the other. The first load will be considered a stabilization load and loads 2 through 5 are considered test loads. The time between subsequent loads needs to be minimized once the fryer has returned to 320°F after the previous load has been removed.

10.9.3 Ensure that the frying medium is loaded to the indicated fryer fill line. Confirm that the frying medium temperature is 325 ± 5°F as calibrated in 10.3. Allow the fryer to stabilize for 30 min after being turned on, then briefly submerge the frying basket or rack(s) into the oil and allow to drip over the fryer.

NOTE 11—Submerging the frying baskets or racks provides a coating of oil that inhibits food sticking to the containers and facilitates removal of the cooked food product. This procedure should be followed at the beginning of every cook-time determination test.

10.9.4 After the 30–min stabilization, vigorously stir the cold zone with a long spoon or equivalent until the temperature at the bottom of the cold zone is within 10°F of the temperature at the center of the cook zone (fryers with cold zones). Allow the fryer to stabilize for 15 ± 5 min after stirring the cold zone.

10.9.5 Prepare the dipping solution by cooling tap water with ice to achieve a water temperature between 45 and 50°F. Pour the solution in a food grade bucket.

10.9.6 Pour enough flour to fill the breading bin half-way. Allow to stabilize at room temperature.

10.9.7 Remove the chicken pieces from the refrigerator and immerse briefly in the dipping solution. Remove the chicken pieces from the solution and allow to drip briefly over the dipping container. Transfer the dipped pieces of chicken to the breading bin. Ensure that each piece is evenly coated on all sides. The total load weight shall meet the specifications in Table 1. Record the total initial weight of the chicken load.

10.9.8 Measure and record the temperature of 4 randomly selected chicken pieces. The average chicken temperature shall be 50 ± 5°F at the start of the cooking test, before being loaded into the fryer.

10.9.9 Set the fryer's cook timer for the time determined during the cook time determination test (10.8).

10.9.10 Load the chicken into the fryer as follows:

10.9.10.1 For fryers with frying racks, place the breaded chicken pieces onto the fry rack(s). When the fryer has cycled off, immediately load the racks into the fryer per the manufacturer's instructions. Start monitoring time and fryer energy consumption when the racks are loaded into the fryer.

10.9.10.2 For fryers with open fry baskets, lower the empty basket into the oil. When the fryer has cycled off, immediately start methodically dropping the pieces into the oil on even intervals. Start monitoring time and fryer energy consumption when the first chicken pieces are loaded into the fryer. Loading time shall be no more than 15 s for each head of chicken (for example, 60 s for a 4-head fryer). Immediately after loading, vigorously stir the chicken pieces for 5 s to minimize product clumping.

10.9.11 Close and latch the lid per manufacturer's instructions. If necessary, tighten the lid spindle to properly secure and seal the lid.

10.9.12 Activate the fryer's cook timer.

10.9.13 For loads 2 through 4, begin preparing the next load of chicken while the current load is cooking. Time the preparation to ensure that the initial temperature of subsequent loads is 50 ± 5°F.

10.9.14 When the cook time determined in 10.8 has elapsed, cancel the cooking cycle. Wait for the cooking container to depressurize before attempting to open the lid.

10.9.15 Lift the basket and allow to drain over the fryer for approximately 15 s.

10.9.16 Measure and record the temperature of two randomly selected pieces for every head of chicken by inserting a fast response thermocouple probe into a thick (meaty) portion of each piece. The additional temperatures shall be recorded within 5 min of removing the chicken from the cooking oil.

10.9.17 Weigh and record the weight of the cooked load. The weight loss shall be 27 ± 2 %. If the weight loss is not 27 ± 2 %, the test is invalid. Adjust the cooking time as appropriate and repeat 10.9.5 – 10.9.16.

10.9.18 Clean the fry basket(s) of debris between loads, making sure to remove any food that may be stuck on the inside of the basket.

10.9.19 Begin the next load 15 s per head of chicken after removing the previous load from the fryer, or after the cook zone thermocouple indicates that the oil temperature has recovered to 320°F, whichever is longer. Start monitoring elapsed time and fryer energy consumption from the start of load #2. Repeat 10.9.5 – 10.9.18 until all five loads have been cooked.

NOTE 12—The 15 s per head allowed between loads is a preparation time necessary for logistical considerations of running a test (that is, removing one load and placing the next load into the fryer). The actual recovery time may be less than the 15 s per head preparation time.

10.9.20 Terminate the test after removing the fifth (last) load and allowing the cook zone thermocouple to indicate that the oil temperature has recovered to 325 ± 5°F. Record the total elapsed time and energy consumption.

10.9.21 Reserve 4 pieces of cooked chicken (one from each load, from loads 2 through 5) for determining the moisture content. Unless the moisture content test is conducted immediately, place the chicken pieces in a self-sealing plastic bag and place the bag in the freezer.

10.9.22 Perform Replicates #2 and 3 by repeating 10.9.2 – 10.9.21. Ensure that the oil is topped off to the manufacturer's recommended fill line before starting subsequent test runs. Follow the procedure in Annex A1 to determine whether more than three test runs are required.

10.9.23 Determine the moisture content of the previously reserved chicken pieces for each test run in accordance with recognized laboratory procedures (AOAC Official Action 950.46) and calculate the moisture loss based on the initial moisture content of the chicken pieces (10.9.2). This will be used to determine the energy of vaporization component of the cooking energy efficiency equation.

11. Calculation and Report

11.1 *Test Fryer*—Summarize the physical and operating characteristics of the fryer. If needed, describe other design or operating characteristics that may facilitate interpretation of the test results.

11.2 *Apparatus and Procedure:*

11.2.1 Confirm that the testing apparatus conforms to all of the specifications in Section 6. Describe any deviations from those specifications.

11.2.2 For electric fryers, report the voltage for each test.

11.2.3 For gas fryers, report the higher heating value of the gas supplied to the fryer during each test.

11.3 *Gas Energy Calculations:*

11.3.1 For gas fryers, add electric energy consumption to gas energy for all tests, with the exception of the energy input rate test (see 10.2).

11.3.2 For all gas measurements, calculate the energy consumed based on:

$$E_{gas} = V \times HV \quad (1)$$

where:

E_{gas} = energy consumed by the fryer,
HV = higher heating value, that is, energy content of gas measured at standard conditions, Btu/ft^3, and
V = actual volume of gas corrected for temperature and pressure at standard conditions, ft^3, determined by the following:

$$V_{meas \times} T_{cf} \times P_{cf}$$

where:

V_{meas} = measured volume of gas, ft^3,
T_{cf} = temperature correction factor, as determined by:

$$\frac{absolute\ standard\ gas\ temperature\ {}^\circ R}{absolute\ actual\ gas\ temperature {}^\circ\ R}$$

and

$$\frac{absolute\ standard\ gas\ temperature\ {}^\circ R}{[gas\ temp\ {}^\circ F + 459.67]\ {}^\circ R}$$

P_{cf} = pressure correction factor, as determined by:

$$\frac{absolute\ actual\ gas\ pressure, \text{ psia}}{absolute\ standard\ pressure, \text{ psia}}$$

and

$$\frac{gas\ gage\ pressure \text{ psig} + barometric\ pressure, \text{ psia}}{absolute\ standard\ pressure, \text{ psia}}$$

NOTE 13—Absolute standard gas temperature and pressure used in this calculation should be the same values used for determining the higher heating value. Standard conditions are 519.67°R and 14.73 psia.

11.4 *Energy Input Rate:*

11.4.1 Report the manufacturer's nameplate energy input rate in Btu/h for a gas fryer and kW for an electric fryer.

11.4.2 For gas or electric fryers, calculate and report the measured energy input rate (Btu/h or kW) based on the energy consumed by the fryer during the period of peak energy input according to the following:

$$q_{input} = \frac{E \times 60}{t} \quad (2)$$

where:

q_{input} = measured energy input rate, Btu/h or kW,
E = energy consumed during period of energy input, Btu or kWh, and
t = period of energy input, min.

11.5 *Fryer Temperature Calibration*—Report the average bulk temperature for the frying medium in the cook zone after calibration. Report any discrepancies between the temperature indicated on the control and the measured average frying medium temperature.

11.6 *Preheat Energy and Time:*

11.6.1 Report the preheat energy consumption (Btu or kWh) and preheat time (min).

11.6.2 Calculate and report the average preheat rate (°F/min) based on the preheat period.

11.7 *Idle Energy Rate*—Calculate and report the idle energy rate (Btu/h or kW) based on:

$$q_{idle} = \frac{E \times 60}{t} \quad (3)$$

where:

q_{idle} = idle energy rate, Btu/h or kW,
E = energy consumed during the test period, Btu or kWh, and
t = test period, min.

11.7.1 For gas fryers, report separately a gas idle energy rate and an electric idle energy rate.

11.8 *Pilot Energy Rate*—Calculate and report the pilot energy rate (Btu/h) based on:

$$q_{pilot} = \frac{E \times 60}{t} \quad (4)$$

where:

q_{pilot} = pilot energy rate, Btu/h,
E = energy consumed during the test period, Btu, and
t = test period, min.

11.9 *Cooking Energy Efficiency and Cooking Energy Rate:*

11.9.1 Calculate and report the cooking energy rate for heavy-load cooking tests based on:

$$q_{cook} = \frac{E \times 60}{t} \quad (5)$$

where:

q_{cook} = cooking energy rate, Btu/h or kW,
E = energy consumed during cooking test, Btu or kWh, and
t = cooking test period, including recovery time, min.

NOTE 14—The cooking test period includes the actual cooking time, depressurization time, and recovery time.

11.9.1.1 For gas fryers, report separately a gas cooking energy rate and an electric cooking energy rate.

11.9.2 Calculate and report the energy consumption per pound of food cooked for heavy-load cooking tests based on:

$$E_{per\ pound} = \frac{E_{appliance}}{W} \quad (6)$$

where:

$E_{per\ pound}$ = energy per pound, Btu/lb or kWh/lb,
$E_{appliance}$ = energy consumed during the cooking test, Btu or kWh, and
W = total initial weight of the chickens, lb.

11.9.3 Calculate and report the cooking energy efficiency for heavy-load cooking tests based on:

$$\eta_{cook} = \frac{E_{food}}{E_{fryer}} \times 100 \quad (7)$$

where:

η_{cook} = cooking energy efficiency, %,
E_{food} = energy into food, Btu, as determined by:

$$E_{sens} + E_{evap}$$

where:

E_{sens} = quantity of heat added to the chicken, which causes its temperature to increase from the starting temperature to the average bulk temperature of a done load of chicken (that is, 195 ± 5°F), Btu, as determined by:

$$(W_i)(C_p)(T_f - T_i)$$

where:

W_i = initial weight of chicken, lb,
C_p = specific heat of chicken, Btu/lb, °F, or 0.688,
T_f = final internal temperature of the cooked chicken,° F,
T_i = initial internal temperature of the chicken, °F,
E_{evap} = latent heat (of vaporization) added to the chicken, which causes some of the moisture contained in it to evaporate; the heat of vaporization cannot be perceived by a change in temperature and must be calculated after determining how much moisture was lost from a done load of chicken, as determined by:

$$W_{loss} \cdot H_v$$

where W_{loss} = weight loss of water during cooking, lb, as determined by:

$$W_{w,i} - W_{w,f}$$

where:

$W_{w,i}$ = initial weight of the water in the raw chicken, lb,
$W_{w,f}$ = final weight of the water in the cooked chicken, lb,
H_v = heat of vaporization, Btu/lb, or 970 Btu/lb at 212°F, and
E_{fryer} = energy into the fryer, Btu.

NOTE 15—For this analysis, the specific heat (C_p) of a load of chicken is considered to be the weighted average of the specific heat of its components (for example, water, fat, and nonfat protein). Research conducted by PG&E has determined that the weighted average of the specific heat for chicken pieces cooked in accordance with this test method was approximately 0.688 Btu/lb, °F.

11.9.4 Calculate production capacity (lb) based on:

$$PC = \frac{W \times 60}{t} \quad (8)$$

where:

PC = production capacity of the fryer, lb/h,
W = total weight of food cooked during heavy-load cooking test, lb, and
t = total time of heavy-load cooking test, min.

11.9.5 Report the cook time for the heavy-load tests.

12. Precision and Bias

12.1 *Precision:*

12.1.1 *Repeatability (Within Laboratory, Same Operator and Equipment):*

12.1.1.1 For the cooking energy efficiency, cooking energy rate, and production capacity results, the percent uncertainty in each result has been specified to be no greater than ±10 % based on at least three test runs.

12.1.1.2 The repeatability of each remaining reported parameter is being determined.

12.1.2 *Reproducibility (Multiple Laboratories)*—The interlaboratory precision of the procedure in this test method for measuring each reported parameter is being determined.

12.2 *Bias*—No statement can be made concerning the bias of the procedures in this test method because there are no accepted reference values for the parameters reported.

13. Keywords

13.1 efficiency; energy; kettle fryer; performance; pressure fryer; production capacity; throughput

ANNEX

(Mandatory Information)

A1. PROCEDURE FOR DETERMINING THE UNCERTAINTY IN REPORTED TEST RESULTS

NOTE A1.1—This procedure is based on the ASHRAE method for determining the confidence interval for the average of several test results (ASHRAE Guideline 2-1986(RA90)). It should only be applied to test results that have been obtained within the tolerances prescribed in this test method (for example, thermocouples calibrated, appliance operating within 5 % of rated input during the test run).

A1.1 For the cooking energy efficiency and production capacity results, the uncertainty in the averages of at least three test runs is reported. For each loading scenario, the uncertainty of the cooking energy efficiency and production capacity must be no greater than ±10 % before any of the parameters for that loading scenario can be reported.

A1.2 The uncertainty in a reported result is a measure of its precision. If, for example, the production capacity for the appliance is 30 lb/h, the uncertainty must not be greater than ±3 lb/h. Thus, the true production capacity is between 27 and 33 lb/h. This interval is determined at the 95 % confidence level, which means that there is only a 1 in 20 chance that the true production capacity could be outside of this interval.

A1.3 Calculating the uncertainty not only guarantees the maximum uncertainty in the reported results, but is also used to determine how many test runs are needed to satisfy this requirement. The uncertainty is calculated from the standard deviation of three or more test results and a factor from Table A1.1, which lists the number of test results used to calculate the average. The percent uncertainty is the ratio of the uncertainty to the average expressed as a percent.

A1.4 *Procedure:*

NOTE A1.2—Application of this procedure is shown in A1.5.

A1.4.1 *Step 1*—Calculate the average and the standard deviation for the test result (cooking-energy efficiency or production capacity) using the results of the first three test runs, as follows:

A1.4.1.1 The formula for the average (three test runs) is as follows:

$$Xa_3 = (1/3) \times (X_1 + X_2 + X_3) \quad (A1.1)$$

where:

Xa_3 = average of results for three test runs, and
X_1, X_2, X_3 = results for each test run.

A1.4.1.2 The formula for the sample standard deviation (three test runs) is as follows:

$$S_3 = \left(1/\sqrt{2}\right) \times \sqrt{(A_3 - B_3)} \quad (A1.2)$$

where:

S_3 = standard deviation of results for three test runs,
A_3 = $(X_1)^2 + (X_2)^2 + (X_3)^2$, and
B_3 = $(⅓) \times (X_1 + X_2 + X_3)^2$.

NOTE A1.3—Eq A1.1 and A1.2 may be used to calculate the average and sample standard deviation. However, a calculator with statistical function is recommended, in which case be sure to use the sample standard deviation function. The population standard deviation function will result in an error in the uncertainty.

NOTE A1.4—A is the sum of the squares of each test result, and B is the square of the sum of all test results multiplied by a constant (⅓ in this case).

A1.4.2 *Step 2*—Calculate the absolute uncertainty in the average for each parameter listed in Step 1. Multiply the standard deviation calculated in Step 1 by the uncertainty factor corresponding to three test results from Table A1.1.

A1.4.2.1 The formula for the absolute uncertainty (3 test runs) is as follows:

$$U_3 = C_3 \times S_3, \quad (A1.3)$$

$$U_3 = 2.48 \times S_3$$

where:

U_3 = absolute uncertainty in average for three test runs, and

C_3 = uncertainty factor for three test runs (Table A1.1).

A1.4.3 *Step 3*—Calculate the percent uncertainty in each parameter average using the averages from Step 1 and the absolute uncertainties from Step 2.

A1.4.3.1 The formula for the percent uncertainty (3 test runs) is as follows:

$$\%U_3 = (U_3/Xa_3) \times 100\,\% \quad (A1.4)$$

where:

$\%U_3$ = percent uncertainty in average for three test runs,
U_3 = absolute uncertainty in average for three test runs, and
Xa_3 = average of three test runs.

A1.4.4 If the percent uncertainty, $\%U_3$, is not greater than ±10 % for the cooking-energy efficiency and production capacity, report the average for these parameters along with their corresponding absolute uncertainty, U_3, in the following format:

$$Xa_3 \pm U_3$$

If the percent uncertainty is greater than ±10 % for the cooking energy efficiency or production capacity, proceed to Step 5.

A1.4.5 *Step 5*—Run a fourth test for each loading scenario whose percent uncertainty was greater than ±10 %.

A1.4.6 *Step 6*—When a fourth test is run for a given loading scenario, calculate the average and standard deviation for test results using a calculator or the following formulas:

A1.4.6.1 The formula for the average (four test runs) is as follows:

$$Xa_4 = (1/4) \times (X_1 + X_2 + X_3 + X_4) \quad (A1.5)$$

where:

Xa_4 = average of results for four test runs, and
X_1, X_2, X_3, X_4 = results for each test run.

A1.4.6.2 The formula for the standard deviation (four test runs) is as follows:

$$S_4 = \left(1/\sqrt{3}\right) \times \sqrt{(A_4 - B_4)} \quad (A1.6)$$

where:

S_4 = standard deviation of results for four test runs,

TABLE A1.1 Uncertainty Factors

Test Results, n	Uncertainty Factor, C_n
3	2.48
4	1.59
5	1.24
6	1.05
7	0.92
8	0.84
9	0.77
10	0.72

A_4 = $(X_1)^2 + (X_2)^2 + (X_3)^2 + (X_4)^2$, and
B_4 = $(1/4) \times (X_1 + X_2 + X_3 + X_4)^2$.

A1.4.7 *Step 7*—Calculate the absolute uncertainty in the average for each parameter listed in Step 1. Multiply the standard deviation calculated in Step 6 by the uncertainty factor for four test results from Table A1.1.

A1.4.7.1 The formula for the absolute uncertainty (four test runs) is as follows:

$$U_4 = C_4 \times S_4, \quad (A1.7)$$

$$U_4 = 1.59 \times S_4$$

where:

U_4 = absolute uncertainty in average for four test runs, and
C_4 = uncertainty factor for four test runs (Table A1.1).

A1.4.8 *Step 8*—Calculate the percent uncertainty in the parameter averages using the averages from Step 6 and the absolute uncertainties from Step 7.

A1.4.8.1 The formula for the percent uncertainty (four test runs) is as follows:

$$\%U_4 = (U_4/Xa_4) \times 100\,\% \quad (A1.8)$$

where:

$\%U_4$ = percent uncertainty in average for four test runs,
U_4 = absolute uncertainty in average for four test runs, and
Xa_4 = average of four test runs.

A1.4.9 *Step 9*—If the percent uncertainty, $\%U_4$, is not greater than ±10 % for the cooking energy efficiency and production capacity, report the average for these parameters along with their corresponding absolute uncertainty, U_4, in the following format:

$$Xa_4 \pm U_4$$

If the percent uncertainty is greater than ±10 % for the cooking energy efficiency or production capacity, proceed to Step 10.

A1.4.10 *Step 10*—The steps required for five or more test runs are the same as those described in A1.4.9. More general formulas are listed below for calculating the average, standard deviation, absolute uncertainty, and percent uncertainty.

A1.4.10.1 The formula for the average (*n* test runs) is as follows:

$$Xa_n = (1/n) \times (X_1 + X_2 + X_3 + X_4 \ldots + X_n) \quad (A1.9)$$

where:

n = number of test runs,
Xa_n = average of results *n* test runs, and
$X_1, X_2, X_3, X_4, \ldots X_n$ = results for each test run.

A1.4.10.2 The formula for the standard deviation (*n* test runs) is as follows:

$$S_n = \left(1/\sqrt{(n-1)}\right) \times \left(\sqrt{(A_n - B_n)}\right) \quad (A1.10)$$

where:

S_n = standard deviation of results for *n* test runs,
A_n = $(X_1)^2 + (X_2)^2 + (X_3)^2 + (X_4)^2 + \ldots + (X_n)^2$, and
B_n = $(1/n) \times (X_1 + X_2 + X_3 + X_4 + \ldots + X_n)^2$.

A1.4.10.3 The formula for the absolute uncertainty (*n* test runs) is as follows:

$$U_n = C_n \times S_n \quad (A1.11)$$

where:

U_n = absolute uncertainty in average for *n* test runs, and
C_n = uncertainty factor for *n* test runs (Table A1.1).

A1.4.10.4 The formula for the percent uncertainty (*n* test runs) is as follows:

$$\%U_n = (U_n/Xa_n) \times 100\,\% \quad (A1.12)$$

where:

$\%U_n$ = percent uncertainty in average for *n* test runs,
U_n = absolute uncertainty in average for *n* test runs, and
Xa_n = average of *n* test runs.

When the percent uncertainty, $\%U_n$, is less than or equal to ±10 % for the cooking energy efficiency and production capacity, report the average for these parameters along with their corresponding absolute uncertainty, U_n, in the following format:

$$Xa_n \pm U_n \quad (A1.13)$$

NOTE A1.5—The researcher may compute a test result that deviates significantly from the other test results. Such a result should be discarded only if there is some physical evidence that the test run was not performed in accordance with the conditions specified in this test method. For example, a thermocouple was out of calibration, the appliance's input capacity was not within 5 % of the rated input, or the food product was not within specification. To ensure that all results are obtained under approximately the same conditions, it is good practice to monitor those test conditions specified in this test method.

A1.5 *Example of Determining Uncertainty in Average Test Result:*

A1.5.1 Three test runs for the full-load cooking scenario yielded the following production capacity (PC) results:

Test	PC, lb/h
Run #1	33.8
Run #2	34.1
Run #3	31.0

A1.5.2 *Step 1*—Calculate the average and standard deviation of the three test results for the PC.

A1.5.2.1 Averaging the three test results using Eq A1.1 and the PC results from A1.5.1 yields the equation $Xa_3 = (1/3) \cdot (33.8 + 34.1 + 31.0)$, therefore, $Xa_3 = 33.0$ lb/h.

A1.5.2.2 To calculate the standard deviation of the three test results, first calculate "A_3" and "B_3." Since $A_3 = (X_1)^2 + (X_2)^2 + (X_3)^2$, using the values given in A1.5.1 yields $A_3 = (33.8)^2 + (34.1)^2 + (31.0)^2$, then $A_3 = 3266$. Further, since $B_3 = (1/3) \times [(X_1 + X_2 + X_3)^2]$, using the values given in A1.5.1 yields $B_3 = (1/3) \times [(33.8 + 34.1 + 31.0)^2]$, then $B_3 = 3260$.

A1.5.2.3 Using Eq A1.2, the new standard deviation for the PC is $S_3 = \left(1/\sqrt{2}\right) \times \sqrt{(3266 - 3260)}$, or 1.73 lb/h.

A1.5.3 *Step 2*—Using Eq A1.3, and the values in A1.5.1, the uncertainty in average is calculated to be $U_3 = 2.48 \times 1.73$, or 4.29 lb/h.

A1.5.4 *Step 3*—Using Eq A1.4 and the values given in A1.5.1, the percent uncertainty is calculated to be $\%U_3 = (4.29/33.0) \cdot 100\,\%$, or 13.0 %.

A1.5.5 *Step 4*—Run a fourth test. Since the percent uncertainty for the production capacity is greater than ±10 %, the precision requirement has not been satisfied. An additional test is run in an attempt to reduce the uncertainty. The PC from the fourth test run was 32.5 lb/h.

A1.5.6 *Step 5*—Recalculate the average and standard deviation for the PC using the fourth test result.

A1.5.6.1 Using Eq A1.5 and the values given in A1.5.1 and A1.5.5, the new average PC is calculated to be Xa_4 = (1/4) × (33.8 + 34.1 + 31.0 + 32.5), or 32.9 lb/h.

A1.5.6.2 To calculate the new standard deviation, first calculate "A_4" and "B_4." Since $A_4 = (X_1)^2 + (X_2)^2 + (X_3)^2 + (X_4)^2$, using the values in A1.5.1 and A1.5.5 yields $A_4 = (33.8)^2 + (34.1)^2 + (31.0)^2 + (32.5)^2$, then A_4 = 4322. Further, since $B_4 = (1/4) \times [(X_1 + X_2 + X_3 + X_4)^2]$, using the values in A1.5.1 and A1.5.5 yields $B_4 = (1/4) \times [(33.8 + 34.1 + 31.0 + 32.5)^2]$, then B_4 = 4316.

A1.5.6.3 Using Eq A1.6, the new standard deviation for the PC is $S_4 = \left(1/\sqrt{3}\right) \times \sqrt{(4322 - 4316)}$, or 1.41 lb/h.

A1.5.7 *Step 6*—Using Eq A1.7 and the values given in A1.5.1 and A1.5.5, the absolute uncertainty, using the new standard deviation and uncertainty factor, is recalculated to be U_4 = 1.59× 1.41, or 2.24 lb/h.

A1.5.8 *Step 7*—Using Eq A1.8 and the values given in A1.5.1 and A1.5.5, the percent uncertainty, using the new average, is recalculated to be $\%U_4$ = (2.24/32.9) · 100 %, or 6.8 %.

A1.5.9 *Step 8*—Since the percent uncertainty, $\%U_4$, is less than ±10 %, the average for the production capacity is reported along with its corresponding absolute uncertainty, U_4 as "PC: 32.9 ± 2.24 lb/h." The production capacity can be reported assuming the ±10 % precision requirement has been met for the corresponding cooking energy efficiency value. The cooking energy efficiency and its absolute uncertainty can be calculated following the same steps.

APPENDIX

(Nonmandatory Information)

X1. RESULTS REPORTING SHEETS

Manufacturer ______________________________
Model ______________________________
Date ______________________________
Test Reference Number (optional) ______

Section 11.1 Test Fryer

Description of operational characteristics: ____
____
____
____
____
____
____
____

Section 11.2 Apparatus

_____ Check if testing apparatus conformed to specifications in Section 6.
Deviations ____
____
____
____
____
____
____

Section 11.4 Energy Input Rate

Test Voltage (V) _________
Gas Heating Value (Btu/ft^3) _________
Measured (Btu/h or kW) _________
Rated (Btu/h or kW) _________
Percent Difference between Measured and Rated (%) _________

Section 11.5 Thermostat Calibration

Average Cook-Zone Temperature (°F) ________
Dial Setting (°F) ________

Section 11.6 Preheat Energy and Time

Test Voltage (V) ________
Gas Heating Value (Btu/ft^3) ________
Starting Temperature (°F) ________
Energy Consumption (Btu or kWh) ________
Electric Energy Consumption (kW, gas fryers only) ________
Duration (min) ________
Preheat Rate (°F/min) ________

Section 11.7 Idle Energy Rate

Test Voltage (V) ________
Gas Heating Value (Btu/ft^3) ________
Idle Energy Rate (Btu/h or kW) ________
Electric Energy Rate (kW, gas fryers only) ________

Section 11.8 Pilot Energy Rate ***(if applicable)***

Gas Heating Value (Btu/ft^3) ________
Pilot Energy Rate (Btu/h or kW) ________

Section 11.9 Cooking Energy Efficiency, Cooking Energy Rate, and Production Capacity

Heavy Load:

Test Voltage (V) ________
Gas Heating Value (Btu/ft^3) ________
Cooking Time (min) ________
Load Size (pieces) ________
Production Capacity (lb/h) ________
Energy to Food (Btu/lb) ________
Energy to Basket (Btu) ________
Cooking Energy Rate (Btu/h or kW) ________
Electric Energy Rate (kW, gas fryers only) ________
Energy per Pound of Food Cooked (Btu/lb or kWh/lb) ________
Cooking Energy Efficiency (%) ________