Standard Test Method for Performance of Braising Pans[1]

This standard is issued under the fixed designation F 1786; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method evaluates the energy consumption and cooking performance of braising pans. The food service operator can use this evaluation to select a braising pan and understand its energy consumption and performance characteristics.

NOTE 1—Braising pans also are commonly referred to as tilting skillets. This test method uses the term *braising pan* in accordance with Specification F 1047.

1.2 This test method is applicable to self-contained gas or electric braising pans. The braising pan can be evaluated with respect to the following, where applicable:

1.2.1 Maximum energy input rate (10.2).

1.2.2 Capacity (10.3).

1.2.3 Heatup energy efficiency and energy rate (10.4).

1.2.4 Production capacity (10.4).

1.2.5 Simmer energy rate (10.5).

1.2.6 Surface temperature uniformity, optional, (10.6).

1.2.7 Pilot energy rate (10.7).

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

1.4 *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]

F 1047 Specification for Frying and Braising Pans, Tilting Type

F 1275 Test Methods for the Performance of Griddles

2.2 *ANSI Standard:*

ANSI Z83.14 Gas Food Service Equipment—Counter Appliances[2]

2.3 *ASHRAE Documents:*[3]

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

ASHRAE *Handbook of Fundamentals*, "Thermodynamic Properties of Water at Saturation," Chapter 6, Table 2, 1989

3. Terminology

3.1 *Definitions:*

3.1.1 *braising pan*, *n*—an appliance wherein heat is imparted to food in a shallow-sided flat-bottomed vessel by conduction through the heated pan bottom.

3.1.2 *control electric energy*, *n*—the electric energy, for example, for controls, fans, consumed by braising pans whose primary fuel source is not electricity, that is, gas. Control electric energy is measured and reported separately from primary fuel energy so that their respective fuel prices can be applied to estimate energy costs.

3.1.3 *fill-to-spill capacity*, *n*—the maximum food capacity (gal) of the braising pan as determined by filling to the point of overflow.

3.1.4 *heatup energy*, *n*—energy consumed by the braising pan as it is used to heat the specified food product to a specified temperature.

3.1.5 *heatup energy efficiency*, *n*—a quantity of energy imparted to the specified food product, expressed as a percentage of energy consumed by the braising pan during the heatup event.

3.1.6 *heatup energy rate*, *n*—the average rate of energy consumption (kBtu/h or kW) during the heatup energy efficiency test.

3.1.7 *maximum energy input rate*, *n*—the peak rate (kBtu/h or kW) at which a braising pan consumes energy, as measured in this test method.

3.1.8 *nameplate energy input rate*, *n*—the peak rate (kBtu/h or kW) at which a braising pan consumes energy, as stated by the manufacturer.

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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 Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), 1791 Tullie Circle, NE, Atlanta, GA 30329.

3.1.9 *nameplate capacity*, *n*—the food capacity (gal) of the braising pan, as stated by the manufacturer.

3.1.10 *pilot energy rate*, *n*—the rate of energy consumption (kBtu/h) by a gas braising pan's standing pilot, where applicable.

3.1.11 *production capacity*, *n*—the highest rate (lb/h) at which a braising pan can bring the specified food product to a specified temperature.

3.1.12 *simmer energy rate*, *n*—the rate (kBtu/h or kW) at which a braising pan consumes energy while maintaining the specified food product at a specified simmer temperature.

3.1.13 *surface temperature uniformity*, *n*—the variation in cooking surface temperature measured at several points across the pan bottom.

3.1.14 *testing capacity*, *n*—the capacity (gal) at which the braising pan is operated during the heatup and simmer tests, that is, 80 % of fill-to-spill capacity.

4. Summary of Test Method

4.1 Connect the braising pan to the appropriate metered energy source, and determine the energy input rate to confirm that it is operating within 5 % of the nameplate energy input rate.

4.2 Fill the braising pan to the point of overflow to determine the fill-to-spill capacity. For subsequent tests, a smaller volume or testing capacity, is calculated to allow adequate freeboard between the waterline and the lip of the pan.

4.3 Set the braising pan to maximum input and monitor as it heats water from 80°F to 160°F, which yields the heatup energy efficiency, heatup energy rate, and production capacity.

4.4 Adjust the braising pan controls to maintain water at 165°F for 3 h, yielding the simmer energy rate.

4.5 Monitor the surface temperature of the pan at several points to determine temperature uniformity (optional).

4.6 When applicable, measure the energy required to maintain the standing pilot for a gas appliance, and report pilot energy rate.

5. Significance and Use

5.1 Use the maximum energy input rate test to confirm that the braising pan is operating within 5 % of the manufacturer's rated input so that testing may continue. This test method also may disclose any problems with the electric power supply or gas service pressure. The maximum input rate can be useful to food service operators for managing power demand.

5.2 The capacity test determines the maximum volume of food product the pan can hold and the amount of food product that will be used in subsequent tests. Food service operators can use the results of this test method to select a braising pan, which is appropriately sized for their operation.

5.3 Production capacity is used by food service operators to choose a braising pan that matches their food output.

5.4 Heatup energy efficiency and simmer energy rate allow the operator to consider energy performance when selecting a braising pan.

5.5 Use the surface temperature uniformity to select a braising pan suitable for griddling applications.

5.6 Use the pilot energy rate to estimate energy consumption for gas-fired braising pans with standing pilots during non-cooking periods.

6. Apparatus

6.1 *Analytical Balance Scale*, for measuring weights up to 25 lb with a resolution of 0.01 lb and an uncertainty of 0.01 lb, for measuring the quantity of water loaded into the pan.

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

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

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

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

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

6.7 *Strain Gage Welder*[4], capable of welding thermocouples to steel.

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

6.9 *Thermocouples*, fiberglass insulated, 24-gage, Type K thermocouple sire, peened flat at the exposed ends and spot welded to surfaces with a strain gage welder.

6.10 *Thermocouple Probe*, industry standard Type T or Type K thermocouples capable of immersion with a range from 50 to 250°F and an uncertainty of ±1°F.

6.11 *Watt-Hour Meter*, for measuring the electrical energy consumption of a braising pan, having a resolution of at least 1 Wh and a maximum uncertainty no greater than 1.5 % of the measured value for any demand greater than 100 W. For any demand less than 100 W, the meter shall have a resolution of at least 1 Wh and a maximum uncertainty no greater than 10 %.

7. Reagents and Materials

7.1 *Water*, from municipal water supply or other potable source.

[4] The sole source of supply of the apparatus known to the committee at this time is Eaton Model W1200 Strain Gage Welder, available from Eaton Corp., 1728 Maplelawn Rd., 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.

8. Sampling

8.1 *Braising Pan*—Select a representative production model for performance testing.

9. Preparation of Apparatus

9.1 Install the appliance in accordance with the manufacturer's instructions under a 4-ft deep canopy exhaust hood mounted against the wall, with the lower edge of the hood 6 ft, 6 in. from the floor. Position the braising pan with the front edge of the pan body inset 6 in. from the front edge of the hood at the manufacturer's recommended working height. The length of the exhaust hood and active filter area shall extend a minimum of 6 in. past both sides of the pan body. In addition, both sides of the appliance shall be a minimum of 3 ft from any side wall, side partition, or other operating appliance. The exhaust ventilation rate shall be 300 cfm/linear ft of hood length. The application of a longer hood is acceptable, provided the ventilation rate is maintained at 300 cfm/linear ft over the entire length of the active hood. The associated heating or cooling system shall be capable of maintaining an ambient temperature of 75 ± 5°F within the testing environment when the exhaust ventilation system is operating.

9.2 Connect the braising pan 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 instrumentation to record both the pressure and temperature of the gas supplied to the braising pan 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 braising pan, during maximum energy input, adjust 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 appliance 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 braising pan, while the elements are energized, confirm 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 testing procedure herein to evaluate the performance of a braising pan 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 braising pan is designed to operate at two voltages without a change in the resistance of the heating elements, the performance of the unit, for example, preheat time, may differ at the two voltages.

9.5 Determine the control settings necessary to maintain a stable "simmer" temperature in the pan averaging 165 ± 1°F. If necessary, identify these control positions with a mark so that the tester may quickly adjust the pan between heatup and simmer tests.

10. Procedures

10.1 *General*:

10.1.1 If the braising pan is equipped with a lid, all tests shall be conducted with the lid removed or fully raised.

10.1.2 Optionally, all tests may be repeated with the lid closed and the braising pan reevaluated as a separate appliance.

NOTE 3—PG & E found that the simmer energy rate is reduced by as much as 50 % when the braising pan is evaluated with the lid down.

10.1.3 For gas braising pans, the following shall be obtained and recorded for each test run: higher heating value; standard gas pressure and temperature used to correct measured gas volume to standard conditions; measured gas temperature; measured gas pressure; barometric pressure; ambient temperature; and, energy input rate during or immediately prior to test.

NOTE 4—The preferred method for determining the heating value of gas supplied to the braising pan under test is by using a calorimeter or gas chromatograph in accordance with accepted laboratory procedures. It is recommended that all testing be performed with gas with a heating value between 1000 and 1075 Btu/ft^3.

10.1.4 For gas braising pans, control electric energy consumption also shall be measured and added to gas energy for all tests, with the exception of the maximum energy input rate test (see 10.2).

NOTE 5—If it is clear that the control electric energy consumption rate is constant during a test, an instantaneous power measurement can be made when convenient during the test, rather than continuous monitoring of accumulated energy consumption. Energy can be estimated later, based on the power measurement and the duration of the test.

10.1.5 For electric braising pans, the following shall be obtained and recorded for each run of every test; voltage while elements are energized; measured peak input rate during or immediately prior to test; and, ambient temperature.

10.1.6 For each run of every test, confirm that the peak input rate is within ±5 % of rated nameplate input or power. Terminate testing and contact the manufacturer if the difference is greater than 5 %. The manufacturer may make appropriate changes or adjustments to the braising pan.

10.2 *Maximum Energy Input Rate*:

10.2.1 Fill the braising pan with water. It is not necessary to measure the amount. Set the controls to full input and start the pan. Operate the pan at maximum input for 10 min.

NOTE 6—The 10-min stabilization period allows the burner orifices to expand in a gas appliance and the elements to heat up in an electric appliance, both of which may affect the energy input rate.

10.2.2 Continue to operate the pan at full input. Record time and energy consumption for 15 min. If the appliance is a gas braising pan, do not include control electrical energy in the energy consumption total.

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

10.3 *Capacity*:

10.3.1 Fill the pan with water to the point of overflow and record the quantity as the fill-to-spill capacity.

10.3.2 Calculate and record the testing capacity as 80 % of the fill-to-spill capacity, for example, a pan with a 40-gal fill-to-spill capacity would have a testing capacity of 80 % × 40 = 32 gal.

10.4 *Heatup Energy Efficiency, Heatup Energy Rate, and Production Capacity*:

10.4.1 The pan shall initially be at room temperature. Fill the pan to testing capacity ±1 % with 70 ± 2°F water. Position a thermocouple probe at the geometric center of the water. The same probe will be used for all subsequent heatup and simmer tests.

10.4.2 Set the appliance controls to full input and turn the braising pan on.

10.4.3 When the temperature passes 80.0°F, commence recording time, water temperature, and energy consumption.

10.4.4 When the temperature passes 160.0°F, turn off the pan. Record final time, water temperature, and energy consumption.

10.5 *Simmer Energy Rate*:

10.5.1 Fill the pan to its testing capacity ±1 % with water. If this test method is run immediately after a heatup test, it is not necessary to adjust the water level. Turn the braising pan on and set the controls so that the pan maintains the water at an average temperature of 165 ± 1°F.

10.5.2 Allow the water temperature to stabilize before proceeding. When the temperature has averaged 165 ± 1°F for several cycles, commence monitoring time, temperature, and energy consumption. Monitoring shall begin as a heating cycle ends, for example, when the burners or elements cycle off.

10.5.3 Continue monitoring for 3 h, then turn the pan off at the end of a heating cycle. If the burners or elements are on at the 3-h mark, continue until they cycle off, then record final time and energy consumption. If the burners or elements are off at the 3-h mark, continue monitoring until they cycle on, and record time and energy consumption at the end of that cycle.

10.6 *Surface Temperature Uniformity (optional)*:

10.6.1 Contact the manufacturer of the braising pan to confirm that the pan may be heated dry at 375°F for 3 h without damaging the pan. Do not proceed with this section unless the manufacturer states that the appliance can operate safely in this manner.

10.6.2 Conduct the surface temperature uniformity test as described in Test Methods F 1275.

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

10.7.1 Where applicable, set the gas valve that controls gas supply to the appliance at the "pilot" position. Otherwise, set the braising pan controls to the "off" position.

10.7.2 Light and adjust pilots in accordance with the manufacturer's instructions. Record the time and meter reading.

10.7.3 Record the elapsed time and gas meter reading after a minimum of 8 h of pilot operation.

11. Calculation and Report

11.1 *Test Braising Pan*—Using Specification F 1047, summarize the physical and operating characteristics of the braising pan. Use additional text to describe any design characteristics that may facilitate interpretation of the test results.

11.2 *Apparatus and Procedure*:

11.2.1 Report the status of the appliance as "lid up" if the braising pan did not have a lid or the lid was not used during the tests. Report the status of the appliance as "lid down" if a lid was used.

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

11.2.3 Report whether the optional surface temperature uniformity test was performed.

11.3 *Gas Energy Calculations*:

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

11.3.2 For gas braising pans, energy consumed (E_{input}) shall be calculated using the following formula:

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

where:

HV = higher heating value,
= energy content of gas measured at standard conditions (Btu/ft^3 × °F (kJ/m^3 × °C)), and

V = actual volume of gas corrected to standard conditions (ft^3(m^3)).

$$V_{meas} \times T_{cf} \times P_{cf} \tag{2}$$

where:

V_{meas} = measured volume of gas (ft^3 (m^3))

T_{cf} = temperature correction factor,

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

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

P_{cf} = pressure correction factor

$$= \frac{\textit{actual gas pressure}\text{ psia, (kPa)}}{\textit{standard pressure}\text{ psia, (kPa)}}$$

$$= \frac{\textit{gas gage pressure}\text{, psi (kPa)} + \textit{barometric pressure}\text{, psi (kPa)}}{\textit{standard pressure}\text{, psia (kPa)}}$$

NOTE 7—Standard gas temperature and pressure used in this calculation should be the same values used for determining of the heating value. PG & E standard conditions are 519.67°R (288.56°K) and 14.73 psia (101.5 kPa).

11.4 *Testing Capacity*—Report the testing capacity for the pan (gal) as:

$$C_{test} = 0.90 \times C_{spill} \tag{3}$$

where:

C_{test} = testing capacity of the braising pan, gal, and

C_{spill} = measured fill-to-spill capacity of the pan (10.3.1), gal.

11.5 *Maximum Energy Input Rate*:

11.5.1 Report the manufacturer's rated input in Btu/h for a gas braising pan and kW for an electric braising pan.

11.5.2 For gas braising pans, calculate and report the maximum energy input rate (Btu/h (kJ/h)) based on the energy consumed by the braising pan during the input period in accordance with the following relationship:

$$\textit{maximum energy input rate}\ (\text{Btu/h(kJ/h)}) = \frac{E_{input}\ (\text{Btu (kJ)}) \times 60\ (\text{min/h})}{\text{input time (min)}} \quad (4)$$

11.5.3 For electric braising pans, report the measured maximum energy input rate (kW).

11.6 *Heatup Energy Efficiency and Heatup Energy Rate*:

11.6.1 Calculate and report the heatup energy efficiency for heatup tests based on:

$$\eta_{heatup} \frac{E_{water}}{E_{pan}} \times 100 \quad (5)$$

where:

η_{heatup} = heatup energy efficiency, %, and
E_{water} = energy into water, Btu.

$$(T_f - T_i) \times W_{water} \times (1\ \text{Btu/lb} \times {}^\circ\text{F}) \quad (6)$$

where:

T_f = final temperature of water, °F,
T_i = initial temperature of water,° F,
W_{water} = weight of water, lb,
= gallons of water × 8.35 lb/gal, and
E_{pan} = energy consumed by the braising pan, Btu.

11.6.2 Calculate and report the heatup energy rate as follows:

$$HR = \frac{E_{pan}}{t} \times 60 \quad (7)$$

where:

HR = energy input rate during the 80 to 160°F heatup interval, Btu/h,
E_{pan} = energy into the appliance over the same interval, Btu, and
t = time required to heat the water from 80°F to 160°F, min.

11.6.3 Calculate and report the production capacity as lb/h of water that can be heated from 80°F to 160°F:

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

where:

PC = production capacity of the braising pan, lb/h,
W = total weight of water in the pan, and
t = time required to heat the water from 80°F to 160°F, min.

11.7 *Simmer Energy Rate*—Calculate and report the simmer energy rate as follows:

$$SR = \frac{E_{pan}}{t} \times 60 \quad (9)$$

where:

SR = energy input rate during the nominal 3-h simmer, Btu/h,
E_{pan} = energy into the appliance over the same interval, Btu, and
t = actual length of the simmer, min.

11.8 *Surface Temperature Uniformity*—Report the average temperature at each additional temperature measurement location on a plan drawing of the pan bottom. Report the maximum deviation between the average temperatures at any measurement location on the pan surface not closer than 3 in. from the pan sides.

11.9 *Pilot Energy Rate*—Calculate and report the energy input rate (Btu/h (kJ/h) or kW) based on the energy consumed by the braising pan during the pilot test period in accordance with the following relationship:

$$\textit{pilot energy rate}\ (\text{Btu/h (kJ/h) or kW}) = \frac{\textit{pilot energy consumption}\ (\text{Btu (kJ) or kWh}) \times 60}{\textit{pilot test time}\ (\text{min})} \quad (10)$$

12. Precision and Bias

12.1 *Precision*:

12.1.1 *Repeatability (Within Laboratory, Same Operator and Equipment)*—The repeatability of each reported parameter is being determined.

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

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

13. Keywords

13.1 braising pan; energy efficiency; performance; production capacity; temperature uniformity; test method; 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 only should be applied to test results that have been obtained within the tolerances prescribed in this test method, for example, thermocouples calibrated, appliance operating within 5 % of rated input during the test run.

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

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

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

A1.4 *Procedure*—Section A1.5 shows how to apply this procedure.

A1.4.1 *Step 1*—Calculate the average and the standard deviation for the test result (heatup energy efficiency, production capacity, or simmer energy rate) 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:

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

where:

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

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

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

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 A1.2—The formulas may be used to calculate the average and sample standard deviation. A calculator with statistical function is recommended, however, 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:

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

$$U_3 = 2.48 \times S_3$$

where:

U_3 = absolute uncertainty in average for three test runs, and
C_3 = uncertainty factor for three test runs (Table A1.1).

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

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

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

where:

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

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

$$Xa_3 \pm U_3 \quad \text{(A1.5)}$$

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

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

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

A1.4.6 *Step 6*—When a fourth test is run for a given parameter, 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:

$$Xa_4 = (1/4) \times (X_1 + X_2 + X_3 + X_4) \quad \text{(A1.6)}$$

where:

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

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

$$S_4 = (1/\sqrt{3}) \times \sqrt{(A_4 - B_4)} \quad \text{(A1.7)}$$

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

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

$$U_4 = C_4 \times S_4 \quad \text{(A1.8)}$$
$$U_4 = 1.59 \times S_4$$

where:

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

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

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

$$\% U_4 = (U_4/Xa_4) \times 100 \% \quad \text{(A1.9)}$$

where:

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

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

$$Xa_4 \pm U_4 \quad \text{(A1.10)}$$

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

A1.4.10 *Step 10*—The steps required for five or more test runs are the same as those described above. More general formulas are listed as follows 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:

$$Xa_n = (1/n) \times (X_1 + X_2 + X_3 + X_4 + ... + X_n) \quad \text{(A1.11)}$$

where:

n = number of test runs,
Xa_n = average of results 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:

$$S_n = (1/\sqrt{(n-1)}) \times (\sqrt{(A_n - B_n)}) \quad \text{(A1.12)}$$

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:

$$U_n = C_n \times S_n \quad \text{(A1.13)}$$

where:

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

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

$$\% U_n = (U_n/Xa_n) \times 100 \% \quad \text{(A1.14)}$$

where:

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

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

$$Xa_n \pm U_n \quad \text{(A1.15)}$$

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 there is some physical evidence that the test run was not performed in accordance with the conditions specified in this test method. For example, a thermocouple is out of calibration, the appliance's input capacity is not within 5 % of the rated input, or the food product is not within specification. To ensure that all results are obtained under approximately the same conditions, it is good practice to monitor those test conditions specified in this test method.

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

A1.5.1 Three test runs for the heatup test yielded the following production capacity (PC) results:

Test	PC
Run #1	33.8 g/h
Run #2	34.1 g/h

Run #3 31.0 g/h

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:

$$Xa_3 = (1/3) \times (X_1 + X_2 + X_3), \quad (A1.16)$$
$$Xa_3 = (1/3) \times (33.8 + 34.1 + 31.0),$$
$$Xa_3 = 33.0 g/h$$

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

$$A_3 = (X_1)^2 + (X_2)^2 + (X_3)^2, \quad (A1.17)$$
$$A_3 = (33.8)^2 + (34.1)^2 + (31.0)^2,$$
$$A_3 = 3266$$
$$B_3 = (1/3) \times [(X_1 + X_2 + X_3)^2],$$
$$B_3 = (1/3 \times [(33.8 + 34.1 + 31.0)^2],$$
$$B_3 = 3260$$

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

$$S_3 = (1/\sqrt{2}) \times \sqrt{(3266 - 3260)}, \quad (A1.18)$$
$$S_3 = 1.71 g/h$$

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

$$U_3 = 2.48 \times S_3, \quad (A1.19)$$
$$U_3 = 2.48 \times 1.71,$$
$$U_3 = 4.24 g/h$$

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

$$\%U_3 = (U_3/Xa_3) \times 100\%, \quad (A1.20)$$
$$\%U_3 = (4.24/33.0) \times 100\%,$$
$$\%U_3 = 12.9\%$$

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

$$Xa_4 = (1/4) \times (X_1 + X_2 + X_3 + X_4), \quad (A1.21)$$
$$Xa_4 = (1/4) \times (33.8 + 34.1 + 31.0 + 32.5),$$
$$Xa_4 = 32.9 g/h$$

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

$$A_4 = (X_1)^2 + (X_2)^2 + (X_3)^2 + (X_4)^2, \quad (A1.22)$$
$$A_4 = (33.8)^2 + (34.1)^2 + (31.0)^2 + (32.5)^2,$$
$$A_4 = 4323$$
$$B_4 = (1/4) \times [(X_1 + X_2 + X_3 + X_4)^2],$$
$$B_4 = (1/4) \times [(33.8 + 34.1 + 31.0 + 32.5)^2],$$
$$B_4 = 4316$$

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

$$S_4 = (1/\sqrt{3}) \times \sqrt{(4323 - 4316)}, \quad (A1.23)$$
$$S_4 = 1.42 g/h$$

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

$$U_4 = 1.59 \times S_4, \quad (A1.24)$$
$$U_4 = 1.59 \times 1.42,$$
$$U_4 = 2.25 g/h$$

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

$$\%U_4 = (U_4/Xa_4) \times 100\%, \quad (A1.25)$$
$$\%U_4 = (2.25/32.9) \times 100\%,$$
$$\%U_4 = 6.8\%$$

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:

$$PC: \quad 32.9 \pm 2.25 g/h \quad (A1.26)$$

The production capacity can be reported assuming the ±10 % precision requirement has been met for the corresponding heatup energy efficiency value. The heatup energy efficiency and its absolute uncertainty can be calculated following the same steps.

APPENDIX

(Nonmandatory Information)

X1. RESULTS REPORTING SHEETS

Manufacturer
Model
Date
Test Reference Number (optional)

Section 11.1 Test Braising Pan
Description of physical and operating characteristics:

Section 11.2 Apparatus and Procedure
Lid status during testing (lid up/lid down):______
______ Check if optional surface temperature uniformity test performed.
______ Check if testing apparatus conformed to specification in Section 6.
Deviations from Section 6:

Section 11.4 Testing Capacity
Testing capacity (gal) ______

Section 11.5 Maximum Energy Input Rate
Test Voltage (V) ______
Gas Heating Value (Btu/ft^3) ______
Measured (Btu/h or kW) ______
Rated ______
Percentage Difference between Measured and Rated ______

Section 11.6 Heatup Energy Efficiency and Energy Rate
Test Voltage (V) ______
Gas Heating Value (Btu/ft^3) ______
Heatup Time 80°F–160°F (min) ______
Production Capacity (lb/hr) ______
Heatup Energy Efficiency (%) ______
Heatup Energy Rate (Btu/hr or kW) ______

Section 11.7 Simmer Energy Rate
Test Voltage (V) ______
Gas Heating Value (Btu/ft^3) ______
Simmer Energy Rate (Btu/h or kW) ______

Section 11.8 Surface Temperature Uniformity
Maximum deviation between average pan bottom temperatures (°F)______
Average temperatures plotted on plan drawing of pan bottom:

Section 11.9 Pilot Energy Rate
Gas Heating Value (Btu/ft^3) ______
Pilot Energy Rate (Btu/h)

FIG. X1.1 Sample Results Reporting Sheets