



Standard Test Method for Performance of Cook-and-Hold Ovens¹

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1. Scope

1.1 This test method evaluates the energy consumption and cooking performance of cook-and-hold ovens. The food service operator can use this evaluation to select a cook-and-hold oven and understand its energy consumption.

1.2 This test method is applicable to gas and electric cook-and-hold ovens.

1.3 The cook-and-hold oven can be evaluated with respect to the following (where applicable):

1.3.1 Energy input rate (10.2).

1.3.2 Preheat energy consumption and time (10.3).

1.3.3 Idle energy rate (10.4).

1.3.4 Pilot energy rate (if applicable) (10.5).

1.3.5 Cooking energy rate, and production capacity (10.7).

1.3.6 Holding energy rate, energy utilization factor, and product yield (10.7).

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

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

2. Referenced Documents

2.1 ASTM Standards:²

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

2.2 ASHRAE Documents:³

ASHRAE Handbook of Fundamentals, “Thermal and Related Properties of Food and Food Materials,” Chapter 30, Table 1, 1989

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

3. Terminology

3.1 Definitions:

3.1.1 *cook-and-hold oven, n*—an appliance with a closed heated cavity designed specifically for low-temperature cooking, followed by a holding period at a specified temperature.

3.1.2 *cooking energy rate, n*—average rate of energy consumption (Btu/h or kW) during the energy utilization factor tests.

3.1.3 *energy input rate, n*—peak rate at which a cook-and-hold oven consumes energy (Btu/h or kW).

3.1.4 *energy utilization factor, n*—the ratio of the energy consumed per pound yield (Wh/lbs) of food product during the cook-and-hold test.

3.1.5 *holding energy rate, n*—the rate of energy consumed (Btu/h or kW) by the cook-and-hold oven while maintaining the temperature of the cooked food product for a specified period.

3.1.6 *idle energy rate* (ready-to-cook condition), *n*—the cook-and-hold oven’s rate of energy consumption (Btu/h or kW), when empty, required to maintain its cavity temperature at the specified thermostat set point or to otherwise maintain the oven in a ready-to-cook condition.

3.1.7 *oven cavity, n*—that portion of the cook-and-hold oven in which food products are heated or cooked.

3.1.8 *pilot energy rate, n*—rate of energy consumed (Btu/h) by a cook-and-hold oven’s continuous pilot (if applicable).

3.1.9 *preheat energy, n*—amount of energy consumed (Btu or kWh), by the cook-and-hold oven while preheating its cavity from ambient temperature to the specified thermostat set point

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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, <http://www.ashrae.org>.

or while preheating any other component of the oven, for example an integral heat exchanger, to a ready-to-cook condition.

3.1.10 *preheat time, n*—time (min.) required for the cook-and-hold oven cavity to preheat from ambient temperature to the specified thermostat set point or for the cook-and-hold oven to achieve a ready-to-cook condition.

3.1.11 *production capacity, n*—maximum rate (lb/h) at which a cook-and-hold oven can bring the specified food product to a specified “cooked” condition.

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

4. Summary of Test Method

4.1 Accuracy of the cook-and-hold oven thermostat is checked at a setting of 225°F. This is accomplished by comparing the oven’s temperature control setting with the temperature at the center of the oven’s cavity. If necessary, the control is adjusted so that the maximum difference between its reading and the temperature at the center of the cavity is no more than $\pm 5^\circ\text{F}$.

4.2 Energy input rate is determined to confirm that the cook-and-hold oven is operating within 5 % of the nameplate energy input rate. For gas combination ovens, the pilot energy rate and the fan and control energy rates are also determined.

4.3 The time and energy required to preheat the oven from room temperature ($75 \pm 5^\circ\text{F}$) to a ready-to-cook condition (for example, $225 \pm 5^\circ\text{F}$).

4.4 Idle energy rate is determined with the cook-and-hold oven set to maintain a ready-to-cook condition (for example, $225 \pm 5^\circ\text{F}$).

4.5 Cooking energy rate and production capacity are determined during heavy-load conditions using beef round roasts.

4.6 Holding energy rate, energy utilization factor, and average product yield are determined immediately following the cooking cycle.

5. Significance and Use

5.1 The energy input rate test is used to confirm that the cook-and-hold oven is operating properly prior to further testing.

5.2 Preheat energy and time can be useful to food service operators to manage power demands and to know how quickly the cook-and-hold oven can be ready for operation.

5.3 Idle energy rate and pilot energy rate can be used to estimate energy consumption during non-cooking periods.

5.4 Energy utilization factor is a precise indicator of a cook-and-hold oven’s energy performance while cooking and holding a typical food product under various loading conditions. If energy performance information is desired using a food product other than the specified test food, the test method could be adapted and applied. Energy performance information allows an end user to better understand the operating characteristics of a cook-and-hold oven.

5.5 Production capacity information can help an end user to better understand the production capabilities of a cook-and-hold oven as it is used to cook a typical food product and this could help in specifying the proper size and quantity of equipment. If production information is desired using a food product other than the specified test food, the test method could be adapted and applied.

5.6 Holding energy rate may be used to determine the cost of holding cooked product in the cook-and-hold oven.

5.7 Product yield may be used by the food service operator to compare relative product output from one cook-and-hold oven to another. Additionally, product shrinkage during holding may be used by the food service operator to evaluate the cook-and-hold oven’s performance when holding cooked product.

6. Apparatus

6.1 *Analytical Balance Scale*, for measuring weights up to 20 lb, with a resolution of 0.01 lb and an uncertainty of 0.01 lb.

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

6.3 *Flow Meter*, for measuring total water consumption of the appliance (if applicable). The meter shall have a resolution of 0.01 gal, and an uncertainty of 0.01 gal, at flow rate as low as 0.2 gpm.

6.4 *Gas Meter*, for measuring the gas consumption of a cook-and-hold oven, shall be a positive displacement type with a resolution of at least 0.01 ft³ and a maximum uncertainty no greater than 1% of the measured value for any demand greater than 2.2 ft³/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 ft³ and a maximum uncertainty no greater than 2% of the measured value.

6.5 *Pressure Gage*, for monitoring natural gas pressure. Shall have a range of zero to 10 in. H₂O, a resolution of 0.5 in. H₂O, and a maximum uncertainty of 1% of the measured value.

6.6 *Stop Watch*, with a 1-sec resolution.

6.7 *Temperature Sensor*, for measuring natural gas temperature in the range from 50 to 100°F, with an uncertainty of $\pm 1^\circ\text{F}$.

6.8 *Thermocouple Probes*, Type K stainless-steel sheathed exposed junction with a range from -20 to 400°F , with a resolution of 0.2°F , and an uncertainty of 0.5°F , for measuring oven cavity and food product temperatures.

NOTE 1—To facilitate monitoring food temperatures, it is recommended that only stainless-steel sheathed thermocouple probes be used.

6.9 *Watt-Hour Meter*, for measuring the electrical energy consumption of a cook-and-hold oven, shall have 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. For any demand less than 100 W, the meter shall have a resolution of at least 10 Wh and a maximum uncertainty no greater than 10%.

7. Reagents and Materials

7.1 *Roast*, for the cooking energy efficiency test. Roasts shall be raw, unfrozen, 100% Choice beef top (inside) round with a ¼-inch trim, 12 ± 0.25 lb per roast. The raw roasts shall be stabilized in a refrigerator at $37 \pm 2^\circ\text{F}$.

7.2 *Hotel Pan*, solid 12 by 20 by 2½ in. (300 by 500 by 65 mm) stainless steel weighing 2.8 ± 0.5 lb (1.3 ± 0.2 kg).

8. Sampling, Test Units

8.1 *Cook-and-Hold Oven*—Select one representative production model for performance testing.

9. Preparation of Apparatus

9.1 Install the cook and hold oven according to the manufacturer's instructions in an appropriate space. All sides of the hot food holding cabinets shall be a minimum of 3 ft from any side wall, side partition, or other operating appliance and add 2 in. clearance from back wall or manufacture's listed requirement whichever is largest in length. The associated heating or cooling system for the space shall be capable of maintaining an ambient temperature of $75 \pm 5^\circ\text{F}$ within the testing environment.

9.2 Connect the cook-and-hold oven 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 cook-and-hold oven 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 $\pm 2.5\%$ of the manufacturer's nameplate voltage.

9.3 For an electric cook-and-hold oven, confirm (while the cook-and-hold oven elements are energized) that the supply voltage is within $\pm 2.5\%$ of the manufacturer's nameplate voltage. Record the test voltage for each test.

NOTE 2—It is the intent of the testing procedure herein to evaluate the performance of a cook-and-hold oven 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 cook-and-hold oven 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.

9.4 For a gas cook-and-hold oven, adjust (during maximum energy input) the gas supply pressure downstream from the appliance's pressure regulator to within $\pm 2.5\%$ of the operating manifold pressure specified by the manufacturer. Make adjustments to the appliance following the manufacturer's recommendations for optimizing combustion.

9.5 If the cook-and-hold oven has manually controlled vents, then adjust the vents to remain 100% open during all tests.

10. Procedure

10.1 General:

10.1.1 For gas appliances, record the following for each test run: (1) Higher heating value, (2) Standard gas pressure and

temperature used to correct measured gas volume to standard conditions, (3) Measured gas temperature, (4) Measured gas pressure, (5) Barometric pressure, and (6) Energy input rate during or immediately prior to test (for example, during the preheat for that days testing).

NOTE 3—Using a calorimeter or gas chromatograph in accordance with accepted laboratory procedures is the preferred method for determining the higher heating value of gas supplied to the cook-and-hold oven under test. It is recommended that all testing be performed with gas having a higher heating value of 1000 to 1075 Btu/ft³.

10.1.2 For gas cook-and-hold ovens, add electric energy consumption to gas energy for all tests, with the exception of the energy input rate test (section 10.3).

10.1.3 For electric cook-and-hold ovens, record the following for each test run: (1) Voltage while elements are energized, and (2) Energy input rate during or immediately prior to test (for example, during the preheat for that days testing).

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

10.2 Energy Input Rate and Thermostat Calibration:

10.2.1 Install a thermocouple at the geometric center (top to bottom, side to side, and front to back) of the cook-and-hold oven cooking cavity.

10.2.2 Set the temperature control to 150°F and turn the cook-and-hold oven on. Record the time and energy consumption from the time when the unit is turned on until the time when any of the burners or elements first cycle off.

10.2.3 Calculate and record the cook-and-hold oven's energy input rate and compare the result to the rated nameplate input. For gas appliances, only the burner energy consumption is used to compare the calculated energy input rate with the rated gas input; any electrical energy use shall be calculated and recorded separately as the fan/control energy rate.

10.2.4 Allow the cook-and-hold oven to idle for 60 min after the burners or elements commence cycling at the thermostat set point.

10.2.5 After the 60-min idle period, start monitoring the oven cavity temperature, and record the average temperature over a 15-min period. If this recorded temperature is $150 \pm 5^\circ\text{F}$, then the cook-and-hold oven's thermostat is calibrated.

10.2.6 If the average temperature is not $150 \pm 5^\circ\text{F}$, adjust the temperature control following the manufacturer's instructions and repeat 10.2.5 until it is within this range. Record the corrections made to the controls during calibration.

10.2.7 In accordance with 11.4, calculate and report the cook-and-hold oven energy input rate, fan/control energy rate where applicable, and rated nameplate input.

10.3 Preheat Energy Consumption and Time:

10.3.1 Verify that the cook-and-hold oven cavity temperature is $75 \pm 5^\circ\text{F}$. Set the calibrated temperature control to 225°F and turn the oven on.

10.3.2 Record the time, temperature, and energy consumption required to preheat the cook-and-hold oven, from the time when the unit is turned on until the time when the oven cavity reaches a temperature of $225 \pm 5^\circ\text{F}$.

10.3.3 In accordance with 11.5, calculate and report the preheat energy consumption and time, and generate a preheat temperature versus time graph.

10.4 Idle Energy Rate:

10.4.1 Turn the cook-and-hold oven on and allow it to achieve a ready-to-cook state. Allow the oven to idle for 60 min. after it is fully preheated.

10.4.2 After the 60 min stabilization period, then run idle energy rate test shall be run for a minimum of 3 h and include a minimum of 10 complete thermal cycles or heater cycles. After the test period (either 3 h or 10 thermal/heater cycles, whichever is longer), end the test. If the test unit does not exhibit clear thermal cycles, then the test shall be run for 3 h.

NOTE 4—Models with proportional controls may not exhibit distinct heater cycles. The intent of the test is to accurately represent the average energy consumption of the holding cabinet, while minimizing any error that may be introduced as a result of capturing partial thermal cycles.

10.4.3 In accordance with section 11.6, calculate and report the cook-and-hold oven's idle energy rate.

10.5 Pilot Energy Rate:

10.5.1 For a gas cook-and-hold oven with a standing pilot, set the gas valve at the "pilot" position and set the cook-and-hold oven's temperature control to the "off" position.

10.5.2 Light and adjust the pilot according to the manufacturer's instructions.

10.5.3 Monitor gas consumption for a minimum of 3 hr of pilot operation.

10.5.4 In accordance with section 11.7, calculate and report the pilot energy rate.

10.6 Test Product Preparation:

10.6.1 Determine the roasting capacity of the cook-and-hold oven by measuring the internal height and depth of the oven cavity. Place the oven racks between 6 and 7-in. apart, starting from the bottom rack position, and leaving a minimum of 6-in. from the top rack to the cavity ceiling. Count the number of racks. Each rack will hold a single roast for every 13-in. of rack depth. For example, an oven with an internal cavity height of 25-in., and a rack depth of 15-in. will have a load size of 3 roasts.

10.6.2 Remove the roasts from the refrigerator, remove any packaging and weigh the roasts, not including any juice that may accompany the roast. Note the weight of the individual roasts. Each roast shall be 12 ± 0.25 lb.

10.6.3 The total load weight shall be the number of roasts times 12 lb and the tolerance of the total load weight shall reference Table 1. For example, a cook-and-hold oven with four full-size racks can accommodate 8 total roasts. The total test weight for the example oven is $8 \times 12 \pm 1.0$ lb, or $96.0 \pm$

1.0 lb. For total load weight of <100 lbs, the tolerance shall be ± 1.0 lb, for total load weight ≥ 100 lbs, the tolerance shall be ± 2.0 lb. Refer to Table 1.

10.6.4 The roasts shall have an average load weight of 12.0 ± 0.25 lb. If the total weight is greater than the number of roasts, $n \times 12 + 0.25$ lb, then trim the ends of the largest roasts to bring the total load weight to within the tolerance specified in Table 1. If the total weight is less than the number of roasts, $n \times 12 \pm 0.25$ lb, then substitute the smallest roasts for larger roasts until the total load weight is within the tolerance specified in Table 1.

10.6.5 Place thermocouple probes into the geometric center of each roast to facilitate monitoring internal roast temperatures.

10.6.6 Place each roast into individual hotel pans and cover with plastic wrap. Return the roasts to the refrigerator until they stabilize at $37 \pm 2^\circ\text{F}$.

10.6.7 Monitor the internal temperature of each roast with a thermocouple probe. Its internal temperature must be $37 \pm 2^\circ\text{F}$ before the roasts can be removed from the refrigerator and loaded into the cook-and-hold oven. If necessary, adjust the refrigerator temperature to achieve this required internal temperature.

10.7 Cooking Energy Rate, Production Capacity, Holding Energy Rate, and Energy Utilization Factor:

10.7.1 The cooking energy rate, production capacity, holding energy rate, and energy utilization factor, tests are to be run a minimum of three times. Additional test runs may be necessary to obtain the required precision for the reported test results (see Annex A1). The reported values of cooking energy rate, production capacity, holding energy rate, energy utilization factor, and product yield shall be the average of the replications (runs).

10.7.2 Fill water pan if required by manufacture's recommendations. Turn the cook-and-hold oven on and allow it to achieve a ready-to-cook state reach temperature of 225°F . Allow the oven to idle for a minimum of 60 min after it is fully preheated.

10.7.3 Remove the roasts from the refrigerator and remove the plastic wrap. Open the door of the cook-and-hold oven and commence loading the roasts into the oven, starting from the bottom and preceding to the top. Allow 10 s for each rack position (for example, a heavy load of 3 racks times $10 \text{ s} = 30$ sec maximum loading time). The initial average temperature of the roasts (all roasts together) when the test is started (the cook-and-hold oven door is closed) shall be $40 \pm 2^\circ\text{F}$ ($4 \pm 1^\circ\text{C}$). Keep the door open for the maximum load time, even if the loading is accomplished in less time.

10.7.4 Shut the door and start the oven cooking cycle to begin the test. Start monitoring time, temperature, energy consumption, and water consumption (if applicable).

10.7.5 When the temperature of the last roast reaches a minimum of $90\text{--}110^\circ\text{F}$, note the total elapsed time and oven energy (and water, if applicable) consumption and then switch the controls to hold mode. Hold the cavity temperature at 150°F until last roast internal temperature is 130°F for a minimum of 112 minutes.

TABLE 1 Oven Roasting Capacity and Cooking Test Load Weight

Roasting Capacity	Cooking Test Weight
2 Roasts	24.0 ± 1.0 lb
3 Roasts	36.0 ± 1.0 lb
4 Roasts	48.0 ± 1.0 lb
8 Roasts	96.0 ± 1.0 lb
12 Roasts	144.0 ± 2.0 lb
16 Roasts	192.0 ± 2.0 lb
20 Roasts	240.0 ± 2.0 lb