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Standard Test Method for Performance of Retherm Ovens¹

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1. Scope

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

1.2 This test method is applicable to gas and electric retherm ovens.

1.3 The retherm 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), and

1.3.5 Cooking Energy Rate, Production Capacity, Cooking Energy Efficiency (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 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*²

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 the Annual Book of ASTM standards volume information, refer the standard's Document Summary page on the ASTM website.

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

2.2 *ASHRAE Documents:*³

ASHRAE Handbook of Refrigeration “Thermal Properties of Food,” Chapter 19, Table 3, 2014.

3. Terminology

3.1 *Definitions:*

3.1.1 *cooking energy efficiency, n*—the ratio of the quantity of energy absorbed by the food product to the quantity of energy input to the oven during a cooking energy efficiency test expressed as a percent.

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

3.1.3 *energy input rate, n*—the peak rate at which a retherm oven consumes energy (Btu/h or kW).

3.1.4 *idle energy rate* (ready-to-cook condition), *n*—the retherm 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.

3.1.5 *oven cavity, n*—the portion of the retherm oven in which food products are heated.

3.1.6 *pilot energy rate, n*—the rate of energy consumed (Btu/h) by a retherm oven's continuous pilot (if applicable).

3.1.7 *preheat energy, n*—the amount of energy consumed (Btu or kWh), by the retherm oven while preheating its cavity from ambient temperature to the specified thermostat set point or while preheating any other component of the oven, for example an integral heat exchanger, to a ready-to-cook condition.

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

³ Available from American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), 1791 Tullie Circle, NE, Atlanta, GA 30329.

3.1.9 *production capacity, n*—the maximum rate (lb/h or kg/h) at which a retherm oven can bring the specified food product to a specified “cooked” condition.

3.1.10 *retherm oven, n*—an appliance with a closed, heated cavity, designed specifically for low-temperature reheating.

3.1.11 *uncertainty, n*—the 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 *Thermostat Calibration*—Accuracy of the retherm oven thermostat is checked at a setting of 250°F (121°C). 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 $\pm 5^\circ\text{F}$ (3°C).

4.2 *Energy Input Rate*—The input rate of the oven is determined to check whether the retherm oven is operating within 5 % of its nameplate energy input rate. For gas combination ovens, the pilot energy rate and the fan and control energy rates are also determined.

4.3 *Preheat Energy Consumption and Time*—The time and energy required to preheat the oven from room temperature ($75 \pm 5^\circ\text{F}$ or $24 \pm 3^\circ\text{C}$) to a ready-to-cook condition (for example, $250 \pm 5^\circ\text{F}$ or $121 \pm 3^\circ\text{C}$).

4.4 *Idle Energy Rate*—Idle energy rate is determined with the retherm oven set to maintain a ready-to-cook condition (for example, $250 \pm 5^\circ\text{F}$ or $121 \pm 3^\circ\text{C}$).

4.5 *Cooking Energy Efficiency and Production Capacity*—The cooking energy efficiency and production rate are determined during heavy-load cooking tests.

5. Significance and Use

5.1 *Energy Input Rate*—Energy input rate is used to confirm that the retherm oven is operating properly prior to further testing.

5.2 *Preheat Energy Consumption and Time*—Preheat energy and time can be useful to food service operators to manage power demands and to know how quickly the retherm oven can be ready for operation.

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

5.4 *Production Capacity*—Production capacity information can help an end user to better understand the production capabilities of a retherm 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.

5.5 *Cooking Energy Efficiency*—This test provides a measure of the oven’s energy efficiency while heavy loads are being cooked.

6. Apparatus

6.1 *Analytical Balance Scale*, for measuring weights up to 20 lb (9.1 kg), with a resolution of 0.01 lb (4 g) and an uncertainty of 0.01 lb (4 g).

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 (0.03 L), and an uncertainty of 0.01 gal (0.03 L), at flow rate as low as 0.2 gpm (0.76 L/min).

6.4 *Gas Meter*, for measuring the gas consumption of a retherm 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 Gauge*, 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-s resolution.

6.7 *Temperature Sensor*, for measuring natural gas temperature in the range from 50 to 100°F (10 to 38°C), with an uncertainty of $\pm 1^\circ\text{F}$ (0.6°C).

6.8 *Thermocouple Probes*, Type K stainless steel-sheathed exposed junction with a range from -20 to 400°F (-29 to 204°C), with a resolution of 0.2°F (0.1°C), and an uncertainty of 0.5°F (0.3°C), 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 retherm oven, shall have a resolution of 10 Wh or better 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 *Mashed Potato Packages*, for the cooking energy efficiency test, mashed potatoes shall be lightly seasoned, pre-cooked, unfrozen ($37 \pm 3^\circ\text{F}$ or $3 \pm 1^\circ\text{C}$), in sealed packages, and 4 ± 0.1 lb (1.8 ± 0.05 kg) per package. The mashed potatoes shall be stabilized in a refrigerator at $37 \pm 3^\circ\text{F}$ ($2.8 \pm 1.7^\circ\text{C}$).

7.2 *Steam Pans*, for cooking energy efficiency test, pans shall be perforated 12 by 20 by $2\frac{1}{2}$ in. (305 by 508 by 64 mm) stainless steel weighing 2.5 ± 0.5 lb (1.1 ± 0.2 kg).

7.3 *Baskets*, for cooking energy efficiency test, baskets shall be open-wired $13\frac{3}{8}$ by $25\frac{7}{8}$ by $2\frac{5}{8}$ in. (340 by 657 by 67 mm) stainless steel weighing 3.4 ± 0.3 lb (1.5 ± 0.1 kg).

8. Sampling, Test Units

8.1 *Retherm Oven*—Select one representative production model for performance testing.

9. Preparation of Apparatus

9.1 Install the retherm oven according to the manufacturer's instructions in an appropriate space. All sides of the hot food retherm cabinets shall be a minimum of 3 ft (91 cm) from any side wall, side partition, or other operating appliance and add 2 in. (51 mm) 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 $75 \pm 5^\circ\text{F}$ ($24 \pm 3^\circ\text{C}$) within the testing environment.

9.2 Connect the retherm 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 retherm 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 retherm oven, confirm (while the retherm oven's heating 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 retherm oven at its rated gas pressure or electric voltage. If an electric unit is rated dual voltage (in other words, designed to operate at either 240 or 480 V with no change in components), the voltage selected by the manufacturer or tester, or both, shall be reported. If a retherm 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 retherm 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 retherm 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 retherm 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 retherm ovens, add electric energy consumption to gas energy for all tests, with the exception of the energy input rate test (10.3).

10.1.3 For electric retherm 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 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 retherm 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 retherm oven cooking cavity.

10.2.2 Set the temperature control to 250°F (121°C) and turn the retherm 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 retherm 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 retherm 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 $250 \pm 5^\circ\text{F}$ ($121 \pm 3^\circ\text{C}$), then the retherm oven's thermostat is calibrated.

10.2.6 If the average temperature is not $250 \pm 5^\circ\text{F}$ ($121 \pm 3^\circ\text{C}$), 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 retherm 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 retherm oven cavity temperature is $75 \pm 5^\circ\text{F}$ ($24 \pm 3^\circ\text{C}$). Set the calibrated temperature control to 250°F (121°C) and turn the oven on.

10.3.2 Record the time, temperature, and energy consumption required to preheat the retherm oven, from the time when the unit is turned on until the time when the oven cavity reaches a temperature of $250 \pm 5^\circ\text{F}$ ($121 \pm 3^\circ\text{C}$).

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 retherm 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.