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An American National Standard

Standard Test Method for Enhanced Performance of Combination Oven in Various Modes[1]

This standard is issued under the fixed designation F2861; 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 covers the evaluation of the energy and water consumption and the cooking performance of combination ovens that can be operated in hot air convection, steam, and the combination of both hot air convection and steam modes. The test method is also applicable to convection ovens with moisture injection. The results of this test method can be used to evaluate a combination oven and understand its energy consumption.

1.2 This test method is applicable to gas and electric combination ovens that can be operated in convection, steam and combination modes.

1.3 The combination oven can be evaluated with respect to the following (where applicable):

1.3.1 Energy input rate and thermostat calibration (10.2).

1.3.2 Preheat energy consumption and time (10.3).

1.3.3 Idle energy rate in convection, steam and combination modes (10.4).

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

1.3.5 Cooking-energy efficiency, cooking energy rate, production capacity, water consumption and condensate temperature in steam mode (10.6).

1.3.6 Cooking-energy efficiency, cooking energy rate, and production capacity in convection mode (10.7).

1.3.7 Cooking uniformity in combination mode (10.8).

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 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

F1217 Specification for Cooker, Steam

F1484 Test Methods for Performance of Steam Cookers

F1495 Specification for Combination Oven Electric or Gas Fired

F1496 Test Method for Performance of Convection Ovens

2.2 *ASHRAE Documents:*[3]

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

ASHRAE Guideline 2-1986 (RA90) Thermal and Related Properties of Food and Food Materials

3. Terminology

3.1 *Definitions:*

3.1.1 *combination mode, n*—for the purposes of this test method, combination mode is defined as moist heat at 350°F (177°C) with the humidity and fan set to operate at their maximum settings, hereafter referred to as combi mode.

3.1.2 *combination oven, n*—device that combines the function of hot air convection (oven mode), steam heating (steam mode), and a combination of both to perform steaming, which includes low or high temperature steaming, baking, roasting, rethermalizing, and proofing of various food products. In general, the term combination oven is used to describe this type of equipment, which is self contained.

3.1.3 *condensate, n*—mixture of condensed steam and cooling water, exiting the combination oven and directed to a drain.

3.1.4 *convection mode, n*—for the purposes of this test method, convection mode is defined as dry heat only at 350°F (177°C) with the fan set to operate at the maximum setting.

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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] See the ASHRAE Handbook of Fundamentals, available from the American Society of Heating, Refrigeration, and Air Conditioning Engineers, Inc., 1791 Tullie Circle, NE, Atlanta, GA 30329.

3.1.5 *cooking-energy efficiency, n*—quantity of energy imparted to the specified food product, expressed as a percentage of energy consumed by the combination oven during the cooking event.

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

3.1.7 *energy input rate, n*—peak rate at which a combination oven consumes energy (Btu/h (kJ/h) or kW).

3.1.8 *idle energy rate, n*—combination oven's rate of energy consumption (Btu/h (kJ/h) or kW), when empty, required to maintain its cavity temperature at the specified thermostat set point.

3.1.9 *oven cavity, n*—that portion of the combination oven in which food products are heated or cooked.

3.1.10 *pilot energy rate, n*—rate of energy consumption (Btu/h (kJ/h)) by a combination oven's continuous pilot (if applicable).

3.1.11 *preheat energy, n*—amount of energy consumed (Btu (kJ) or kWh), by the combination oven while preheating its cavity from ambient temperature to the specified thermostat set point.

3.1.12 *preheat time, n*—time (in min) required for the combination oven cavity to preheat from ambient temperature to the specified thermostat set point.

3.1.13 *production capacity, n*—maximum rate (lb/h (kg/h)) at which a combination oven can bring the specified food product to a specified "cooked" condition. May also be referred to as throughput.

3.1.14 *production rate, n*—rate (lb/h (kg/h)) at which a combination oven brings the specified food product to a specified "cooked" condition. Does not necessarily refer to maximum rate. Production rate varies with the amount of food being cooked.

3.1.15 *rack trolley, n*—as used in this test method, refers to a cart with integrated frame for holding pans that is designed for ease of loading and unloading product in a floor model (Specification F1495 Type 3) combination oven.

3.1.16 *steam generator, n*—as used in this test method, refers to one of three distinct methods which all conform to Grade A classification in F1217, 0 to 2.9 psig maximum compartment pressure:

3.1.16.1 *Discussion*—Injection refers to direct placement of water onto a hot surface in the cavity for moisture production (Specification F1495 Classification Style Injection).

3.1.16.2 *Discussion*—Boiler refers to a compartment outside the oven cavity through which water is heated for moisture production (Specification F1495 Classification Style Boiler).

3.1.16.3 *Discussion*—Water bath refers to a compartment inside the oven cavity through which water is heated for moisture production (Specification F1495 Classification Style Water Bath).

3.1.17 *steam mode, n*—for the purposes of this test method, steam mode is defined as the maximum humidity setting at a nominal 212°F (100°C).

3.1.18 *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 combination oven thermostat is checked at a setting of 350°F (177°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 ±5°F (±2.8°C).

4.2 Energy input rate is determined to confirm that the combination 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 ± 5°F (24 ± 3°C)) to a ready-to-cook state (350°F (177°C)), maximum humidity, if adjustable) is determined.

4.4 Idle energy rate is determined with the combination oven set to maintain a ready-to-cook state without cooking in three operating modes—combi mode (350 ± 5°F (177 ± 2.8°C), maximum humidity, if adjustable), convection mode (350 ± 5°F (177 ± 2.8°C)), and steam mode (nominal 212°F (100°C), maximum humidity, if adjustable).

4.5 Cooking-energy efficiency, cooking energy rate and production rate are determined in steam mode and convection mode while cooking potatoes.

4.6 Water consumption (gal/h (L/h)) is monitored during idle conditions in steam mode, combi mode and convection mode and while cooking potatoes in steam mode and convection mode to characterize the rate of water usage.

4.7 Condensate temperature is monitored to characterize the combination oven's average and maximum drain temperature.

4.8 The uniformity of heating within the combination oven's compartment is determined and reported based on the average temperature on each pan during ice load cooking tests (pans of ice simulating pans of frozen food).

5. Significance and Use

5.1 The energy input rate test and thermostat calibration are used to confirm that the combination oven is operating properly prior to further testing and to ensure that all test results are determined at the same temperature.

5.2 Preheat energy and time can be useful to food service operators to manage power demands and to know how quickly the combination 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 Cooking-energy efficiency is a precise indicator of combination oven energy performance under various operating conditions. This information enables the food service operator to consider energy performance when selecting a combination oven.

5.5 Production capacity can be used by food service operators to choose a combination oven that matches their food output requirements.

5.6 Water consumption characterization is useful for estimating water and sewage costs associated with combination oven operation.

5.7 Condensate temperature measurement is useful to verify that the condensate temperature does not violate applicable building codes.

5.8 Cooking uniformity provides information regarding the combination oven's ability to cook food at the same rate throughout the oven compartment.

6. Apparatus

6.1 *Analytical Balance Scale,* for measuring weights up to 20 lb (9.0 kg), with a resolution of 0.01 lb (0.005 kg) and an uncertainty of 0.01 lb (0.005 kg).

6.2 *Barometer,* for measuring absolute atmospheric pressure, to be used for adjustment of measured natural gas volume to standard conditions, having a resolution of 0.2 in. Hg (670 Pa) and an uncertainty of 0.2 in. Hg (670 Pa).

6.3 *Canopy Exhaust Hood,* 4-ft (1.2-m) in depth, wall-mounted with the lower edge of the hood 72 in. (2.0 m) from the floor and with the capacity to operate at a nominal exhaust ventilation rate of 300 cfm per linear foot (360 L/s per linear meter) of active hood length. This hood shall extend a minimum of 6 in. (150 mm) past both sides and the front of the cooking appliance and shall not incorporate side curtains or partitions.

6.4 *Flowmeter,* for measuring total water consumption of the appliance, having a resolution of 0.01 gal (40 mL) and an uncertainty of 0.01 gal (40 mL) at a flow rate as low as 0.2 gpm (13 mL/s).

6.5 *Gas Meter,* for measuring the gas consumption of a combination oven, shall be a positive displacement type with a resolution of at least 0.01 ft^3 (0.0003 m^3) and a maximum uncertainty no greater than 1 % of the measured value for any demand greater than 2.2 ft^3/h (0.06 m^3/h). If the meter is used for measuring the gas consumed by the pilot lights, it shall have a resolution of at least 0.01 ft^3 (0.0003 m^3) and a maximum uncertainty no greater than 2 % of the measured value.

6.6 *Pressure Gage,* for monitoring natural gas pressure, having a range from 0 to 15 in. H_2O (0 to 3.7 kPa), a resolution of 0.5 in. H_2O (125 Pa), and a maximum uncertainty of 1 % of the measured value.

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

6.8 *Temperature Sensor,* for measuring natural gas temperature in the range from 50 to 100°F (10 to 40°C), with an uncertainty of ±1°F (0.3°C).

6.9 *Calibrated Exposed Junction Thermocouple Probes,* with a range from –20 to 400°F (–30 to 200°C), with a resolution of 0.2°F (0.1°C), and an uncertainty of ±1.0°F (±0.6°C), for measuring oven cavity and food product temperatures. Calibrated Type K thermocouples (24 GA wire) are a good choice.

6.10 *Thermocouple Probes,* with a range from 0 to 250°F (–18 to 121°C), with a resolution of 0.2°F (0.1°C), and an uncertainty of ±1.0°F (±0.6°C), for measuring temperature of the water entering the combination oven and condensate water entering the drain.

6.11 *Watt-hour Meter,* for measuring the electrical energy consumption of a combination oven, having a resolution of at least 10 Wh and a maximum uncertainty no greater than 1.5 % of the measured value for any demand greater than 100 W. 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 %.

6.12 *Hotel Pans,* for ice loads, solid 12 by 20 by 2½-in. (300 by 500 by 65-mm) stainless steel, weighing 2.8 ± 0.2 lb (1.3 ± 0.1 kg), with a temperature sensor located in the center of each pan ⅝ in. (16 mm) from the bottom. A convenient method is to have Type T thermocouple probes with a stainless-steel protective sheath fabricated in the shape shown in Fig. 1. The sensing point is exposed and isolated thermally from the stainless-steel sheath. The probe is strapped to the pan using steel shim stock welded to the pan using a strain gage welder. The thermocouple lead TFE-fluorocarbon sheath is minimum thickness (TFE-fluorocarbon wrap rather than extruded TFE-fluorocarbon) to minimize the escape of steam where the thermocouple exits the cooking compartment. The lead is long enough to allow connection to the monitoring device while the ice loads are in the freezer, while they are being weighed, and while they are in the oven.

6.13 *2/3 Hotel Pans,* for ice loads, 13.875 by 12.750 by 2.5 in. (352 by 323 by 64 mm) stainless steel, weighing 1.8 ± 0.2 lb (0.8 ± 0.1 kg), with a temperature sensor located in the center of each pan ⅝ in. (16 mm) from the bottom (Fig. 1).

7. Reagents and Materials

7.1 *Water,* incoming water to the appliance shall have a maximum hardness of three grains per gallon and shall be within 70 ± 5°F (21 ± 3°C). If the tester's water supply does not meet the specification, a water softener or tempering kit or both may be required.

7.2 *Red Potatoes,* for the steam mode efficiency tests shall be fresh, whole, US No. 1, Size B, red potatoes. The average weight of the potatoes shall be 0.16 ± 0.02 lb (73 ± 9 g).

NOTE 1—Red potatoes are sold in three sizes: A, B, and C. This test uses Size B.

7.3 *Russet Potatoes,* for the convection mode efficiency tests shall be fresh, whole, prewashed, U.S. No. 1 Russets. Size shall be 100 count. The average weight of the potatoes shall be 0.48 ± 0.02 lb (218 ± 91 g).

7.4 *Steam Pans,* for the steam performance tests on half and full size combination ovens (Specification F1495, Classification Capacity A and B), shall be perforated 12 by 20 by 2½ in. (323 by 508 by 64 mm) stainless steel weighing 2.5 ± 0.5 lb (1.1 ± 0.2 kg).

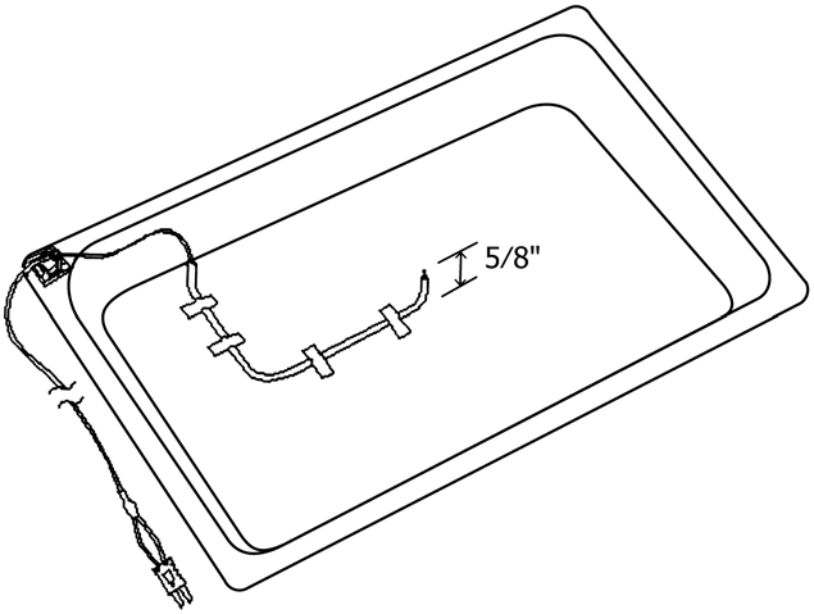

FIG. 1 Hotel Pan with Thermocouple Probe for Ice Loads

7.5 *Shallow Steam Pans,* for the convection performance tests on half and full size combination ovens (Specification F1495, Classification Capacity A and B), shall be perforated 12 by 20 by 1¼ in. (323 by 508 by 32 mm) stainless steel weighing 2.1 ± 0.5 lb (0.95 ± 0.2 kg).

7.6 *Two-Thirds Size Pans,* for testing 2/3-size combination ovens (Specification F1495, Classification Capacity C), shall be 13.875 by 12.750 by 2½ in. (352 by 323 by 64 mm) stainless steel weighing 1.6 ± 0.5 lb (0.7 ± 0.2 kg).

8. Sampling and Test Units

8.1 *Combination Oven*—Select a representative production model for performance testing.

9. Preparation of Apparatus

9.1 Install the appliance according to the manufacturer's instructions under a canopy exhaust hood. Position the combination oven so that a minimum of 6 in. is maintained between the edge of the hood and the vertical plane of the front and sides of the appliance. In addition, both sides of the combination oven shall be a minimum of 3 ft (1.1 m) from any side wall, side partition, or other operating appliance. The exhaust ventilation rate shall be 300 cfm per linear foot (360 L/s per linear meter) of hood length. The associated heating or cooling system shall be capable of maintaining an ambient temperature of 75 ± 5°F (24 ± 3°C) within the testing environment when the exhaust ventilation system is operating.

9.2 Connect the combination 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 combination 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 ±2.5 % of the manufacturer's nameplate voltage.

9.3 For an electric combination oven, confirm (while the combination oven elements are energized) that the supply voltage is within ±2.5 % of the operating voltage specified by the manufacturer. Record the test voltage for each test.

NOTE 2—If an electric combination oven is rated for dual voltage (for example, 208/240 V), the voltage selected by the manufacturer or tester, or both, shall be reported. If an oven is designed to operate at two voltages without a change in the resistance of the heating elements, the performance of the oven (for example, preheat time) may differ at the two voltages.

9.4 For a gas combination oven, 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.

9.5 Install a flowmeter to the combination oven water inlet such that total water flow to the appliance is measured.

9.6 Install temperature sensors at the point where the drain water exits the combination oven and in the drain line such that the sensor is immersed in the condensate water path just as it enters the drain.

9.7 Tape a temperature sensor firmly to the surface of a section of the metal tubing through which city water enters the combination oven.

9.8 Install a water regulator on incoming water lines. Adjust the dynamic water pressure to 45 psi (3.1 bar).

9.9 Determine the test capacity of the combination oven. For half-size (Capacity A) and full-size (Capacity B) combination ovens, the test capacity is equivalent to the manufacturer's stated capacity of standard 12 by 20 by 2½ in. (323 by 508 by 64 mm) hotel pans. For two-third size combination ovens

(Capacity C), the test capacity is the manufacturer' stated capacity of 13.875 by 12.750 by 2½ in. (352 by 323 by 64 mm) hotel pans. This will be the test capacity for all cooking tests (10.6, 10.7, 10.8).

9.10 For countertop (Specification F1495 Type 1) and stand mounted (Specification F1495 Type 2) combination ovens, the pan rack shall remain inside the oven for all tests. For floor model (Specification F1495 Type 3) combination ovens designed for operation with a removable rack trolley, the manufacturer may a provide removable bridge or a second rack trolley to close any remaining gap in the door when the rack is outside the oven during the stabilization period prior to conducting the cooking tests (10.6, 10.7, and 10.8).

10. Procedure

NOTE 3—Prior to starting these tests, the tester should read the operating manual and fully understand the operation of the appliance.

10.1 *General:*

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

10.1.1.1 Higher heating value,

10.1.1.2 Standard gas pressure and temperature used to correct measured gas volume to standard conditions,

10.1.1.3 Measured gas temperature,

10.1.1.4 Measured gas pressure,

10.1.1.5 Barometric pressure, and

10.1.1.6 Energy input rate during or immediately prior to test (for example, during the preheat for that day's testing).

NOTE 4—Using a calorimeter or gas chromatograph in accordance with accepted laboratory procedures is the preferred method for determining the higher heating value of gas supplied to the combination oven under test. It is recommended that all testing be performed with gas having a higher heating value of 1000 to 1075 Btu/ft^3.

10.1.2 For gas combination ovens, add electric energy consumption to gas energy for all tests, with the exception of the energy input rate test (see 10.3).

10.1.3 For electric combination ovens, record the following for each test run:

10.1.3.1 Voltage while elements are energized, and

10.1.3.2 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 combination oven.

10.1.5 For all tests, measure and record the ambient temperature, oven cavity temperature, incoming water temperature and condensate drain temperature.

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 combination oven cooking cavity. For floor mounted (Type 3) combination ovens with a removable rack trolley, place the rack trolley inside the oven.

10.2.2 Set the temperature control to 350°F (177°C); set the controls to operate in the combi mode at maximum humidity; and turn the combination 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 (combination oven) first cycle off.

10.2.3 Calculate and record the combination oven's energy input rate and compare the result to the rated nameplate input. For gas combination ovens, 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 combination 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 combination oven cavity temperature, and record the average temperature over a 15-min period. If this recorded temperature is 350 ± 5°F (177 ± 3°C), then the combination oven's thermostat is calibrated.

10.2.6 If the average temperature is not 350 ± 5°F (177 ± 3°C), adjust the combination oven's temperature control following the manufacturer's operator 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 combination oven energy input rate, fan/control energy rate where applicable, and rated nameplate input.

10.3 *Preheat Energy Consumption and Time:*

10.3.1 The preheat test shall be run as the first test of the day after allowing the oven to cool down for a minimum of 12 h.

NOTE 5—It is the intent of the preheat test to determine the amount of time for the combination oven to reach a ready-to-cook state in each mode after it has been off for an extended period (for example, overnight). The preheat tests for each mode should be conducted as the first appliance operation on the day of tests for each operating mode (for example, combi, convection, steam).

10.3.2 For floor mounted (Type 3) combination ovens with a removable rack trolley, place the rack trolley inside the oven.

10.3.3 Fill the boiler or reservoir (boiler or water-bath style combination ovens). Record the time required to fill it. Monitor the average temperature of the water as it enters the boiler or reservoir. If the average temperature was not 70 ± 5°F (21 ± 3°C), then allow the filled boiler or reservoir to sit until the temperature is within that range. Temperature of the water in the boiler can be estimated by measuring the boiler surface temperature using a surface temperature probe.

NOTE 6—In some units the filling and heating phases cannot be individually controlled. Heating may start as soon as the water level reaches the minimum while still filling the entire unit.

10.3.4 Verify that the combination oven cavity temperature is 75 ± 5°F (24 ± 3°F). Set the calibrated temperature control to 350°F; set the controls to operate in the combi mode at maximum humidity and the fan set to operate in the maximum speed; and turn the combination oven on.

10.3.5 Record the time, temperature, and energy consumption required to preheat the combination oven, from the time when the unit is turned on until the time when the combination oven cavity reaches a temperature of 350 ± 2°F (177 ± 1°C).

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

10.3.7 After allowing the oven to cool for a minimum of 12 h, determine the preheat energy consumption and time for the oven operating in convection mode. Repeat 10.3.1 through 10.3.6 with the oven set to operate in convection (dry heat) mode, with the fan set to operate at its maximum speed and the oven cavity vent in the closed position.

10.3.8 After allowing the oven to cool for a minimum of 12 h, determine the preheat energy consumption and time for the oven operating in steam mode. Set the oven to steam mode (maximum humidity, maximum fan speed) at a nominal temperature setting of 212°F (100°C), based on the manufacturer controls.

10.3.9 Start the preheat and monitor energy consumption and time as soon as the unit is turned on. For a gas combination oven, the recorded preheat time shall include any delay between the time the unit is turned on and when the burners actually ignite. Preheat is judged complete when the primary burners, elements, or steam coil cycles off or when the steamer compartment reaches 205°F. Record preheat energy consumption, duration, and final temperature.

10.3.10 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:*

NOTE 7—It is the intent of the idle test to determine the average energy and water use under each operating mode (combination, convection and steam), while not cooking food.

10.4.1 For floor mounted (Type 3) combination ovens with a removable rack trolley, place the rack trolley inside the oven.

10.4.2 Determine the idle energy rate in combi mode. Set the temperature controls to maintain the average cavity air temperature at 350 ± 5°F (177 ± 2.8°C) and the oven set to operate in full combi mode (maximum humidity, maximum fan speed), then turn the combination oven on.

10.4.3 Allow the combination oven to stabilize at these settings for 60 min after the burners or elements commence cycling in that mode.

10.4.4 At the end of 60 min stabilization period, begin recording the elapsed time, oven cavity temperature, and combination oven energy and water consumption for a minimum of 3 h.

10.4.5 At the end of the 3-h test, stop saving data, turn off the oven and open the door to cool and vent the cavity. Leave the door open for a minimum of 10 min to allow the cavity to fully vent before running additional idle tests.

10.4.6 Determine the idle energy rate in convection mode. Set the oven to operate in convection (dry heat) mode, with the fan set to operate at its maximum speed and the oven cavity vent in the closed position. Turn the oven on and repeat 10.4.3 through 10.4.5.

10.4.7 Determine the idle energy rate in steam mode. Set the oven to operate in steam mode (maximum humidity, maximum fan speed) at a nominal 212°F (100°C). Turn the oven on and repeat 10.4.3 through 10.4.5.

10.4.8 In accordance with 11.6, calculate and report the combination oven's idle energy rate and water consumption rate in each operating mode.

10.5 *Pilot Energy Rate (if applicable, for standing pilots):*

10.5.1 For a gas combination oven with a standing pilot, set the gas valve at the "pilot" position, and set the combination 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 8 h of pilot operation.

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

10.6 *Steam Mode Cooking Energy Efficiency:*

10.6.1 The steam mode cooking energy efficiency test shall be repeated a minimum of three times. Additional test runs may be necessary to obtain the required precision for the reported test results (Annex A1). The reported values of cooking energy efficiency, production capacity, cooking energy rate, condensate temperature, and water consumption shall be the average of the replications (runs).

10.6.2 For half-size (Capacity A) and full-size (Capacity B) combination ovens, the steam pans as specified in 7.4 shall be used for the steam mode cooking-energy efficiency tests. For two-thirds size (Capacity C) combination ovens the steam pans specified in 7.6 shall be used for the steam mode cooking-energy efficiency tests.

10.6.3 Number each steam pan and record the weight of each (empty) steam pan.

10.6.4 Prepare a minimum number of loads for three test runs. For half-size (Capacity A) and full-size (Capacity B) combination ovens, load each steam pan with 8.0 ± 0.2 lb (3.6 ± 0.1 kg) of red potatoes (7.2). Each pan shall contain between 48 and 52 red potatoes (see Fig. 2). For two-thirds size (Capacity C) combination ovens, load each steam pan with 5.3 ± 0.2 lb (2.4 ± 0.1 kg) of red potatoes (7.2). Each pan shall contain between 32 and 36 red potatoes. Record the actual weight and count of the potato load in each pan.

NOTE 8—If the weight of the potatoes on a pan is outside the 8.0 ± 0.2 lb (3.6 ± 0.1 kg) weight range specified above, substitute smaller or larger potatoes, as necessary, until the weight of the potatoes on each pan is within the required weight range while maintaining a count of 50 ± 2 potatoes per pan.

10.6.5 If the combination oven has a removable rack trolley, the rack trolley shall remain outside the oven until loading takes place (10.6.10). A manufacturer-supplied bridge or supplemental rack trolley may be required. Refer to the oven operator's manual.

10.6.6 For half-size (Capacity A) and full-size (Capacity B) combi ovens, randomly select 20 potatoes from the potato load for temperature monitoring, such that the monitored potatoes are located on each level of the combination oven, from top to bottom. For ⅔-size (Capacity C) combi ovens, select 10 potatoes from the potato load for temperature monitoring.

NOTE 9—For a given pan, monitor potatoes at different combinations of locations for each test run. For example, if for Run No. 1, potatoes on Pan No. 5 are monitored at Location Nos. 5, 17, and 29, potatoes on this pan