Standard Test Method for Performance of Double-Sided Griddles[1]

This standard is issued under the fixed designation F1605; 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 covers the energy consumption and cooking performance of double-sided griddles. The food service operator can use this evaluation to select a double-sided griddle and understand its energy efficiency and productivity.

1.2 This test method is applicable to thermostatically controlled, double-sided gas and electric (or combination gas and electric) contact griddles with separately heated top surfaces.

1.3 The double-sided griddle can be evaluated with respect to the following (where applicable):

1.3.1 Energy input rate (10.2);

1.3.2 Temperature uniformity across the cooking surface(s) and thermostats accuracy (10.3);

1.3.3 Preheat energy and time (10.4);

1.3.4 Idle energy rate (10.5);

1.3.5 Pilot energy rate, if applicable (10.6);

1.3.6 Cooking energy rate and efficiency (10.7); and

1.3.7 Production capacity and cooking surface temperature recovery time (10.7).

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

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 *ASTM Standards:*[2]

D3588 Practice for Calculating Heat Value, Compressibility Factor, and Relative Density of Gaseous Fuels

F1919 Specification for Griddles, Single-Sided and Double-Sided, Gas and Electric

2.2 *ANSI Standard:*[3]

ANSI Z83.11 American National Standard for Gas Food Service Equipment

2.3 *ASHRAE Document:*[4]

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

3. Terminology

3.1 *Definitions:*

3.1.1 *cook time, n*—the time required to cook frozen hamburgers, as specified in 7.4, to a 35 ± 2 % weight loss during a cooking energy efficiency test.

3.1.2 *cooking energy, n*—energy consumed by the double-sided griddle as it is used to cook hamburger patties under heavy- and light-load conditions.

3.1.3 *cooking energy efficiency, n*—a quantity of energy imparted to the hamburgers, expressed as a percentage of energy consumed by the double-sided griddle during the cooking event.

3.1.4 *cooking energy rate, n*—the average rate of energy consumption (Btu/h (kJ/h) or kW) during the cooking energy efficiency tests. It refers to all loading scenarios (heavy and light).

3.1.5 *cooking zone, n*—the heated area defined by the inside perimeter (⅛-in. for the outside edge) of the upper cooking surface when in the lowered position.

3.1.6 *double-sided griddle, n*—a device for cooking food by direct contact with two actively heated surfaces.

3.1.7 *energy input rate, n*—the peak rate at which a double-sided griddle consumes energy (Btu/h (kJ/h) or kW).

3.1.8 *idle energy rate, n*—the average rate of energy consumed (Btu/h (kJ/h) or kW) by the double-sided griddle while" holding" or "idling" the cooking surface at the thermostat 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.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

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

3.1.9 *pilot energy rate, n*—the average rate of energy consumption (Btu/h (kJ/h)) by a double-sided griddle's continuous pilot (if applicable).

3.1.10 *preheat energy, n*—the amount of energy consumed by the double-sided griddle while preheating the cooking surface from ambient room temperature to 340°F (171°C).

3.1.11 *preheat rate, n*—the average rate (°F/min (°C/min)) at which the cooking surface temperature of the double-sided griddle is heated from ambient temperature to 340°F (171°C).

3.1.12 *preheat time, n*—the time required for the cooking surface to preheat from ambient room temperature to 340°F (171°C).

3.1.13 *production capacity, n*—the maximum rate (lb/h (kg/h)) at which the double-sided griddle can bring the specified food product to a specified "cooked" condition.

3.1.14 *production rate, n*—the average rate (lb/h (kg/h)) at which the double-sided griddle brings the specified food product to a specified "cooked" condition. It does not necessarily refer to the maximum rate. The production rate varies with the amount of food being cooked.

3.1.15 *recovery time, n*—the average time from the removal of the last hamburger patty of a load until all sections of the cooking surfaces are back up to within 10°F (5.56°C) of set temperature and are ready to be reloaded.

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

4. Summary of Test Method

4.1 The double-sided griddle is connected to the appropriate metered energy source, and the energy input rate is determined to confirm that it is operating within 5 % of the nameplate energy input rate.

4.2 The bottom cooking surface is monitored directly above the thermostat sensing points and at additional predetermined locations while the double-sided griddle is idled at a calibrated 350°F (177°C). The temperature uniformity of the bottom cooking surface is determined.

4.3 The amount of energy and time required to preheat the double-sided griddle to 340°F (171°C) is determined with the upper platens in the raised and lowered positions.

4.4 The idle energy rate is determined with the thermostats set to a calibrated 350°F (177°C) for both raised and lowered upper platen positions.

4.5 When applicable, the pilot energy rate is determined for gas double-sided griddles.

4.6 The double-sided griddle is used to cook frozen, ¼-lb (0.11-kg) 20 % fat, pure beef hamburger patties to a medium-done condition with the thermostats set to a calibrated 350°F (177°C). Cooking energy efficiency, cooking energy rate, production capacity, and bottom surface recovery time are determined for heavy and light-load test conditions.

5. Significance and Use

5.1 The energy input rate test is used to confirm that the double-sided griddle is operating properly prior to further testing.

5.2 The temperature uniformity of the bottom cooking surface may be used by food service operators to select a double-sided griddle that provides a uniformly cooked product.

5.3 The preheat energy and time can be useful to food service operators to manage power demands and to know how rapidly the double-sided griddle can be ready for operation.

5.4 The idle energy rate and pilot energy rate can be used to estimate energy consumption during non-cooking periods.

5.5 Cooking energy efficiency is a precise indicator of double-sided griddle energy performance under various loading conditions. This information enables the food service operator to consider energy performance when selecting a double-sided griddle.

5.6 Production capacity is used by food service operators to choose a double-sided griddle that matches their food output requirements.

6. Apparatus

6.1 *Analytical Balance Scale,* for measuring weights up to 10 lb (4.5 kg), with a resolution of 0.01 lb (0.004 kg) and an uncertainty of 0.01 lb (0.004 kg).

6.2 *Barometer,* for measuring absolute atmospheric pressure, for adjustment of the measured gas volume to standard conditions. It shall have a resolution of 0.2 in. Hg (670 Pa) and an uncertainty of 0.2 in. Hg (670 Pa).

6.3 *Canopy Exhaust Hood,* 4 ft (1.2 m) in depth, wall-mounted, with the lower edge of the hood 6 ft, 6 in. (1.98 m) from the floor and with the capacity to operate at a nominal net exhaust ventilation rate of 300 cfm per linear foot (460 L/s per linear metre) of active hood length. This hood shall extend a minimum of 6 in. (152 mm) past both sides and the front of the cooking appliance and shall not incorporate side curtains or partitions. Makeup air shall be delivered through face registers or from the space, or both.

6.4 *Convection Drying Oven,* electric or indirect gas-fired convection oven with adjustable fan speed and the temperature controlled at 220 ± 5°F (104 ± 2.5°C), used to determine the 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 and updating at least every 2 s.

6.6 *Gas Meter,* for measuring the gas consumption of a double-sided griddle, being a positive displacement type with a resolution of at least 0.01 ft^3 (0.0003 m^3) and a maximum uncertainty no greater than 1 % of the measured value for any demand greater than 2.2 ft^3/h (0.06 m^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 (0.0003 m^3) and a maximum uncertainty no greater than 2 % of the measured value.

6.7 *Pressure Gage,* for monitoring gas pressure, having a range of 0 to 15 in. H_2O (0 to 3.7 kPa), resolution of 0.5 in. H_2O (125 Pa), and maximum uncertainty of 1 % of the measured value.

6.8 *Strain Gage Welder,* capable of welding thermocouples to steel.[5]

6.9 *Stop Watch,* with a 1-s resolution.

6.10 *Temperature Sensor,* for measuring gas temperature in the range of 50 to 100°F (10 to 38°C) with an uncertainty of ±1°F (0.56°C).

6.11 *Thermocouple(s),* insulated to withstand 500°F, 24 gage, Type K thermocouple wire, peened flat at the exposed ends and spot welded to surfaces with a strain gage welder.

6.12 *Thermocouple Probe(s),* industry standard Type T or K thermocouples capable of immersion with a range of 50° to 200°F (10 to 93°C) and an uncertainty of ±1°F (0.56°C).

6.13 *Watt-Hour Meter,* for measuring the electrical energy consumption of a double-sided griddle, having a resolution of at least 10 Wh and a maximum uncertainty no greater than 1.0 % of the measured value for any demand greater than 100 W. The meter shall have a resolution of at least 1 Wh and a maximum uncertainty no greater than 1.0 % for any demand less than 100 W.

7. Reagents and Materials

7.1 *Drip Rack,* large enough to hold a full load of hamburger patties in a single layer (that is, 24 patties for a 24 by 36-in. (61 by 94-cm) double-sided griddle).

7.2 *Freezer Paper,* waxed commercial grade, 18-in. (46-cm) wide.

7.3 *Half-Size Sheet Pans,* measuring 18 by 13 by 1 in. (46 by 33 by 2.5 cm), for use in packaging frozen hamburger patties.

7.4 *Hamburger Patties*—A sufficient quantity of frozen hamburger patties shall be obtained from a meat purveyor to conduct the heavy- and light-load cooking tests. Specifications for the patties shall be four per pound, nominal 20 % fat (by weight), finished grind, pure beef patties. The prefrozen ¼-lb (0.11-kg) patties shall be machine prepared to produce perforated 0.475 ± 0.025-in. (9.5 ± 0.6-mm) thick patties with a minimal diameter of 4.75 in. (114 mm) and a maximum diameter of 5.25 in. (133 mm).

7.4.1 Visually inspect the patties for flatness, cupping, warpage, and dropping (excessive meat frozen to surface which causes a high spot).

7.4.2 Measure 2 % of the patties from a container for thickness, each is measured at three points around the patty (120° from each other). Use this average in setting the gap between platens (9.7).

7.4.3 Gravimetric moisture analysis shall be performed as follows: to determine moisture content, place a 1 lb sample of the test food on a dry, aluminum sheet pan and place the pan in a convection drying oven at a temperature of 220 ± 5°F for a period of 24 h. Weigh the sample before it is placed in the oven and after it is removed and determine the percent moisture content based on the percent weight loss of the sample. The sample must be thoroughly chopped (⅛ in. or smaller squares) and spread evenly over the surface of the sheet pan in order for all of the moisture to evaporate during drying and it is permissible to spread the sample on top of baking paper in order to protect the sheet pan and simplify cleanup.

NOTE 1—It is important to confirm by laboratory tests that the hamburger patties are within the above specifications because these specifications impact directly on cook time and cooking energy consumption.

7.5 *Plastic Wrap,* commercial grade, 18-in. (46-cm) wide.

8. Sampling, Test Units

8.1 *Double-Sided Griddle*—Select a representative production model for performance testing.

9. Preparation of Apparatus

9.1 Install the appliance according to the manufacturer's instructions under a 4-ft (1.2-m) deep canopy exhaust hood mounted against the wall, with the lower edge of the hood 6 ft, 6 in. (1.98 m) from the floor. Position the double-sided griddle with the front edge of the cooking surface inset 6 in. (152 mm) 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. (152 mm) past both sides of the double-sided griddle. In addition, both sides of the appliance shall be a minimum of 3 ft (0.9 m) from any side wall, side partition, or other operating appliance. The exhaust ventilation rate shall be 300 cfm per linear foot (460 L/s per linear metre) of hood length. (For example, a 3-ft (0.9-m) double-sided griddle shall be ventilated, at minimum, by a hood 4 by 4 ft (1.2 by 1.2 m) with a nominal air flow rate of 1200 cfm (1840 L/s). The application of a longer hood is acceptable, provided the ventilation rate is maintained at 300 cfm per linear foot (460 L/s per linear metre) over the entire length of active hood.) The associated heating or cooling system shall be capable of maintaining an ambient temperature of 75 ± 5°F (24 ± 2.8°C) within the testing environment when the exhaust ventilation system is operating.

9.2 Connect the double-sided griddle to a calibrated energy test meter. For gas installations, install a pressure regulator downstream from the meter to maintain a constant pressure of gas for all tests. Install the instrumentation to record both the pressure and temperature of the gas supplied to the double-sided griddle and the barometric pressure during each test so that the measured gas flow can be corrected to standard conditions. For electric installations, a voltage regulator may be required during tests if the voltage supply is not within ±2.5 % of the manufacturer's nameplate voltage.

9.3 For a gas double-sided griddle, adjust (during maximum energy input) the gas supply pressure downstream from the

[5] The sole source of supply of the apparatus (Eaton Model W1200 Strain Gauge Welder) known to the committee at this time is Eaton Corporation, 1728 Maplelawn Road, Troy, MI 48084. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

appliance's pressure regulator to within ±2.5 % of the operating manifold pressure specified by the manufacturer. Make adjustments to the appliance following the manufacturer's recommendations for optimizing combustion. Proper combustion may be verified by measuring air-free CO in accordance with ANSI Z83.11.

9.4 For an electric double-sided griddle, confirm (while the 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—It is the intent of the test procedure herein to evaluate the performance of a double-sided griddle at its rated gas pressure or electric voltage. If an electric unit 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 double-sided griddle is designed to operate at two voltages without a change in the resistance of the heating elements, the performance of the unit (for example, the preheat time) may differ at the two voltages.

9.5 Condition the bottom cooking surface in accordance with the manufacturer's instructions. If not specified by the manufacturer, follow the procedures described in 9.5.1.

9.5.1 Heat the bottom griddle surface to a calibrated average of 350 ± 5°F (177 ± 2.8°C). Coat the entire cooking surface with a salt-free cooking oil. Wipe off the oil residue after heating for 5 min. The bottom griddle surface is now conditioned for testing.

9.6 As applicable, follow the manufacturer's instructions to attach non-stick surfaces or condition top platen surfaces, or both.

9.7 Follow the manufacturer's recommended procedure to set the gap between the top and bottom cooking surfaces for hamburger patties with an average thickness as determined in 7.4.2. If specified by the manufacturer's installation procedure, a qualified service person may be required to set the gap. Contact the manufacturer for assistance if this is not accomplished easily.

10. Procedure

10.1 *General:*

10.1.1 For gas appliances, record the following for each test run: (*1*) higher heating value, (*2*) standard gas pressure and temperature used to correct the measured gas volume to standard conditions, (*3*) measured gas temperature, (*4*) measured gas pressure, (*5*) barometric pressure, (*6*) ambient temperature, and (*7*) energy input rate during or immediately prior to the test.

NOTE 3—Using 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 double-sided griddle under test. It is recommended that all testing be performed with gas having a higher heating value of 1000 to 1075 Btu/ft^3 (37 300 to 40 100 kJ/m^3).

10.1.2 For gas double-sided griddles, add electric energy consumption to gas energy for all tests, with the exception of the energy input rate test (10.2).

10.1.3 For electric double-sided griddles, record the following for each test run: (*1*) voltage while elements are energized, (*2*) ambient temperature, and (*3*) energy input rate during or immediately prior to the test run.

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

10.2 *Energy Input Rate:*

10.2.1 Operate the double-sided griddle with the temperature calibrated to maintain an average bottom cooking surface temperature of 350°F (177°C) and top cooking surface temperature of 350°F (177°C). Ensure that the upper platens are in the lowered position. Monitor the energy consumption for 10 min after the unit is turned on (or all burners have ignited). If the preheat time is less than 10 min (that is, the burners or elements have commenced cycling in that time), monitor the energy consumption and time after the unit is turned on until the first burner or element cycles off.

10.2.2 Confirm that the measured input rate or power (Btu/h and kW for a gas double-sided griddle and kW for an electric double-sided griddle) is within 5 % of the rated nameplate input or power. (It is the intent of the test procedure herein to evaluate the performance of a double-sided griddle at its rated energy input rate.) Terminate testing and contact the manufacturer if the difference is greater than 5 %. The manufacturer may make appropriate changes or adjustments to the double-sided griddle or supply another double-sided griddle for testing.

10.3 *Temperature Uniformity and Thermostat Accuracy:*

10.3.1 Tack-weld thermocouples to the bottom cooking surface directly above each thermostat sensing probe that is embedded in, or located below, the plate.

NOTE 4—Research at Pacific Gas and Electric Co. (PG&E) indicates that thermocouples may be optimized for surface temperature measurement by flattening the thermocouple ends with locking pliers and tack-welding them to the bottom surface with a strain gage welder at the medium setting. Each end of the thermocouple is welded separately to the bottom surface ⅛ ± 1⁄16 in. (3.2 ± 1.6 mm) apart from the other (Fig. 1).

10.3.2 Preheat all sections (bottom and top) of the griddle to the calibrated 350°F (177°C) and stabilize for 60 min after the cooking surfaces commence cycling at the thermostat set point.

10.3.3 Monitor the surface temperature over several complete cycles of the cooking surfaces, where applicable. Determine the average temperature for each thermostat sensor location.

NOTE 5—Double-sided griddles equipped with modulating thermostat controls may not exhibit cycling clearly. In this case, monitor the thermostat bulb temperatures for a minimum of 1 h.

10.3.4 Where required (as indicated by the average temperature), adjust the bottom temperature controls to attain an actual average surface temperature of 350 ± 5°F (177 ± 2.8°C). Repeat the step given in 10.3.3 to confirm that the temperature at each sensing location is 350 ± 5°F (177 ± 2.8°C).

10.3.5 To facilitate further testing of the double-sided griddle in accordance with 10.4 – 10.7, calibrate the bottom temperature controls at 350°F (177°C), following the manufacturer's instructions. If calibration is not recommended or accomplished easily, mark (on the dial) the exact position of

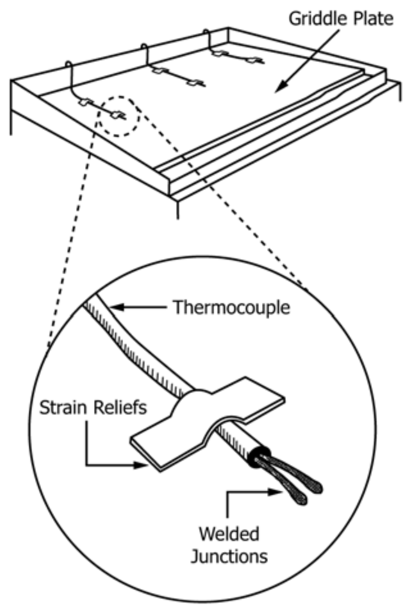

FIG. 1 Sample of Thermocouple Welding for a 3 by 2-ft (0.9 by 0.6-m) Double-Sided Griddle

the thermostat control that corresponds to an average surface temperature of 350°F (177°C).

10.3.6 Measure additional surface temperatures in the cooking zone with no more than 5 in. (127 mm) between adjacent measurement points under a single platen by tack-welding thermocouples to the bottom cooking surface. The additional points shall not be less than 1 in. (25 mm) from the outside edge of the cooking zone.

NOTE 6—It is possible for points under two separate platens to be separated by more than 5 in. (127 mm).

NOTE 7—The additional measurement points on the 24 by 36-in. (61 by 91-cm) bottom surface with three 12-in. (30-cm) wide upper platens can be arranged most effectively in a 4 by 6 grid. This 24-point grid is representative of the placement of hamburger patties during cooking and provides a good representation of the bottom surface temperatures. A sample placement of the measurement points is shown in Fig. 2.

10.3.7 With both the top and bottom set to 350°F (177°C), monitor the temperature for a minimum of 1 h after the cooking surfaces have stabilized at the set temperature. The upper platens shall be in the lowered position.

10.3.8 Record the maximum temperature difference on the bottom surface. The maximum difference is the highest average temperature minus the lowest average temperature at any point on the cooking surface no less than 1 in. (25 mm) away from the outside edge of the cooking zone.

NOTE 8—It is the intent of this procedure to determine the effective temperature uniformity of the double-sided griddle as it will be used in production.

10.4 *Preheat Energy and Time:*

NOTE 9—The preheat test should be conducted as the first appliance operation on the day of the test.

10.4.1 Tack-weld thermocouples to the cooking surface directly above the thermostat sensing points as in 10.3.1.

10.4.2 Record the cooking surface temperature and ambient kitchen temperature at the start of the test (both cooking surface temperatures shall be 75 ± 5°F (24 ± 2.8°C) at the start of the test).

10.4.3 Turn the unit on with the temperature controls set to attain a bottom and top surface temperature of 350°F (177°C), as determined in 10.3. If possible, activate the griddle with the upper platens in the lowered position. Begin monitoring time and energy consumption immediately after the unit is turn on. For a gas double sided griddle, the preheat time shall include any delay between the time the unit is turned on and when the burners ignite.

10.4.4 Preheat is judged complete when the last of the monitored bottom surface temperatures reaches 340°F (171°C). Record the energy consumption and time to preheat all sections of the double-sided griddle jointly.

10.4.5 Repeat the steps given in 10.4.2 – 10.4.4 with the upper platens in the raised position. Repeat preheat test a minimum of three times with the upper platen in the lowered and up position.

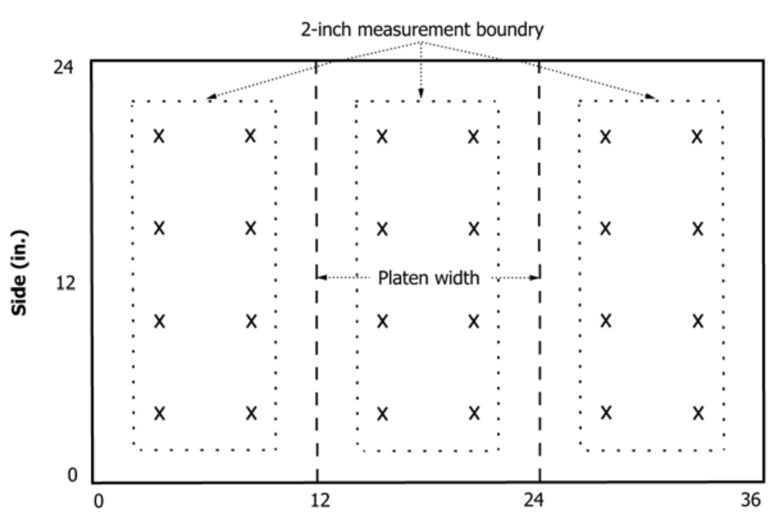

FIG. 2 Sample Placement of Thermocouples on a 3 by 2-ft (0.9 by 0.6-m) Double-Sided Griddle with 12-in. (30.5-cm) Wide Upper Platens

10.5 *Idle Energy Rate:*

10.5.1 Allow the top and bottom cooking surfaces to stabilize at 350°F (177°C) for at least 60 min. Place the upper platens in the lowered position.

10.5.2 Monitor the energy consumption of the double-sided griddle while it is operated at 350°F (177°C) for a minimum of 2 h after the hour stabilization.

10.5.3 Repeat the steps given in 10.5.1 and 10.5.2 with the upper platens in the raised position.

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

10.6.1 Where applicable, set the gas valve that controls gas supply to the appliance at the "pilot" position. Otherwise, set the double-sided griddle temperature controls to the "off" position.

10.6.2 Light and adjust the pilots according to the manufacturer's instructions.

10.6.3 Record the gas reading after a minimum of 8 h of pilot operation.

10.7 *Cooking Energy Efficiency and Production Capacity:*

10.7.1 Run the cooking energy efficiency test a minimum of three times for each loading scenario. Additional test runs may be necessary to obtain the required precision for the reported test results (Annex A1).

10.7.2 Randomly select a minimum of six hamburger patties each for fat and moisture content determination. Determine the fat content using a calibrated fat analyzer or other recognized laboratory procedures. Use the procedure in Annex A2 to measure the moisture content of the randomly selected patties.

10.7.3 Weigh the necessary patties for each load and prepare them for the test by loading them onto half-size 18 by 13 by 1-in. (46 by 33 by 2.5-cm) sheet pans (Fig. 3). Package 24 patties per sheet (6 patties per level by 4 levels), separating each level by a double-sided sheet of waxed freezer paper (Fig. 4). Record the total weight of the beef patties prepared for each load as the initial weight. To facilitate verification that the patties are at the required temperature for the beginning of the test, implant a thermocouple horizontally into at least one hamburger patty on a sheet pan. Cover the entire package with a commercial grade plastic wrap. Place the sheet pans in a freezer near the double-sided griddle test area until the temperature of the patties has stabilized at the freezer temperature.

10.7.4 Monitor the temperature of a frozen patty with a thermocouple probe. Its internal temperature must reach 0 ± 5°F (−18 ± 2.8°C) before the hamburger patties can be removed from the freezer and loaded onto the double-sided griddle. Adjust the freezer temperature to achieve this required internal temperature (the typical freezer setting is −5°F) (−21°C)) if necessary.

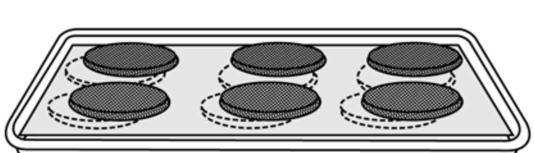

FIG. 3 Example of Hamburger Patty Packaging

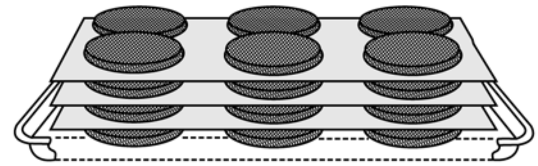

FIG. 4 Cutaway View of Packaged Hamburgers

10.7.5 Prepare a minimum number of loads for the three test runs (Figs. 5 and 6). Use four patties per square foot of cooking zone for the cooking tests and count on 7 to 10 loads per test run.

10.7.6 Tack-weld thermocouples to the bottom cooking surface directly above each thermostat sensing probe that is embedded in, or located below, the plate. Thermocouple positions shall not be less than 1 in. (25 mm) from the outside edge of the cooking zone.

10.7.7 Preheat the top and bottom cooking surfaces to 350°F (177°C). Refer to the manufacturer's recommendations concerning the minimum surface area required for each loading scenario. Allow the cooking surfaces to stabilize at the set temperature for 1 h.

10.7.8 Remove each load of patties separately from the freezer, based on the previously determined elapsed time that is required for the patties to warm to the specified 0 ± 5°F (–18 ± 2.8°C) loading temperature. Do not hand-hold the patties until loading takes place.

10.7.9 Load the patties sequentially on the bottom cooking surface over a maximum 15-s time period for each linear foot of cooking surface (for example, 45 s for a 36-in. (91-cm) double-sided griddle and a maximum 60 s for a 48-in. (122-cm) double-sided griddle). Lower each upper cooking section as the area beneath it is loaded.

10.7.10 Cook the patties for 2.5 min, starting from the time the first hamburger patty is placed on the cooking surface.

10.7.11 Remove the patties in the order placed on the unit over a maximum 15-s time period for each linear foot of cooking surface.

10.7.12 The hamburger patties shall be cooked to an internal temperature of 163°F (73°C) to confirm a medium-done condition. This can be accomplished by cooking the patties to a 35 % weight loss.

NOTE 10—Research conducted by PG&E has determined that the final internal temperature of cooked hamburger patties may be approximated by the percent weight loss incurred during cooking. The two are connected by a linear relationship (Fig. 7), provided that the hamburger patties are within the specifications described in 7.4.

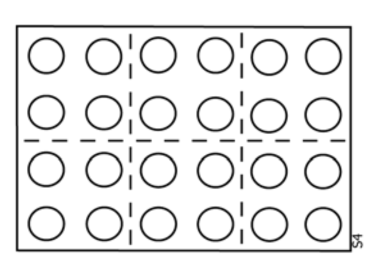

FIG. 5 Patty Positions for Heavy-Load Tests on a 36 by 24-in. (91 by 61-cm) Double-Sided Griddle Surface

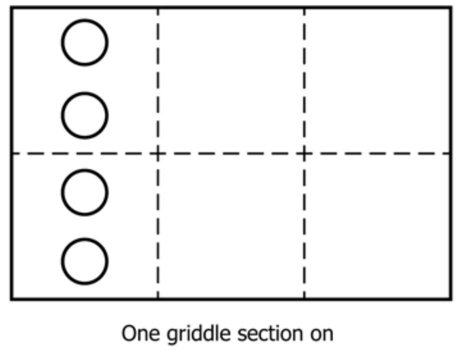

FIG. 6 Sample Placement of Hamburger Patties for Light-Load Tests on a 36 by 24-in. (91 by 61-cm) Bottom Griddle Surface

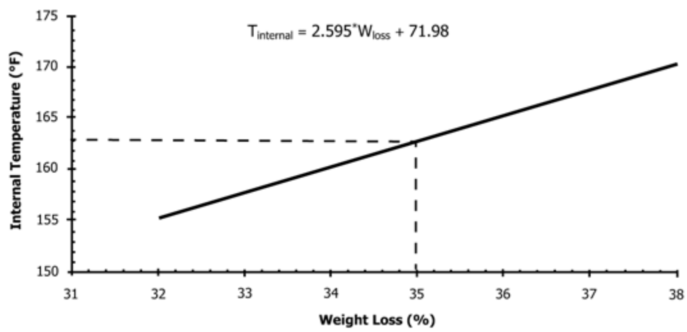

FIG. 7 Bulk Internal Temperature Versus Weight Loss of Cooked Hamburger Patties

10.7.13 Spread the patties on a drip rack using tongs. Turn the patties over after 1 min. Transfer the patties to a separate pan for weighing after another min. Calculate the weight loss using the average patty weight determined in 10.7.2. The percent weight loss shall be 35 ± 2 %.

NOTE 11—The actual cook time depends on the length of time that the patties remain on the double-sided griddle, average temperature of the cooking surfaces, gap between the top and bottom cooking surfaces, and total weight of the food being cooked.

10.7.14 If the percent weight loss is not 35 ± 2 %, repeat the steps given in 10.7.8 – 10.7.13, adjusting the total cooking time to attain a 35 ± 2 % weight loss.

NOTE 12—Research at PG&E indicates that a double-sided griddle cooking surface has recovered sufficiently to cook another load when the surface temperature recovers to within 10°F (5.6°C) of the set temperature (that is, 340°F (171°C) when the thermostats are set to maintain 350°F (177°C)).

10.7.15 After removing the patties, allow a minimum of 15 s per linear foot of cooking surface to scrape the top and bottom cooking surfaces. After the scraping period, reload the double-sided griddle when all monitored points have recovered to at least 340°F (171°C).

10.7.16 Run as many stabilization loads as necessary to stabilize the double-sided griddle response (that is, maintain the 35 ± 2 % weight loss). Run an additional six loads after the double-sided griddle has stabilized. Monitor the energy consumption and total test time for the final six loads. Record the percent weight loss for each load. Ensure that the average weight loss for the six-load test is 35 ± 2 %.

NOTE 13—The test is invalid and must be repeated if the average weight loss for the six-load test is not within 35 ± 2 %.

10.7.17 Allow the bottom cooking surface to recover after the last load before terminating the test. *Do not terminate the test (and energy monitoring) after removing the last patty from the last load.*

NOTE 14—The energy required to bring the double-sided griddle back up to a ready to cook condition after removing the last load is considered part of the energy required by the cooking process.

10.7.18 Reserve six cooked patties (one from each load) to determine the moisture content. Place the patties in a freezer inside a self-sealing plastic bag unless the moisture content test is conducted immediately.

10.7.19 Determine the moisture content of the cooked patties in accordance with the procedure in Annex A2, and calculate the moisture loss based on the initial moisture content of the patties (as determined in 10.7.2).

10.7.20 Perform Runs 2 and 3 by repeating the steps given in 10.7.14 – 10.7.19. Follow the procedure in Annex A1 to determine whether more than three test runs is required.

10.7.21 Repeat the steps given in 10.7.20 for each loading scenario (heavy and light).

11. Calculation and Report

11.1 *Test Double-Sided Griddle:*

11.1.1 Summarize the physical and operating characteristics of the double-sided griddle. Describe other design or operating characteristics that may facilitate interpretation of the test results if needed.

11.2 *Apparatus and Procedure:*

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

11.2.2 For electric double-sided griddles, report the voltage for each test.

11.2.3 For gas double-sided griddles, report the higher heating value of the gas supplied to the double-sided griddle during each test.

11.3 *Gas Energy Calculations:*

11.3.1 For gas double-sided griddles, add electric energy consumption to gas energy for all tests, with the exception of the energy input rate test (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 appliance,
HV = higher heating value,
= energy content of gas measured at standard conditions, Btu/ft^3 (kJ/m^3), and
V = actual volume of gas corrected for temperature and pressure at standard conditions, ft^3 (m^3),
= $V_{meas} \times T_{cf} \times P_{cf}$

where:

V_{meas} = measured volume of gas, ft^3 (m^3),
T_{cf} = temperature correction factor,
= $\frac{\text{absolute standard gas temperature °R (°K)}}{\text{absolute actual gas temperature° R (°K)}}$,
= $\frac{\text{absolute standard gas temperature °R (°K)}}{[\text{gas temperature °F (°C)} + 459.67] \text{ °R (°K)}}$, and

P_{cf} = pressure correction factor,
= $\frac{\text{absolute actual gas pressure psia (kPa)}}{\text{absolute standard pressure psia (kPa)}}$,
= $\frac{\text{gas gage pressure psig (kPa)} + \text{barometric pressure psia (kPa)}}{\text{absolute standard pressure psia (kPa)}}$.

NOTE 15—The absolute standard gas temperature and pressure used in this calculation should be the same values used for determining the higher heating value. PG&E standard conditions are 519.67°R (288.56°K) and 14.73 psia (101.5 kPa).

11.4 *Energy Input Rate:*

11.4.1 Report the manufacturer's nameplate energy input rate in Btu/h (kJ/h) for a gas double-sided griddle and kW for an electric double-sided griddle.

11.4.2 For gas or electric double-sided griddles, calculate and report the measured energy input rate (Btu/h (kJ/h) or kW) based on the energy consumed by the double-sided griddle during the period of peak energy input according to the following relationship:

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

where:

$E_{input\ rate}$ = measured peak energy input rate, Btu/h (kJ/h) or kW,
E = energy consumed during the period of peak energy input, Btu (kJ) or kWh, and
t = period of peak energy input, min.

11.5 *Temperature Uniformity and Thermostat Accuracy:*

11.5.1 Report any discrepancies greater than 5°F (2.8°C) between the temperature indicated on the control and the measured average cooking surface temperature of 350°F (177°C) for each thermostat.

11.5.2 Report the average temperature at each additional temperature measurement location on a plan drawing of the top and bottom cooking surfaces. Report the maximum deviation between the average temperature at any measurement location on the bottom cooking surface not closer than 3 in. (76 mm) from the edge of the cooking surface.

11.6 *Preheat Energy and Time:*

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

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

11.6.3 Generate a graph showing the temperature of the bottom cooking surface versus time for the preheat period.

11.7 *Idle Energy Rate:*

11.7.1 Calculate and report the idle energy rate (Btu/h (kJ/h) or kW) based on

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

where:

$E_{idle\ rate}$ = idle energy rate, Btu/h (kJ/h) or kW,
E = energy consumed during the test period, Btu (kJ) or kWh, and
t = test period, min.

11.8 *Pilot Energy Rate:*

11.8.1 Calculate and report the pilot energy rate (Btu/h (kJ/h)) based on

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

where:

$E_{pilot\ rate}$ = pilot energy rate, Btu/h (kJ/h),
E = energy consumed during the test period, Btu (kJ), and
t = test period, min.

11.9 *Cooking Energy Efficiency and Cooking Energy Rate:*

11.9.1 Calculate and report the cooking energy efficiency for heavy- and light-load cooking tests based on

$$\eta_{cook} = \frac{E_{food}}{E_{appliance}} \times 100 \quad (5)$$

where:

η_{cook} = cooking energy efficiency, %, and
E_{food} = energy into food, Btu (kJ),
= $E_{sens} + E_{thaw} + E_{evap}$

where:

E_{sens} = quantity of heat added to the hamburger patties, which causes their temperature to increase from the starting temperature to the average bulk temperature of a medium-done patty, Btu (kJ),
= $(W_i)(C_p)(T_f - T_i)$

where:

W_i = initial weight of hamburger patties, lb (kg), and
C_p = specific heat of hamburger patty, Btu/lb, °F, (kJ/kg, °C)
= 0.72 (0.93).

NOTE 16—For this analysis, the specific heat, C_p, of a hamburger patty 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[6] has determined that the weighted average of the specific heat for frozen hamburger patties cooked in accordance with this test method was approximately 0.72 Btu/lb, °F/(0.93 kJ/kg, °C).

T_f = final internal temperature of the cooked hamburger patties, °F (°C),
= $2.595 \times W_{tl} + 71.98$.

NOTE 17—Research conducted by PG&E has determined that the final internal temperature of cooked hamburger patties and the percent weight loss are connected by the above relationship provided that the hamburger patties are within the specifications described in 7.4. Weight loss is expressed as a percentage, and the internal temperature is in °F.

where:

W_{tl} = average percent weight loss for the six-load run, %,

T_i = initial patty temperature,° F (°C), and
E_{thaw} = latent heat (of fusion) added to the hamburger patties, which causes the moisture (in the form of ice) contained in the patties to melt when the temperature of the patties reaches 32°F (0°C) (the additional heat required to melt the ice is not reflected by a change in the temperature of the patties), Btu (kJ),
= $W_{iw} \times H_f$

where:

W_{iw} = initial weight of water in patty, lb (kg),
H_f = heat of fusion, Btu/lb (kJ/kg),
= 144 Btu/lb (336 kJ/kg) at 32°F (0°C), and
E_{evap} = latent heat (of vaporization) added to the hamburger patties, which causes some of the moisture contained in the patties to evaporate; similar to the heat of fusion, the heat of vaporization cannot be perceived by a change in temperature and must be calculated after determining the amount of moisture lost from a medium-done patty,
= $W_{loss} \times H_v$

where:

W_{loss} = weight loss of water during cooking, lb (kg),
H_v = heat of vaporization, Btu/lb (kJ/kg),
= 970 Btu/lb (2256 kJ/kg) at 212°F (100°C), and
$E_{appliance}$ = energy into the appliance, Btu (kJ).

11.9.2 Report the measured percentage fat and moisture content of the raw hamburger patties and the measured percentage moisture content of the cooked hamburger patties.

11.9.3 Calculate and report the cooking energy rate for heavy- and light-load cooking tests based on

$$E_{cook\ rate} = \frac{E \times 60}{t} \qquad (6)$$

where:

$E_{cook\ rate}$ = cooking energy rate, Btu/h (kJ/h) or kW,
E = energy consumed during cooking test, Btu (kJ) or kWh, and
t = cooking test period, min.

Report a gas cooking energy rate and an electric cooking energy rate separately for gas appliances.

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

$$E_{food} = \frac{E}{W} \qquad (7)$$

where:

E_{food} = energy per pound, Btu/lb (kJ/kg) or kWh/lb (kWh/kg),
E = energy consumed during cooking test, Btu (kJ) or kWh, and
W = total initial weight of the frozen hamburger patties, lb (kg).

11.9.5 Calculate the production capacity (lb/h (kg/h)) based on

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

where:

PC = production capacity of the double-sided griddle, lb/h (kg/h),
W = total weight of food cooked during heavy-load cooking test, lb (kg), and
t = total time of heavy-load cooking test, min.

11.9.6 Calculate the production rate (lb/h (kg/h)) for the light-load tests using the relationship from 11.9.5, where *W* equals the total weight of food cooked during the test run and *t* equals the total time of the test run.

11.9.7 Determine the average surface temperature recovery time for the heavy- and light-load tests based on

$$t_r = t - t_{cook} \qquad (9)$$

where:

t_r = appliance recovery time, min,
t = total time for a six-load test (heavy- or light-), min, and
t_{cook} = cooking time, min.

11.9.8 Report the cook time for the heavy- and light-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 and production rate 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 With the exception of temperature uniformity, the repeatability of each remaining reported parameter is being

[6] *Development and Application of a Uniform Testing Procedure for Griddles*, R&D Report 008.1-89.2, Pacific Gas and Electric Co., San Ramon, CA, March 1989.

determined. The repeatability of the temperature uniformity test cannot be determined because of the descriptive nature of the test result.

12.1.2 *Reproducibility (Multiple Laboratories)*—With the exception of temperature uniformity, the interlaboratory precision of the procedure in this test method for measuring each reported parameter is being determined. The reproducibility of the temperature uniformity test cannot be determined because of the descriptive nature of the test result.

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

13. Keywords

13.1 double-sided griddle; energy efficiency; performance; production capacity; test method; throughput

ANNEXES

(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 be applied only to test results that have been obtained within the tolerances prescribed in this test method (for example, thermocouples calibrated and the appliance operating within 5 % of rated input during the test run).

A1.1 The uncertainty in the averages of at least three test runs is reported for the cooking energy efficiency and production capacity results. The uncertainty of the cooking energy efficiency and production capacity must be no greater than ±10 % for each loading scenario 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. For example, if the production capacity for the appliance is 30 lb/h (13.6 kg/h), the uncertainty must not be greater than ±3 lb/h (±1.4 kg/h). The true production capacity is thus between 27 and 33 lb/h (12.2 and 15 kg/h). This interval is determined at the 95 % confidence level, which means that only a 1 in 20 chance exists 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 it is also used to determine the number of test runs necessary 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.

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

A1.4 *Procedure*:

A1.4.1 *Step 1*—Calculate the average and 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, and X_3 = results for each test run.

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

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

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 = $(1/3) \times (X_1 + X_2 + X_3)^2$.

NOTE A1.2—The formulas 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 A1.3—The *A* quantity is the sum of the squares of each test result, and the *B* quantity 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 (three 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 the 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 (three test runs) is as follows:

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

where:

$\% U_3$ = percent uncertainty in the average for three test runs,
U_3 = absolute uncertainty in the 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 4.

A1.4.5 *Step 4*—Run a fourth test for each loading scenario whose percent uncertainty was greater than ±10 %.

A1.4.6 *Step 5*—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
$X_1, X_2, X_3, and X_4$ = results for each test run.

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

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

where:

S_4 = standard deviation of results for four test runs,
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 6*—Calculate the absolute uncertainty in the average for each parameter listed in Step 1. Multiply the standard deviation calculated in Step 5 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 the average for four test runs, and
C_4 = uncertainty factor for four test runs (Table A1.1).

A1.4.8 *Step 7*—Calculate the percent uncertainty in the parameter averages using the averages from Step 5 and the absolute uncertainties from Step 6.

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 the average for four test runs,
U_4 = absolute uncertainty in the average for four test runs, and
Xa_4 = average of four test runs.

A1.4.9 *Step 8*—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 9.

A1.4.10 *Step 9*—The steps required for five or more test runs are the same as those described above. 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 the results for 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:

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

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 the 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 the average for n test runs,
U_n = absolute uncertainty in the 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 $\pm 10\,\%$ 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:

$$Xa_n \pm U_n$$

NOTE A1.4—The researcher may compute a test result that deviates significantly from the other test results. Such a result should be discarded only if some physical evidence exists that the test run was not performed according to 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. It is good practice to monitor those test conditions specified in this test method to ensure that all results are obtained under approximately the same conditions.

A2. PROCEDURE FOR DETERMINING THE MOISTURE CONTENT OF FOOD PRODUCTS USING GRAVIMETRIC WEIGHT LOSS

INTRODUCTION

Moisture content of food products can have a significant effect on the amount of energy required for cooking. It was imperative for researchers to be able to quickly and accurately determine whether a food product was within specifications before commencing testing. Moisture contents are also used in energy-to-food calculations. The moisture content of raw and cooked food can be determined using an air drying method and determining the gravimetric weight loss.

A2.1 Scope

A2.1.1 The test procedure in this annex determines the moisture content of raw and cooked food products using gravimetric weight loss on air drying.

A2.2 Referenced Documents

A2.2.1 *AOAC Documents:* AOAC Official Action 984.25 Moisture (Loss of Mass on Drying) in Frozen French Fried Potatoes[7]

A2.3 Apparatus

A2.3.1 *Convection Drying Oven,* electric or indirect gas-fired convection oven with adjustable fan speed and temperature controlled at 220 ± 5°F (104 ± 2.5°C), used to determine moisture content of both the raw and cooked food product.

A2.3.2 *Half-Size Aluminum Sheet Pans,* measuring 18 by 13 by 1 in. (46 by 33 by 2.5 cm) for holding the sample food product.

A2.4 Procedure

NOTE A2.1—This procedure has been adapted from AOAC Official Action 984.25 Moisture (Loss of Mass on Drying) in Frozen French Fried Potatoes. A larger sample is used to reduce the uncertainty in the results.

A2.4.1 Weigh and record the weight of a dry, lined half-size sheet pan.

A2.4.2 Weigh and record the weight of the test food sample.

NOTE A2.2—To obtain an accurate determination of the moisture content in the test food product, a representative sample of the food product must be used for air drying.

A2.4.3 Thoroughly chop, grind, or otherwise break apart the food sample into ⅛-in. or smaller cubes. Evenly spread the sample over the area of the pan.

A2.4.4 Place into a preheated convection drying oven set at 220 ± 5°F and the lowest fan speed setting for a period of 18 h.

A2.4.5 After 18 h have elapsed, weigh and record the weight of the dried sample.

A2.4.6 Return the sample to the oven and dry for an additional 2 h.

A2.4.7 Weigh and record the weight of the sample.

A2.4.8 Compare this weight to the previously recorded weight of the dried sample. Repeat A2.4.6 and A2.4.7 until the difference between successive weighings does not exceed 0.01 lb.

A2.5 Calculation

A2.5.1 Calculate the moisture content of the sample food product based on:

$$M = \frac{(W_i - W_f)}{W_i} \times 100 \quad (A2.1)$$

where:

[7] Available from AOAC International, 481 North Frederick Ave., Suite 500, Gaithersburg, Maryland 20877-2417, http://www.aoac.org.

M = the moisture content (by weight) of the sample food product, %

W_i = the initial weight of the food sample, lb

W_f = the final dried weight of the food sample, lb

APPENDIXES

(Nonmandatory Information)

X1. RESULTS REPORTING SHEETS

Manufacturer ________
Model ________
Date ________
Test Reference Number (optional) ________

Section 11.1

List the Type, Size, Style, and Electrical Class by following the specifications listed in Specification F1919.
List any additional operating characteristics below.

Type ________
Size (Cooking Surface) (W × D) ________
Style ________
Electrical Class ________

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

Section 11.2 Apparatus

___ Check if testing apparatus conformed to specification in Section 6.
Deviations: ____
____
____
____
____

Section 11.3 Energy Input Rate

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

Section 11.4 Temperature Uniformity and Thermostat Accuracy

Thermostat settings required to maintain 375°F (191°C) cooking surface temperature (from left):

Thermostat #1 ________
Bottom Thermostat #2 (if required) ________
Bottom Thermostat #3 (if required) ________
Bottom Thermostat #4 (if required) ________
Bottom Thermostat #5 (if required) ________
Bottom Thermostat #6 (if required) ________

Thermostat #1 ________
Top Thermostat #2 (if required) ________
Top Thermostat #3 (if required) ________
Top Thermostat #4 (if required) ________
Top Thermostat #5 (if required) ________
Top Thermostat #6 (if required) ________

Section 11.5 Preheat Energy and Time

Test Voltage (V) ________
Gas Heating Value (Btu/ft^3 (kJ/m^3)) ________
Energy Consumption (Btu (kJ) or kWh) ________
Duration (min) ________
Preheat Rate (°F/min (°C/min)) ________

Section 11.6 Idle Energy Rate

Tops Raised:

Test Voltage (V) ________

Gas Heating Value (Btu/ft³ (kJ/m³)) ________

Idle Energy Rate (Btu/h (kJ/h) or kW) ________

Electric Energy Rate (kW, gas griddles only) ________

Tops Lowered:

Test Voltage (V) ________

Gas Heating Value (Btu/ft³ (kJ/m³)) ________

Idle Energy Rate (Btu/h (kJ/h) or kW) ________

Electric Energy Rate (kW, gas griddles only) ________

Section 11.7 Pilot Energy Rate (if applicable)

Gas Heating Value (Btu/ft³ (kJ/m³)) ________

Pilot Energy Rate (Btu/h (kJ/h) or kW) ________

Section 11.8 Cooking Energy Efficiency and Cooking Energy Rate

Heavy Load:

Test Voltage (V) ________

Gas Heating Value (Btu/ft³ (kJ/m³)) ________

Cooking Time (min) ________

Average Cooking Surface Recovery Time (min) ________

Production Capacity (lb/h (kg/h)) ________

Energy to Food (Btu/lb (kJ/kg)) ________

Cooking Energy Rate (Btu/h (kJ/h) or kW) ________

Electric Energy Rate (kW, gas griddles only) ________

Energy per Pound of Food Cooked (Btu/lb (kJ/kg) or Wh/lb (Wh/kg)) ________

Cooking Energy Efficiency (%) ________

Light Load:

Test Voltage (V) ________

Gas Heating Value (Btu/ft³ (kJ/m³)) ________

Cooking Time (min) ________

Average Cooking Surface Recovery Time (min) ________

Production Capacity (lb/h (kg/h)) ________

Energy to Food (Btu/lb (kJ/kg)) ________

Cooking Energy Rate (Btu/h (kJ/h) or kW) ________

Electric Energy Rate (kW, gas griddles only) ________

Energy per Pound of Food Cooked (Btu/lb (kJ/kg) or Wh/lb (Wh/kg)) ________

Cooking Energy Efficiency (%) ________

X2. PROCEDURE FOR CALCULATING THE ENERGY CONSUMPTION OF A GRIDDLE BASED ON REPORTED TEST RESULTS

X2.1 Appliance test results are useful not only for benchmarking appliance performance, but also for estimating appliance energy consumption. The following procedure is a guideline for estimating griddle energy consumption based on data obtained from applying the appropriate test method.

X2.2 The intent of this appendix is to present a standard test method for estimating griddle energy consumption based on ASTM performance test results. The examples contained herein are for information only and should not be considered an absolute. To obtain an accurate estimate of energy consumption for a particular operation, parameters specific to that operation should be used (for example, operating time and amount of food cooked under heavy and light loads).

X2.3 The appropriate griddle performance parameters are obtained from Section 11.

X2.4 Procedure

X2.4.1 The calculation will proceed as follows: First, determine the appliance operating time and total number of preheats. Then estimate the quantity of food cooked and establish the breakdown among heavy (whole cooking surface loaded with product) and light (single-serving) loads. For example, a griddle operating for 12 h a day with one preheat cooked 100 lb of food: 70 % of the food was cooked under heavy-load conditions and 30 % was cooked under light-load conditions. Calculate the energy due to cooking at heavy- and light-load cooking rates, and then calculate the idle energy consumption. The total daily energy is the sum of these components plus the preheat energy. For simplicity, it is assumed that subsequent preheats require the same time and energy as the first preheat of the day.

X2.4.2 *Step 1*—Determine the griddle operating time, number of preheats, and amount of food cooked under heavy- (whole cooking surface loaded with product) and light- (single-serving) load conditions. (See Table X2.1.)

X2.4.3 *Step 2*—Calculate the time and energy involved in cooking heavy loads. Heavy loads are the equivalent of loading the entire cooking surface with product.

X2.4.3.1 Determine the total time cooking heavy loads as follows:

$$t_h = \frac{\%\ h \times W}{PC} \tag{X2.1}$$

where:

t_h = total time cooking heavy loads, h,
$\%h$ = percentage of food cooked under heavy-load conditions during the day,
W = total weight of food cooked per day, lb, and
PC = griddle's production capacity as determined in 11.9.4, lb/h.

X2.4.3.2 Calculate the heavy-load energy consumption using the following set of equations. For gas griddles, determine separately any electric energy using the electric equations.

$$E_{gas,h} = q_{gas,h} \times t_h \tag{X2.2}$$

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

where:

$E_{gas,h}$ = total gas heavy-load energy consumption, Btu,
$q_{gas,h}$ = gas heavy-load cooking energy rate as determined in 11.9.1, Btu/h,
$E_{elec,h}$ = total electric heavy-load energy consumption, kWh, and
$q_{elec,h}$ = electric heavy-load cooking energy rate as determined in 11.9.1, kW.

X2.4.4 *Step 3*—Calculate the time and energy involved in cooking light loads. Light loads are the equivalent of cooking a single serving on the griddle.

X2.4.4.1 Determine the total time cooking light loads as follows:

$$t_l = \frac{\%l \times W}{PR_l} \tag{X2.3}$$

where:

t_l = total time cooking light loads, h,
$\%_l$ = food cooked under light-load conditions during the day, %,
W = total weight of food cooked per day, lb,
PR_l = griddle's light-load production rate as determined in 11.9.5, lb/h.

TABLE X2.1 Typical Griddle Operation Assumptions

Operating time	12 h
Number of preheats	1 preheat
Total amount of food cooked	100 lb
Percentage of food cooked under heavy-load conditions	70 % (× 100 lb = 70 lb)
Percentage of food cooked under light-load conditions	30 % (× 100 lb = 30 lb)

X2.4.4.2 Calculate the light-load energy consumption using the following set of equations. For gas griddles, determine separately any electric energy using the electric equations.

$$E_{gas,l} = q_{gas,l} \times t_l \tag{X2.4}$$

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

where:

$E_{gas,l}$ = total gas light-load energy consumption, Btu,
$q_{gas,l}$ = gas light-load cooking energy rate as determined in 11.9.1, Btu/h,
$E_{elec,l}$ = total electric light-load energy consumption, kWh,
$q_{elec,l}$ = electric light-load cooking energy rate as determined in 11.9.1, kW.

X2.4.5 *Step 4*—Calculate the total idle time and energy consumption.

X2.4.5.1 Determine the total idle time as follows:

$$t_i = t_{on} - t_h - t_l - \frac{n_p \times t_p}{60} \tag{X2.5}$$

where:

t_i = total idle time, h,
t_{on} = total daily on-time, h,
n_p = number of preheats,
t_p = preheat time, as determined in 11.6.1, min.

X2.4.5.2 Calculate the idle energy consumption using the following set of equations. For gas griddles, determine separately any electric energy using the electric equations.

$$E_{gas,i} = q_{gas,i} \times t_i \tag{X2.6}$$

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

where:

$E_{gas,i}$ = total gas idle energy consumption, Btu,
$q_{gas,i}$ = gas idle energy rate as determined in 11.7.1, Btu/h,
$E_{elec,i}$ = total electric idle energy consumption, kWh, and
$q_{elec,i}$ = electric idle energy rate as determined in 11.7.1, kW.

X2.4.6 *Step 5*—Calculate the total daily energy consumption as follows:

$$E_{gas,daily} = q_{gas,h} + q_{gas,l} + E_{gas,i} + n_p \times E_{gas,p} \tag{X2.7}$$

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

where:

$E_{gas,daily}$ = total daily gas energy consumption, Btu/day,
n_p = total number of preheats per day,
$E_{gas,p}$ = gas preheat energy consumption as determined in 11.6.1, Btu,
$E_{elec,daily}$ = total daily electric energy consumption, Btu/day, and
$E_{elec,p}$ = electric preheat energy consumption as determined in 11.6.1, Btu.

X2.4.6.1 The complete formulae for calculating daily energy consumption are as follows:

$$E_{gas,daily} = \frac{\%h \times W}{PC} \times q_{gas,h} + \frac{\%l \times W}{PR_l} \times q_{gas,l} + \tag{X2.8}$$

$$+ \left(t_{on} - \frac{\%h \times W}{PC} - \frac{\%_l \times W}{PR_l} - \frac{n_p \times t_p}{60} \right) \times q_{gas,i} + n_p \times E_{gas,p}$$

$$E_{elec,daily} = \frac{\%h \times W}{PC} \times q_{elec,h} + \frac{\%l \times W}{PR_l} \times q_{elec,l} + \left(t_{on} - \frac{\%h \times W}{PC} - \frac{\%_l \times W}{PR_l} - \frac{n_p \times t_p}{60} \right) \times q_{elec,i} + n_p \times E_{elec,p}$$

X2.4.7 *Step 6*—Calculate the average electric demand for griddles in accordance with the following equation:

$$q_{avg} = \frac{E_{elec,daily}}{t_{on}} \quad \text{(X2.9)}$$

where:

q_{avg} = average demand for the griddle, kW,
$E_{elec,daily}$ = total daily electric energy consumption, kWh/day,
t_{on} = total daily on-time, h.

NOTE X2.1—It has been assumed that the appliance's probable contribution to the building's peak demand is the average demand for the appliance. This is useful because the probability of an appliance drawing its average rate during the period that the building peak is set is significantly higher than for any other input rate for that appliance. If data exists otherwise for a given operation, the probable contribution to demand can be other than the average demand.

X2.4.8 *Step 7*—Determine the estimated monthly appliance energy cost as follows:

$$C_{gas,monthly} = r_{gas} \times \frac{E_{gas,daily}}{100000 \frac{Btu}{therm}} \times d_{op} \quad \text{(X2.10)}$$

$$C_{elec,monthly} = r_{elec} \times E_{elec,daily} \times d_{op} + r_{demand} \times q_{avg} \quad \text{(X2.11)}$$

where:

$C_{gas,monthly}$ = monthly appliance gas cost, dollar/month,
r_{gas} = appropriate utility gas rate, dollar/therm,
$E_{gas,daily}$ = total daily gas energy consumption, Btu/day,
d_{op} = average number of operating days per month,
$C_{elec,monthly}$ = monthly appliance electric cost, dollar/month,
r_{elec} = appropriate utility electric rate, dollar/kWh,
$E_{elec,daily}$ = total daily electric energy consumption, kWh/day,
r_{demand} = appropriate utility demand charge, dollar/kW, and
q_{avg} = average demand for the griddle, kW.