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An American National Standard

Standard Test Method for Performance of Griddles[1]

This standard is issued under the fixed designation F 1275; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

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

1.2 This test method is applicable to thermostatically controlled, single-source (bottom) gas and electric griddles.

1.3 The 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 and accuracy of the thermostats (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 (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 the standard. The values 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 *ASTM Standards:*

D 3588 Practice for Calculating Heat Value, Compressibility, and Relative Density of Gaseous Fuels[2]

2.2 *ANSI Standard:*

ANSI Z83.14 Gas Food Service Equipment—Counter Appliances[3]

2.3 *AOAC Documents:*[4]

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

AOAC Official Action 960.39 Fat (Crude) or Ether Extract in Meat

2.4 *ASHRAE Document:*

ASHRAE Guideline 2-1986 (RA90) Engineering Analysis of Experimental Data[5]

3. Terminology

3.1 *Definitions:*

3.1.1 *cook time*, *n*—the time required to cook frozen hamburgers, as specified in 7.1, to a 35 ± 2 % weight loss during a cooking energy efficiency test.

3.1.2 *cooking energy*, *n*—energy consumed (Btu (kJ) or kWh) by the griddle as it is used to cook hamburgers under heavy- and light-load conditions.

3.1.3 *cooking energy efficiency*, *n*—the quantity of energy imparted to the specified food product, expressed as a percentage of energy consumed by the 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 *energy input rate*, *n*—the peak rate (Btu/h (kJ/h) or kW) at which an appliance will consume energy, typically reflected during preheating.

3.1.6 *griddle*, *n*—a device for cooking food in oil or its own juices by direct contact with a hot surface.

3.1.7 *idle energy rate*, *n*—the average rate of energy consumed (Btu/h (kJ/h) or kW) by the griddle while "holding" or maintaining the cooking surface at the thermostat set point.

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

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[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] *Annual Book of ASTM Standards*, Vol 05.06.

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

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

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

3.1.9 *preheat energy*, *n*—the amount of energy consumed (Btu (kJ) or kWh) by the griddle while preheating the cooking surface from ambient room temperature to the thermostat set point.

3.1.10 *preheat rate*, *n*—the average rate (°F/min (°C/min)) at which the cooking surface temperature is heated from ambient temperature to the griddle's thermostat set point.

3.1.11 *preheat time*, *n*—the time required for the cooking surface to preheat from ambient room temperature to the thermostat set point.

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

3.1.13 *production rate*, *n*—the average rate (lb/h (kg/h)) at which a 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.

3.1.14 *recovery time*, *n*—the average time from the removal of the last hamburger patty of a load until all sections of the cooking surface are back up to within 25°F (14°C) of set temperature and are ready to be reloaded.

3.1.15 *test method*, *n*—a definitive procedure for the identification, measurement, and evaluation of one or more qualities, characteristics, or properties of a material, product, system, or service that produces a test result.

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 Methods

4.1 The griddle 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 any further testing.

4.2 The griddle surface temperature is monitored directly above the thermostat sensing points, and the cooking surface is calibrated to 375°F (191°C) based on these points. Additional points are monitored at predetermined locations while the griddle is idled at a nominal 375°F.

4.3 The preheat energy and time and idle energy rate are determined while the griddle is operating with the thermostats set at a calibrated 375°F (191°C). The rate of pilot energy consumption is also determined when applicable to the griddle under test.

4.4 Energy consumption and time are monitored while the griddle is used to cook six loads of frozen, ¼-lb (0.11-kg), 20 % fat pure beef hamburger patties to a medium-done condition with the thermostats set at a calibrated 375°F (191°C). Cooking energy efficiency, cooking energy rate, production capacity, and surface temperature recovery time are determined for heavy- (whole cooking surface loaded with product) and light-load (single serving) test conditions.

5. Significance and Use

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

5.2 The temperature uniformity of the cooking surface is used by food service operators to choose a griddle that provides a uniformly cooked product.

5.3 Preheat energy and time can be useful to food service operators to manage power demands and to know how rapidly the griddle can be ready for operation.

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

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

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

6. Apparatus

6.1 *Watt-Hour Meter*, for measuring the electrical energy consumption of a griddle, having a resolution of at least 10 Wh and a maximum uncertainty no greater than 1.5 % of the measured value for any demand greater than 100 W. The meter shall have a resolution of at least 10 Wh and a maximum uncertainty no greater than 10 % for any demand less than 100 W.

6.2 *Gas Meter*, for measuring the gas consumption of a griddle, being a positive displacement type with a resolution of at least 0.01 ft^3 (0.0003 m^3) and a maximum error 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 have a maximum error no greater than 2 % of the measured value.

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

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

6.5 *Analytical Balance Scale*, for the determination of hamburger patty weight before and after cooking and for the moisture loss determination test, with a resolution of 0.01 lb (0.004 kg).

6.6 *Convection Drying Oven*, with the temperature controlled at 215 to 220°F (101 to 104°C), used to determine the moisture content of both the raw and cooked hamburger.

6.7 *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.

6.8 *Barometer*, for measuring absolute atmospheric pressure, to be used for the adjustment of 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.

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

6.10 *Pressure Gage*, for monitoring gas pressure, having a range from 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.

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

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

6.13 *Strain Gage Welder*, capable of welding thermocouples to steel.[6]

7. Reagents and Materials

7.1 *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, 20 ± 2 % fat (by weight), finished grind, pure beef patties with a moisture content between 58 and 62 % of the total hamburger weight. The prefrozen, ¼-lb (0.11-kg) patties shall be machine-prepared to produce ⅜-in. (9.5-mm) thick patties with a nominal diameter of 5 in. (127 mm).

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 energy consumption.

7.2 *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.

7.3 *Freezer Paper*—Waxed commercial grade, 18-in. (46-cm) wide.

7.4 *Plastic Wrap*—Commercial grade, 18-in. (46-cm) wide.

7.5 *Drip Rack*—Measuring 18 by 26 by 1 in. (46 by 66 by 2.5 cm), to hold a load of cooked hamburger patties in a single layer (that is, 24 patties for a 36 by 24-in. (91 by 61-cm) griddle).

8. Sampling and Test Units

8.1 *Griddle*—A representative production model shall be selected 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 78 in. (198 cm) from the floor. Position the griddle with the front edge of the cooking surface inset 6 in. (15 cm) 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. (15 cm) past both sides of the griddle. In addition, both sides of the griddle shall be a minimum of 3 ft (0.9 m) from any side wall, side partition, or other 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) 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 that the ventilation rate is maintained at 300 cfm per linear foot (460 L/s per linear metre) over the entire length of active hood.) Air flow rates and flow measurement procedures shall be reported. 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 working without the appliance being operated.

9.2 Connect the griddle 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 griddle, 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 all tests.

9.3 For a gas griddle, adjust (during maximum energy input) the gas supply pressure downstream from the appliance's pressure regulator to within ±2.5 % of the operating manifold pressure specified by the manufacturer. Make adjustments to the griddle following the manufacturer's recommendations for optimizing combustion. Proper combustion may be verified by measuring air-free CO in accordance with ANSI Z83.14.

9.4 For an electric griddle, confirm (while the griddle 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 griddle at its rated gas pressure or electric voltage. If an electric griddle 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 griddle is designed to operate at two voltages without a change in the resistance of the heating elements, the performance of the griddle (for example, the preheat time) may differ at the two voltages.

9.5 Make the griddle ready for use in accordance with the manufacturer's instructions. Temper the griddle cooking surface by following the procedures specified by the manufacturer. If not specified by the manufacturer, follow the procedures described in 9.5.1.

9.5.1 Heat the griddle surface to 375°F (191°C) as indicated by the thermostat settings. Coat the entire cooking surface with a salt-free cooking oil. Wipe off the oil residue after 5 min of heating. The griddle surface is now conditioned for testing.

10. Procedure

NOTE 3—Do not conduct griddle performance tests without operating the exhaust ventilation system.

10.1 *General*:

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

(1) Higher heating value,

(2) Standard gas pressure and temperature used to correct measured gas volume to standard conditions,

(3) Measured gas temperature,

[6] Eaton Model W1200 Strain Gauge Welder, available from Eaton Corp., 1728 Maplelawn Road, Troy, MI 48084, has been found satisfactory for this purpose.

(4) Measured gas pressure,

(5) Barometric pressure,

(6) Ambient temperature, and

(7) Energy input rate during or immediately prior to testing.

NOTE 4—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 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 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 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 griddle.

10.2 *Energy Input Rate*:

10.2.1 Operate the griddle with the temperature controls set to maintain an average cooking surface temperature of 375°F (191°C) directly above the thermostat temperature sensing points. The surface temperature shall be 75 ± 5°F (24 ± 2.8°C) at the start of the test. Monitor the consumption of energy 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 for a gas griddle and kW for an electric griddle) is within 5 % of the rated nameplate input or power. Testing shall be terminated and the manufacturer contacted if the difference is greater than 5 %. The manufacturer may make appropriate changes or adjustments to the griddle or choose to supply an alternative griddle for testing. It is the intent of the test procedure herein to evaluate the performance of a griddle at its rated energy input rate.

10.3 *Temperature Uniformity and Thermostat Accuracy*:

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

NOTE 5—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 of the griddle to a temperature of 375°F (191°C) as indicated by the temperature dial on the controls. Stabilize for 60 min after the burners or elements commence cycling at the thermostat set point.

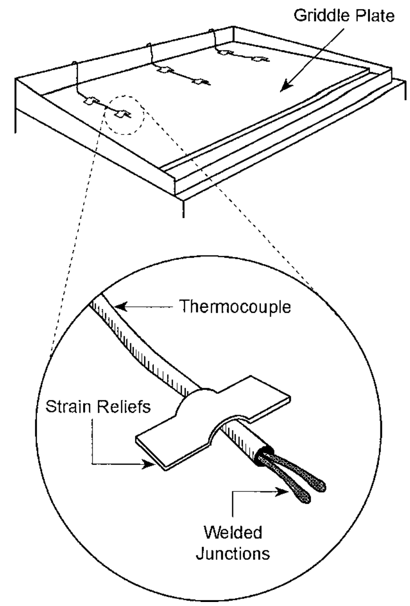


FIG. 1 Sample of Thermocouple Welding for a 3 by 2-ft (0.9 by 0.6-m) Griddle

10.3.3 Monitor the surface temperature over several complete cycles of the elements or burners, where applicable. Determine the average temperature for each thermostat location.

NOTE 6—Griddles equipped with modulating thermostat controls may not exhibit cycling clearly. Monitor the thermostat bulb temperatures for a minimum of 1 h in this case.

10.3.4 Where required (as indicated by the average temperature), adjust the griddle temperature controls to attain an actual average surface temperature of 375 ± 5°F (191 ± 2.8°C). Repeat the step given in 10.3.3 to confirm that the temperature at each sensing location is 375 ± 5°F (191 ± 2.8°C).

10.3.5 To facilitate further testing, mark on the dial the exact position of the thermostat control(s) that corresponds to an average surface temperature of 375°F (191°C).

10.3.6 Additional surface temperatures shall be measured with no more than 5 in. (127 mm) between adjacent measurement points. The additional points shall be no closer to the griddle edge than 1 in. (25 mm).

10.3.7 Record the maximum temperature difference on the griddle surface. The maximum difference is the highest average temperature minus the lowest average temperature at any point on the cooking surface not closer than 1 in. (25 mm) from the griddle edge.

NOTE 7—The additional measurement points on the 2 by 3-ft (0.6 by 0.9-m) griddle surface can be arranged most effectively in a 6 by 8 grid. This 48-point grid is spaced evenly across the surface and provides a good representation of the surface temperatures. A sample placement of the measurement points is shown in Fig. 2.

10.4 *Preheat Energy and Time*:

10.4.1 Tack-weld the thermocouples to the cooking surface directly above the thermostat sensing points as in 10.3.3.

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

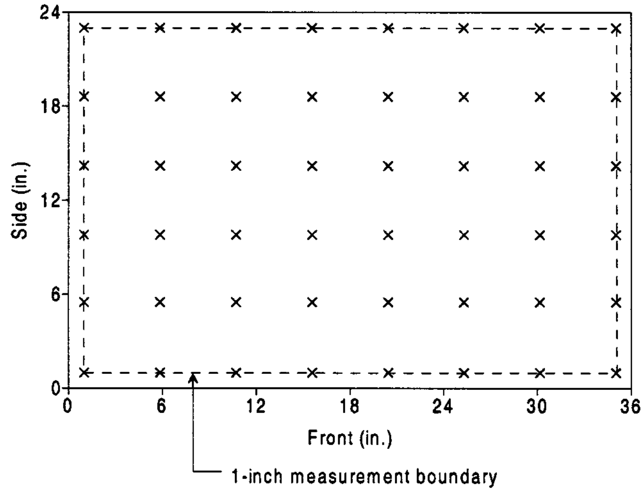


FIG. 2 Sample Placement of Thermocouples on a 3 by 2-ft (0.6 by 0.9-m) Griddle

10.4.3 Turn the griddle on with the temperature controls set to attain a surface temperature of 375°F (191°C), as determined in 10.3.

NOTE 8—The preheat test should be conducted prior to griddle operation on the day of the test.

10.4.4 Record the surface temperature at the monitored locations (10.4.3) at a minimum of 5-s intervals during the course of preheat.

10.4.5 Preheat is judged complete when the last of the monitored temperatures reaches 350°F (177°C). Record the energy and time to preheat all sections of the griddle jointly.

10.5 *Idle Energy Rate*:

10.5.1 Allow the cooking surface temperature to stabilize at 375°F (191°C) for at least 60 min after the last thermostat has commenced cycling at the set point.

10.5.2 Monitor the energy consumption of the griddle while it is operated under this idle condition for a minimum of 2 h.

10.6 *Pilot Energy Rate (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 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 (Hamburger Patties)*:

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 Verify the fat and moisture content of the hamburger patties in accordance with recognized laboratory procedures (AOAC Official Action 960.39 and Official Action 950.46B). Select hamburger patties (1 for every 15) randomly, and weigh them. Record the average weight of these samples to determine the total raw weight of each load.

10.7.3 Prepare patties 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 sheet of waxed freezer paper (Fig. 4). 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 griddle test area until the temperature of the patties has stabilized at the freezer temperature.

10.7.4 Monitor the temperature of the frozen patty with the thermocouple. Its internal temperature must reach 0 ± 5°F (−17.8 ± 2.8°C) before the hamburger patties can be removed from the freezer and loaded onto the griddle surface. Adjust the freezer temperature to achieve this required internal temperature (the typical freezer setting is −5°F (−21°C)) if necessary.

10.7.5 Prepare a minimum number of loads for three test runs, using the number of patties required for the loading scenario. Count on 7 to 10 loads per test run. Determine the number of patties for each loading scenario as follows:

10.7.5.1 *Heavy Loads*—A heavy load shall consist of one horizontal row of hamburger patties for every 5 in. (127 mm) of measured cooking surface depth. Each horizontal row shall consist of two patties per nominal 12 in. (305 mm) of griddle width. For example, a 3-ft (915-mm) griddle with a 24-in. deep cooking surface will require 24 patties per load, while a 3-ft (915-mm) griddle with a 30-in. deep cooking surface will require 36 patties per load for the heavy load tests.

10.7.5.2 *Light Load*—A light load shall consist of four patties positioned in the center of the cooking surface.

10.7.6 Tack-weld K-type thermocouples to the griddle cooking surface at the center of each linear foot, allowing one thermocouple for every 12 in. (30 cm) of griddle length (that is,

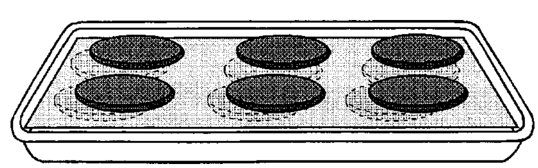


FIG. 3 Sample of Hamburger Patty Packaging

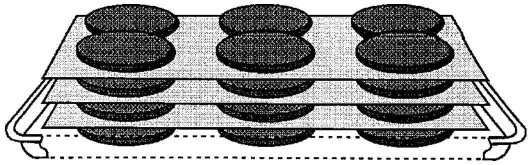


FIG. 4 Cutaway of Packaged Hamburger Patties

3 for a 24 by 36-in. (61 by 91-cm) griddle). For a 24 by 36-in. griddle, the locations are at 6, 18, and 30 in. (15, 46, and 76 cm) from the sides, centered front to back (Fig. 1).

10.7.7 Preheat the cooking surface to 375°F (191°C). Allow the cooking surface to stabilize at the set temperature for 1 h.

10.7.8 Load the patties sequentially on the griddle cooking surface over a 10-s time period for each linear foot of cooking surface (for example, 30 s for a 36-in. (76-cm) griddle and 40 s for a 48-in. (122-cm) griddle).

10.7.9 Cook the patties for 3.5 min on the first side, starting from the time the first hamburger patty is placed on the cooking surface. Do not sear or press the patties during cooking.

10.7.10 Turn the patties in the same order that they were loaded over a 10-s time period for each linear foot of cooking surface. Cook for an additional 2.5 min (including the time to flip hamburger patties). Do not sear or press the patties during cooking.

NOTE 9—Because mechanical searing varies from operator to operator, it is a difficult variable to specify and apply consistently. It has therefore been eliminated from the test procedure. It is recognized that this approach may establish cooking times that are in excess of the time that might be required using the same griddle in an actual food service operation. However, the objective is to determine cooking times and associated cooking energy efficiency values based on a procedure that decreases the bias from one laboratory to another. Cooking times determined for single-source (bottom) griddles using this procedure shall not be compared to cooking times for double-source (two-sided) griddles, as the "top" side inherently combines the searing (pressing) and heating process.

10.7.11 Remove the patties in the order placed on the unit over a 10-s time period for each linear foot of cooking surface.

10.7.12 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. 5), as long as the hamburger patties are within the specifications described in 7.1.

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 an additional minute. Calculate the weight loss using the average patty weight determined in 10.7.2. The percent weight loss shall be 35 ± 2 %.

10.7.14 If the percent weight loss is not 35 ± 2 %, repeat 10.7.8-10.7.13, adjusting the total cooking time to attain the 35 ± 2 % weight loss. Adjust the cooking time to attain even cooking on both sides of the patty (approximately 60 % of the total cooking time on the first side). Ensure that the griddle has recovered to 350°F (177°C) prior to reloading (all monitored points are at least 350°F (177°C)). Scrape the cooking surface during this recovery period as required and as time permits.

NOTE 11—Research at PG&E indicates that a griddle's cooking surface has recovered sufficiently to cook another load when the surface temperature recovers to within 25°F (14°C) of the set temperature (that is, 350°F (177°C) when the thermostats are set to maintain 375°F (191°C)).

10.7.15 Cook a load of patties (10.7.8-10.7.13), using the cooking time determined to produce medium-done patties. After removing the patties, allow a minimum of 10 s per linear foot of cooking surface to scrape the cooking surface and prepare for reloading. Reload the griddle when all monitored points have recovered to at least 350°F (177°C).

10.7.16 Remove each patty load 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 (−17.8 ± 2.8°C) loading temperature. *Do not hand-hold the patties until loading takes place*.

10.7.17 Run as many stabilization loads as necessary to stabilize the griddle response (that is, to maintain the 35 ± 2 % weight loss). Run an additional six loads after the 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 12—The test is invalid and must be repeated if the average weight loss for the six-load test is not 35 ± 2 %.

10.7.18 Allow the cooking surface to recover to the minimum 350°F (177°C) 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 13—The energy required to bring the griddle back up to temperature after removing the last load is considered part of the energy required by the cooking process.

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

10.7.20 Determine the moisture content of the cooked patties in accordance with recognized laboratory procedures (AOAC Official Action 950.46B), and calculate the moisture loss based on the initial moisture content of the patties (10.7.2). Use this value in the cooking energy efficiency calculation (11.9).

10.7.21 Perform Runs 2 and 3 by repeating 10.7.15-10.7.20. Follow the procedure in Annex A1 to determine whether more than three test runs is required.

10.7.22 Repeat 10.7.2-10.7.21 for each loading scenario (see Fig. 6 and Fig. 7).

11. Calculation and Report

11.1 *Test Griddle*:

11.1.1 Summarize the physical and operating characteristics of the 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 conforms to all of the specifications stated in Section 6. Describe any deviations from those specifications.

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

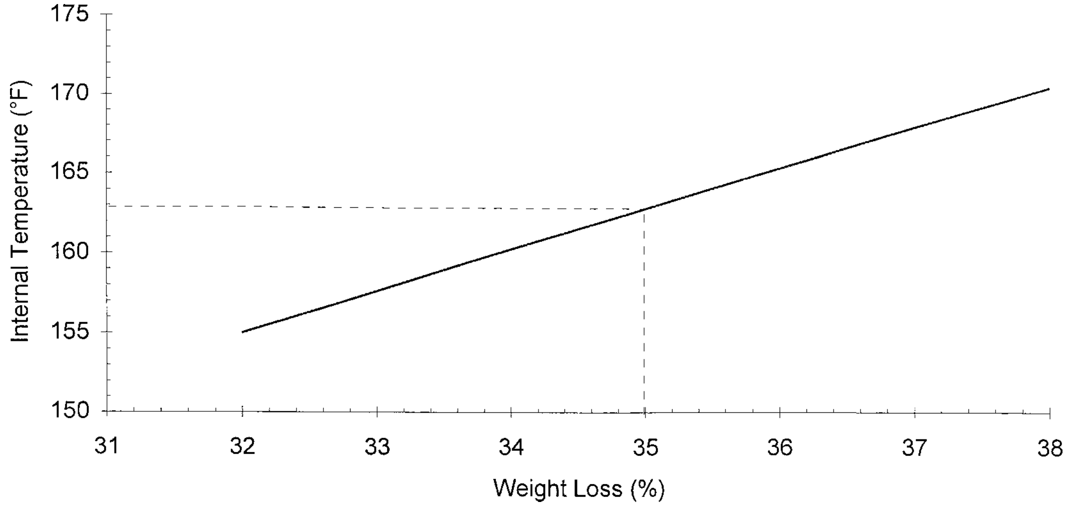
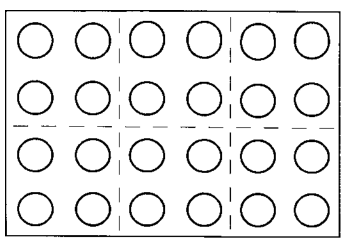


FIG. 5 Relationship Between the Bulk Internal Temperature and the Weight Loss of Cooked Hamburger Patties



All griddle sections on

FIG. 6 Patty Positions for Heavy-Load Tests on a 3 by 2-ft (0.6 by 0.9-m) Griddle Surface

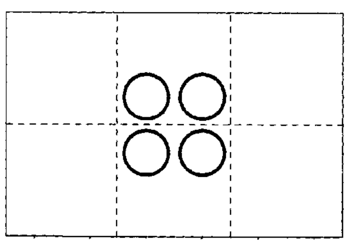


FIG. 7 Sample Placement of Hamburger Patties for Light-Load Tests on a 3 by 2-ft (0.6 by 0.9-m) Griddle Surface

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

11.3 *Gas Energy Calculations*:

11.3.1 For gas griddles, add the electric energy consumption to the 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

$$E_{gas} = V \times HV \tag{1}$$

where:

E_{gas} = energy consumed by the griddle,
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,

$$= \frac{\text{absolute standard gas temperature } °R\ (°K)}{\text{absolute actual gas temperature } °R\ (°K)},$$

$$= \frac{\text{absolute standard gas temperature } °R\ (°K)}{[\text{gas temp } °F\ (°C) + 459.67\ (273)]\ °R\ (°K)}, \text{ and}$$

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 14—The absolute standard gas temperature and pressure used in this calculation should be the same values used for determining the higher heating value. Standard conditions using Method D 3588 are 14.696 psia (101.33 kPa) and 60°F (519.67°R (288.71°K)).

11.4 *Energy Input Rate*:

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

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

$$q_{input} = \frac{E \times 60}{t} \tag{2}$$

where:

q_{input} = 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 Record and report discrepancies greater than 5°F (2.8°C) between the temperature indicated on the control and the measured average griddle temperature of 375°F (191°C) for each thermostat.

11.5.2 Report the average temperature at each additional temperature measurement location on a plan drawing of the griddle cooking surface. The maximum deviation between the average temperature at any measurement location on the cooking surface not closer than 1 in. (25 mm) from the edge of the cooking surface shall be noted and reported.

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 surface temperature 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

$$q_{idle} = \frac{E \times 60}{t} \tag{3}$$

where:
q_{idle} = 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

$$q_{pilot} = \frac{E \times 60}{t} \tag{4}$$

where:
q_{pilot} = 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*:

NOTE 15—The following sections describe the calculation process for cooking energy efficiency and production capacity. The average values of these parameters, along with the average cook times, energy consumption per pound of food cooked, and energy rate, are calculated based on a minimum of three test runs and then reported as described in A1.1.

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

$$\eta_{cook} = \frac{E_{food}}{E_{appliance}} \times 100 \tag{5}$$

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),
= $(W_i) \times (C_p) \times (T_f - T_i)$

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[7] 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,
= $2.595 \times W_{tl} + 71.98$.

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 as long as the hamburger patties are within the specifications described in 7.1. 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 the 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),
= $M_i \times W_i \times M_f \times W_f$

[7] *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.

where:

M_i = initial moisture content (by weight) of the raw hamburger patties, %,
W_i = initial weight of the raw hamburger patties, lb (kg),
M_f = final moisture content (by weight) of the cooked hamburger patties, %,
W_f = final weight of the cooked hamburger patties, lb (kg),

H_v = heat of vaporization, Btu/lb (kJ/kg),
= 970 Btu/lb (2256 kJ/kg) at 212°F (100°C), and
$E_{griddle}$ = energy into the griddle, Btu (kJ).

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

$$q_{cook} = \frac{E \times 60}{t} \tag{6}$$

where:

q_{cook} = 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 griddles.

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

$$q_{per\ pound} = \frac{E}{W} \tag{7}$$

where:

$q_{per\ pound}$ = 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).

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

$$PC = \frac{W \times 60}{t} \tag{8}$$

where:

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

11.9.5 Calculate the production rate (lb/h (kg/h)) for the medium- and light-load tests using the relationship from 11.9.4, where W = the total weight of food cooked during the test run, and t = the total time of the test run.

11.9.6 Determine the average surface temperature recovery time for the heavy- and light-load tests. Also 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 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 these test methods 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 procedures in this test method because there are no accepted reference values for the parameters reported.

13. Keywords

13.1 efficiency; energy; griddle; performance; 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 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.

A1.4 *Procedure:*

NOTE A1.2—The method of applying this procedure is given in Note A1.5.

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.

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

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

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:

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

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 A1.3—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 A1.4—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:

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

$$U_3 = C_3 \times S_3, \quad \text{(A1.3)}$$
$$U_3 = 2.48 \times S_3$$

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:

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

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:

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

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:

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

where:

S_4 = standard deviation of the 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:

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

$$U_4 = 1.59 \times S_4$$

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:

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

where:
n = number of test runs,
Xa_n = average of the results for *n* test runs, and
$X_1, X_2, X_3, X_4, ... X_n$ = 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 = $(X_1)^2 + (X_2)^2 + (X_3)^2 + (X_4)^2 + ... + (X_n)^2$, and
B_n = $(1/n) \times (X_1 + X_2 + X_3 + X_4 + ... + X_n)^2$.

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 ±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 A1.5—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 these test methods. 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 these test methods to ensure that all results are obtained under approximately the same conditions.

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 (kg/h)
Run No. 1	33.8 (15.3)
Run No. 2	34.1 (15.5)
Run No. 3	31.0 (14.1)

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

A1.5.2.1 The average of the three test results is as follows:

$$Xa_3 = (1/3) \times (X_1 + X_2 + X_3), \quad (A1.13)$$

$$Xa_3 = (1/3) \times (33.8 + 34.1 + 31.0),$$

$$Xa_3 = 33.0 \text{ lb/h } (15 \text{ kg/h})$$

A1.5.2.2 The standard deviation of the three test results is as follows. First calculate A_3 and B_3:

$$A_3 = (X_1)^2 + (X_2)^2 + (X_3)^2, \quad (A1.14)$$

$$A_3 = (33.8)^2 + (34.1)^2 + (31.02)^2,$$

$$A_3 = 3266$$

$$B_3 = (1/3) \times [(X_1 + X_2 + X_3)^2],$$

$$B_3 = (1/3) \times [(33.8 + 34.1 + 31.0)^2],$$

$$B_3 = 3260$$

A1.5.2.3 The new standard deviation for the PC is as follows:

$$S_3 = (1/\sqrt{2}) \times \sqrt{(3266 - 3260)}, \quad (A1.15)$$

$$S_3 = 1.71 \text{ lb/h } (0.77 \text{ kg/h})$$

A1.5.3 *Step 2*—Calculate the uncertainty in average:

$$U_3 = 2.48 \times S_3, \quad (A1.16)$$

$$U_3 = 2.48 \times 1.71,$$

$$U_3 = 4.24 \text{ lb/h } (1.92 \text{ kg/h})$$

A1.5.4 *Step 3*—Calculate percent uncertainty:

$$\% U_3 = (U_3/Xa_3) \times 100\,\%, \qquad (A1.17)$$

$$\% U_3 = (4.24/33.0) \times 100\,\%,$$

$$\% U_3 = 12.9\,\%$$

A1.5.5 *Step 4*—Run a fourth test. The precision requirement has not been satisfied since the percent uncertainty for the production capacity is greater than ±10 %. An additional test is run in an attempt to reduce the uncertainty. The PC from the fourth test run was 32.5 lb/h (14.7 kg/h).

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

A1.5.6.1 The new average PC is as follows:

$$Xa_4 = (1/4) \times (X_1 + X_2 + X_3 + X_4), \qquad (A1.18)$$

$$Xa_4 = (1/4) \times (33.8 + 34.1 + 31.0 + 32.5),$$

$$Xa_4 = 32.9 \text{ lb/h } (14.9 \text{ kg/h})$$

A1.5.6.2 The new standard deviation is as follows. First calculate A_4 and B_4:

$$A_4 = (X_1)^2 + (X_2)^2 + (X_3)^2 + (X_4)^2, \qquad (A1.19)$$

$$A_4 = (33.8)^2 + (34.1)^2 + (31.0)^2 + (32.5)^2,$$

$$A_4 = 4323$$

$$B_4 = (1/4) \times [(X_1 + X_2 + X_3 + X_4)^2],$$

$$B_4 = (1/4) \times [(33.8 + 34.1 + 31.0 + 32.5)^2],$$

$$B_4 = 4316$$

A1.5.6.3 The new standard deviation for the PC is as follows:

$$S_4 = (1/\sqrt{3}) \times \sqrt{(4323 - 4316)}, \qquad (A1.20)$$

$$S_4 = 1.42 \text{ lb/h } (0.64 \text{ kg/h})$$

A1.5.7 *Step 6*—Recalculate the absolute uncertainty using the new standard deviation and uncertainty factor:

$$U_4 = 1.59 \times S_4, \qquad (A1.21)$$

$$U_4 = 1.59 \times 1.42,$$

$$U_4 = 2.25 \text{ lb/h } (1.02 \text{ kg/h})$$

A1.5.8 *Step 7*—Recalculate the percent uncertainty using the new average:

$$\% U_4 = (U_4 / Xa) \times 100\,\%, \qquad (A1.22)$$

$$\% U_4 = (2.25/32.9) \times 100\,\%,$$

$$\% U_4 = 6.8\,\%$$

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 follows:

$$PC = 32.9 \pm 2.25 \text{ lb/h } (14.9 \pm 1.02 \text{ kg/h}) \qquad (A1.23)$$

The production capacity can be reported assuming that 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.

APPENDIXES

(Nonmandatory Information)

X1. RESULTS REPORTING SHEETS

X1.1 Refer to the following example.

Manufacturer ______________________

Model ______________________

Date __________

Test Reference Number (optional) __________

Section 11.1 Test Griddle

Description of operational characteristics: ______________________

Section 11.2 Apparatus

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

Deviations ______________________

Section 11.4 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 11.5 Temperature Uniformity and Thermostat Accuracy

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

Thermostat #1 _____

Thermostat #2 (if required) _____

Thermostat #3 (if required) _____

Thermostat #4 (if required) _____

Thermostat #5 (if required) _____

Thermostat #6 (if required) _____

Average Cooking Surface Temperatures

Section 11.6 Preheat Energy and Time

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

Section 11.7 Idle Energy Rate

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

Section 11.8 Pilot Energy Rate (if applicable)

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

Section 11.9 Cooking Energy Efficiency and Cooking Energy Rate

Heavy Load:

Test Voltage (V)		________	
Gas Heating Value (Btu/ft^3(kJ/m^3))		________	
Number of patties per load			________
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/ft^3 (kJ/m^3))	________	
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 in the test method.

X2.4 *Procedure*:

NOTE X2.1—Sections X2.5 and X2.6 show how to apply this 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 lbs 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.

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.

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:

$$q_{avg} = \frac{E_{elec,daily}}{t_{on}} \tag{X2.9}$$

NOTE X2.2—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.

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.

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

$$C_{gas,monthly} = r_{gas} \times \frac{E_{gas,daily}}{100\,000 \frac{\text{Btu}}{therm}} \times d_{op} \tag{X2.10}$$

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

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.

X2.5 *Example of Calculating the Daily Energy Consumption for an Electric Griddle*:

X2.5.1 Application of the test method to an electric griddle yielded the results shown in Table X2.1.

X2.5.2 *Step 1*—The appliance operation as shown in Table X2.2 is assumed:

X2.5.3 *Step 2*—Calculate the total heavy-load energy.

X2.5.3.1 The total time cooking heavy-loads is as follows:

$$t_h = \frac{\%h \times W}{PC} \tag{X2.12}$$
$$t_h = \frac{70\ \% \times 100\ \text{lb}}{36\ \text{lb/h}}$$
$$t_h = 1.94\ \text{h}$$

X2.5.3.2 Then, calculate the total heavy-load energy consumption as follows:

$$E_{elec,h} = q_{elec,h} \times t_h \tag{X2.13}$$
$$E_{elec,h} = 7.0\ \text{kW} \times 1.94\ \text{h}$$
$$E_{elec,h} = 13.6\ \text{kWh}$$

X2.5.4 *Step 3*—Calculate the total light-load energy.

X2.5.4.1 The total time cooking light loads is as follows:

$$t_l = \frac{\%l \times W}{PR_l} \tag{X2.14}$$
$$t_l = \frac{30\ \% \times 100\ \text{lb}}{7\ \text{lb/h}}$$
$$t_l = 4.29\ \text{h}$$

X2.5.4.2 Then, calculate the total light-load energy consumption as follows:

TABLE X2.1 Electric Griddle Test Results—Example

Test	Result
Preheat time	12.0 min
Preheat energy	2.2 kWh
Idle energy rate	2.5 kW
Heavy-load cooking energy rate	7.0 kW
Light-load cooking energy rate	2.1 kW
Production capacity	36 lb/h
Light-load production rate	7 lb/h

TABLE X2.2 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)

$$E_{elec,l} = q_{elec,l} \times t_l \quad (X2.15)$$

$$E_{elec,l} = 2.1 \text{ kW} \times 4.29 \text{ h}$$

$$E_{elec,l} = 9.0 \text{ kWh}$$

X2.5.5 *Step 4*—Calculate the total idle time and energy consumption.

X2.5.5.1 Determine the total idle time as follows:

$$t_i = t_{on} - t_h - t_l - \frac{n_p \times t_p}{60} \quad (X2.16)$$

$$t_i = 12.0 \text{ h} - 1.94 \text{ h} - 4.29 \text{ h} - \frac{1 \text{ preheat} \times 12.0 \text{ min}}{60 \text{ min/h}}$$

$$t_i = 5.57 \text{ h}$$

X2.5.5.2 Then, calculate the idle energy consumption as follows:

$$E_{elec,i} = q_{elec,i} \times t_i \quad (X2.17)$$

$$E_{elec,i} = 2.5 \text{ kW} \times 5.57 \text{ h}$$

$$E_{elec,i} = 13.9 \text{ kWh}$$

X2.5.6 *Step 7*—Calculate the total daily energy consumption as follows:

$$E_{elec,daily} = E_{elec,h} + E_{elec,l} + E_{elec,i} + n_p \times E_{elec,p} \quad (X2.18)$$

$$E_{elec,daily} = 13.6 \text{ kWh} + 9.0 \text{ kWh} + 13.9 \text{ kWh} + 1 \times 2.2 \text{ kWh}$$

$$E_{elec,daily} = 38.7 \text{ kWh/day}$$

X2.5.7 *Step 6*—Calculate the average demand as follows:

$$q_{avg} = \frac{E_{elec,daily}}{t_{on}} \quad (X2.19)$$

$$q_{avg} = \frac{38.7 \text{ kWh}}{12.0 \text{ h}}$$

$$q_{avg} = 3.23 \text{ kW}$$

X2.6 *Example of Calculating the Daily Energy Consumption for a Gas Griddle*:

X2.6.1 Application of the test method to a gas griddle yielded the results in Table X2.3.

X2.6.2 *Step 1*—The appliance operation as shown in Table X2.4 is assumed.

X2.6.3 *Step 2*—Calculate the total heavy-load energy.

TABLE X2.3 Gas Griddle Test Results—Example

Test	Result
Preheat time	14.0 min
Preheat energy	18 000 Btu
Idle energy rate	17 000 Btu/h
Heavy-load cooking energy rate	52 000 Btu/h
Light-load cooking energy rate	18 000 Btu/h
Production capacity	35 lb/h
Light-load production rate	6 lb/h

TABLE X2.4 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)

X2.6.3.1 The total time cooking heavy loads is as follows:

$$t_h = \frac{\%h \times W}{PC} \quad (X2.20)$$

$$t_h = \frac{70 \% \times 100 \text{ lb}}{35 \text{ lb/h}}$$

$$t_h = 2.00 \text{ h}$$

X2.6.3.2 Then, calculate the total heavy-load energy consumption as follows:

$$E_{gas,h} = q_{gas,h} \times t_h \quad (X2.21)$$

$$E_{gas,h} = 52\,000 \text{ Btu/h} \times 2.00 \text{ h}$$

$$E_{gas,h} = 104\,000 \text{ Btu}$$

X2.6.4 *Step 3*—Calculate the total light load energy.

X2.6.4.1 The total time cooking light loads is as follows:

$$t_l = \frac{\%l \times W}{PRl} \quad (X2.22)$$

$$t_l = \frac{30 \% \times 100 \text{ lb}}{6 \text{ lb/h}}$$

$$t_l = 5.00 \text{ h}$$

X2.6.4.2 Then, calculate the total light-load energy consumption as follows:

$$E_{gas,l} = q_{gas,l} \times t_l \quad (X2.23)$$

$$E_{gas,l} = 18\,000 \text{ Btu/h} \times 5.00 \text{ h}$$

$$E_{gas,l} = 90\,000 \text{ Btu}$$

X2.6.5 *Step 4*—Calculate the total idle time and energy consumption.

X2.6.5.1 Determine the total idle time as follows:

$$t_i = t_{on} - t_h - t_l - \frac{n_p \times t_p}{60} \quad (X2.24)$$

$$t_i = 12.0 \text{ h} - 2.00 \text{ h} - 5.00 \text{ h} - \frac{1 \text{ preheat} \times 14.0 \text{ min}}{60 \text{ min/h}}$$

$$t_i = 4.77 \text{ h}$$

X2.6.5.2 Then, calculate the idle energy consumption as follows:

$$E_{gas,i} = q_{gas,i} \times t_i \quad (X2.25)$$

$$E_{gas,i} = 17\,000 \text{ Btu/h} \times 4.77 \text{ h}$$

$$E_{gas,i} = 81\,090 \text{ Btu}$$

X2.6.6 *Step 5*—Calculate the total daily energy consumption as follows:

$$E_{gas,daily} = E_{gas,h} + E_{gas,l} + E_{gas,i} + n_p \times E_{gas,p} \quad (X2.26)$$

$$E_{gas,daily} = 104\,000 \text{ Btu} + 90\,000 \text{ Btu} + 81\,090 \text{ Btu} + 1 \times 18\,000 \text{ Btu}$$

$$E_{gas,daily} = 293\,090 \text{ Btu/day} = 2.93 \text{ therms/day}$$