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An American National Standard

Standard Test Method for Performance of Steam Kettles[1]

This standard is issued under the fixed designation F1785; 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 steam kettles. The food service operator can use this evaluation to select a steam kettle and understand its energy consumption and performance characteristics.

1.2 This test method is applicable to direct steam and self-contained gas or electric steam kettles. The steam kettle 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 Pilot energy rate, if applicable (10.6).

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

1.4 *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]

F1602 Specification for Kettles, Steam-Jacketed, 20 to 200 gal (75.7 to 757 L), Floor or Wall Mounted, Direct Steam, Gas and Electric Heated

F1603 Specification for Kettles, Steam-Jacketed, 32 oz to 20 gal (1 to 75.7 L), Tilting, Table Mounted, Direct Steam, Gas and Electric Heated

2.2 *ANSI Standard:*[3]

Z83.11 American National Standard for Gas Food Service Equipment

2.3 *ASME Documents:*[4]

Standard Specification for Kettles, Steam-Jacketed, 32 oz to 20 gal (1 to 75.7 L), Tilting, Table Mounted, Direct Connected, Gas Fired and Electric Fired

Standard Specification for Kettles, Steam-Jacketed, 20 to 200 gal (75.7 to 757 L), Floor or Wall Mounted, Direct Connected, Gas Fired and Electric Fired

2.4 *ASHRAE Documents:*[5]

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

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

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

[4] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Three Park Ave., New York, NY 10016-5990.

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

3. Terminology

3.1 *Definitions:*

3.1.1 *control electric energy, n*—the electric energy, for example, for controls, fans, consumed by steam kettles whose primary fuel source is not electricity, that is, gas, direct steam. 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.

3.1.2 *fill-to-spill capacity, n*—the maximum food capacity (gal) of the steam kettle as determined by filling to the point of overflow.

3.1.3 *heatup energy, n*—energy consumed by the steam kettle as it is used to heat the specified food product to a specified temperature.

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

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

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

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

3.1.8 *nameplate capacity, n*—the food capacity (gal) of the steam kettle, as stated by the manufacturer.

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

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

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

3.1.12 *steam kettle, n*—an appliance wherein heat is imparted to food in a deep-sided vessel by steam or hot fluid circulating through the jacket of the vessel.

3.1.13 *testing capacity, n*—the capacity (gal) at which the steam kettle is operated during the heatup and simmer tests, that is, 90 % of fill-to-spill capacity.

4. Summary of Test Method

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

4.2 The steam kettle is filled to the point of overflow to determine the fill-to-spill capacity. For subsequent tests a smaller volume, the testing capacity, is calculated to allow adequate freeboard between the waterline and the lip of the kettle.

4.3 The steam kettle is set to maximum input and monitored as it heats water from 80°F to 160°F, which yields the heatup energy efficiency, heatup energy rate, and production capacity.

4.4 The steam kettle controls are adjusted to maintain water at 165°F for three hours, yielding the simmer energy rate.

4.5 When applicable, the energy required to maintain the standing pilot for a gas appliance is measured, and the pilot energy rate is reported.

5. Significance and Use

5.1 The maximum energy input rate test is used to confirm that the steam kettle 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, gas service pressure, or steam supply flow or 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 kettle 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 steam kettle, which is appropriately sized for their operation.

5.3 Production capacity is used by food service operators to choose a steam kettle that matches their food output. The production capacity determined in this test method is a close indicator of how quickly the kettle can bring soups, sauces, and other liquids up to serving temperature.

5.4 Heatup energy efficiency and simmer energy rate allow the operator to consider energy performance when selecting a steam kettle. Simmer energy rate is also an indicator of steam kettle energy performance when preparing foods which require long cook times, for example, potatoes, beans, rice, or stew.

5.5 Pilot energy rate can be used to estimate energy consumption for gas-fired steam kettles 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 kettle.

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 150 cfm/linear ft of active hood length. This hood shall extend a minimum of 6 in. past both sides and the front of the cooking vessel 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 steam kettle, shall be a positive displacement type with a resolution of at least 0.01 ft^3 and a maximum uncertainty no greater than 1 % of the measured value for any demand greater than 2.2 ft^3/h. If the meter is used for measuring the gas consumed by the pilot lights, it shall have a resolution of at least 0.01 ft^3 and a maximum uncertainty no greater than 2 % of the measured value.

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

6.8 *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.

6.9 *Watt-Hour Meter,* for measuring the electrical energy consumption of a steam kettle, 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.

8. Sampling

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

9. Preparation of Apparatus

9.1 Install the appliance in accordance with the manufacturer's instructions under a 4-ft deep canopy exhaust hood mounted against the wall, with the lower edge of the hood 6 ft, 6 in. from the floor. Position the steam kettle with front edge of the cooking vessel 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 cooking vessel. 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 150 cfm/linear ft of hood length. The application of a longer hood is acceptable, provided the ventilation rate is maintained at 150 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 steam kettle 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 steam kettle 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 steam kettle, 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 appliance following the manufacturer's recommendations for optimizing combustion. Proper combustion may be verified by measuring air-free CO in accordance with ANSI Z83.11.

9.4 For an electric steam kettle, 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 1—It is the intent of the testing procedure herein to evaluate the performance of a steam kettle 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 steam kettle 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 kettle averaging 165 ± 1°F. If necessary, identify these control positions with a mark so that the tester may quickly adjust the kettle between heatup and simmer tests.

10. Procedures

10.1 *General:*

10.1.1 If the steam kettle 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 steam kettle reevaluated as a separate appliance.

NOTE 2—PG & E found that the simmer energy rate was reduced by as much as 50 % when the steam kettle was evaluated with the lid down.

10.1.3 For gas steam kettles, the following shall be obtained and recorded for each test run:

10.1.3.1 Higher heating value;

10.1.3.2 Standard gas pressure and temperature used to correct measured gas volume to standard conditions;

10.1.3.3 Measured gas temperature;

10.1.3.4 Measured gas pressure;

10.1.3.5 Barometric pressure;

10.1.3.6 Ambient temperature; and,

10.1.3.7 Energy input rate during or immediately prior to test.

NOTE 3—The preferred method for determining the heating value of gas supplied to the steam kettle 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 steam kettles, 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 4—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 that 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 steam kettles, the following shall be obtained and recorded for each run of every test:

10.1.5.1 Voltage while elements are energized;

10.1.5.2 Measured peak input rate during or immediately prior to test; and,

10.1.5.3 Ambient temperature.

10.1.6 For direct steam kettles, record the supplied steam pressure and average flow rate for each run of every test.

10.1.7 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 steam kettle.

10.2 *Maximum Energy Input Rate:*

10.2.1 Fill the steam kettle with water (it is not necessary to measure the amount). Set the controls to full input and start the kettle. Operate the kettle at maximum input for 10 min.

NOTE 5—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 kettle at full input. Record time and energy consumption for 15 min. If the appliance is a gas or direct steam kettle, 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 steam kettle and kW for an electric steam kettle) is within 5 % of the rated nameplate input or power. It is the intent of the testing procedures herein to evaluate the performance of a steam kettle 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 steam kettle or supply another steam kettle for testing.

10.3 *Capacity:*

10.3.1 Fill the kettle 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 90 % of the fill-to-spill capacity, for example, a kettle with a 40-gal fill-to-spill capacity would have a testing capacity of 90 % × 40 = 36 gal.

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

10.4.1 The kettle shall be initially at room temperature. Fill the kettle 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 kettle 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 kettle. Record final time, water temperature, and energy consumption.

10.5 *Simmer Energy Rate:*

10.5.1 Fill the kettle 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 steam kettle on and set the controls so that the kettle 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 kettle 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 *Pilot Energy Rate (Gas Models with Standing Pilots):*

10.6.1 Where applicable, set the gas valve that controls gas supply to the appliance at the pilot position. Otherwise, set the steam kettle controls to the off position.

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

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

11. Calculation and Report

11.1 *Test Steam Kettle*—Using Specification F1602 or Classification F1603, summarize the physical and operating characteristics of the steam kettle. 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 steam kettle 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.

11.3 *Gas and Steam Energy Calculations:*

11.3.1 For gas steam kettles, electric energy consumption shall be added to gas energy for all tests, with the exception of the maximum energy input rate test (see 10.2).

11.3.2 For gas steam kettles, 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,

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

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

P_{cf} = pressure correction factor,

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

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

NOTE 6—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).

11.3.3 For steam kettles that use a direct external steam source, steam energy shall be calculated as follows:

$$E_{steam} = W_s \times t \times h_s \tag{3}$$

where:

W_s = steam flow rate (lb (kg)/h),
t = steam flow duration (h), and
h_s = latent heat of steam as derived from the measured supply steam pressure (10.1.5) and thermodynamic properties of water at saturation (see the ASHRAE documents listed in 2.2) (Btu/lb (kJ/g)).

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

$$C_{test} = 0.90 \times C_{spill} \tag{4}$$

where:

C_{test} = testing capacity of the steam kettle, gal, and
C_{spill} = measured fill-to-spill capacity of the kettle (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 steam kettle, kW for an electric steam kettle, and lb $(kg)_{steam}$/h for direct steam kettles.

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

$$\textit{maximum energy input rate}\ (\text{Btu/h}\ (\text{kJ/h})) = \frac{E_{input}\ (\text{Btu}\ (\text{kJ})) \times 60\ (\text{min/h})}{\text{input time}\ (\text{min})} \tag{5}$$

11.5.3 For electric steam kettles, report the measured maximum energy input rate (kW).

11.5.4 For direct steam or steam coil steam kettles, report the measured maximum rate of steam consumption (lb(kg)/h).

11.6 *Heatup Energy Efficiency and Heatup Energy Rate:*

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

$$\eta_{heatup} = \frac{E_{water}}{E_{kettle}} \times 100 \tag{6}$$

where:

η_{heatup} = heatup energy efficiency,%
E_{water} = energy into water, Btu
= $(T_f - T_i) \times W_{water} \times (1\ \text{Btu/lb} \times °\text{F})$

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_{kettle} = energy consumed by the steam kettle, Btu.

11.6.2 Calculate and report the heatup energy rate as follows:

$$HR = \frac{E_{kettle}}{t} \times 60 \tag{7}$$

where:

HR = energy input rate during the 80 to 160°F heatup interval, Btu/h,
E_{kettle} = 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 the lb/h of water that can be heated from 80°F to 160°F:

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

where:

PC = production capacity of the steam kettle, lb/h,
W = total weight of water in the kettle, 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:

$$SR = \frac{E_{kettle}}{t} \times 60 \tag{9}$$