Designation: F 2140 – 01

Standard Test Method for Performance of Hot Food Holding Cabinets[1]

This standard is issued under the fixed designation F 2140; 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 preheat energy consumption and idle energy consumption of hot food holding cabinets. The food service operator can use this evaluation to select a hot food holding cabinet and understand its energy performance, temperature uniformity, and relative humidity (if applicable). A hot food holding cabinet is described as a commercial kitchen appliance that is used to hold hot food (usually no greater than 200°F) that has been cooked in a separate appliance at a specified temperature.

1.2 This test method is applicable to electric hot food holding cabinets.

1.3 The hot food holding cabinet can be evaluated with respect to the following (where applicable):

1.3.1 Energy input rate (10.2),

1.3.2 Temperature calibration (10.3),

1.3.3 Preheat energy consumption and time (10.4),

1.3.4 Energy consumption (idle energy rate) (10.5),

1.3.5 Energy consumption with water (humidity pan) device and relative humidity (if applicable) (10.5) and

1.3.6 Temperature uniformity (10.5).

1.4 The values stated in inch-pound units are to be regarded as standard.

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 *ASHRAE Document:*[2]

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

2.2 *NSF Standard:*[3]

Standard Number 4—Commercial Cooking, Rethermalization, and Powered Hot Food Holding and Transport Equipment

3. Terminology

3.1 *Definitions:*

3.1.1 *energy input rate*, *n*—peak rate at which a hot food holding cabinet consumes energy (kW), typically reflected during preheat.

3.1.2 *holding cavity*, *n*—that portion of the appliance in which food products are held.

3.1.3 *hot food holding cabinet*, *n*—an appliance that is designed to hold hot food that has been cooked in a separate appliance at a specified temperature.

3.1.4 *idle energy rate—dry*, *n*—the rate of energy consumed (kW) by the hot food holding cabinet while "idling" the holding cavity at the control set point without using the humidity generating device, if applicable.

3.1.5 *idle energy rate—wet*, *n*—the rate of energy consumed (kW) by the hot food holding cabinet while "idling" the holding cavity at the control set point while generating humidity, if applicable.

3.1.6 *preheat energy*, *n*—amount of energy consumed by the hot food holding cabinet while preheating the cabinet from ambient room temperature (75 ± 2.5°F) to 150°F, with the control(s) set to a calibrated 150°F.

3.1.7 *preheat rate*, *n*—average rate (°F/min) at which the hot food holding cabinet is heated from ambient temperature (75 ± 2.5°F) to 150°F, with the control(s) set to a calibrated 150°F.

3.1.8 *preheat time*, *n*—time required for the hot food holding cabinet to preheat from ambient room temperature (75 ± 2.5°F) to 150°F, with the control(s) set to a calibrated 150°F.

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

3.1.10 *water device*, *n*—a humidity pan or similar water-holding vessel, which is filled with water, that is built into the cabinet.

4. Summary of Test Method

4.1 The hot food holding cabinet is connected to the appropriate metered energy source, and energy input rate is determined to confirm that the appliance is operating within 5 % of the nameplate energy input rate.

4.2 The accuracy of the hot food holding cabinet's temperature control is checked at 150°F and adjusted as necessary to within ± 5°F.

[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] Available from the American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc., 1791 Tullie Circle, NE, Atlanta, GA 30329.

[3] NSF International, PO Box 130140 Ann Arbor, MI 48113-0140.

4.3 The amount of energy and time required to preheat the hot food holding cabinet to 150°F, based on a calibrated 150°F set point, is determined.

4.4 The rate of idle energy consumption is determined with the hot food holding cabinet set to maintain 150°F with no food load and no humidity generation.

4.5 The rate of idle energy consumption with water device and relative humidity (if applicable) with no food load.

4.6 The degree of temperature stratification at 150°F is determined.

5. Significance and Use

5.1 The energy input rate and thermostat calibration tests are used to confirm that the hot food holding cabinet is operating properly prior to further testing.

5.2 Preheat energy and time can be useful to food service operators to manage energy demands and to know how quickly the hot food holding cabinet can be ready for operation.

5.3 Energy consumption (idle energy rate) can be used by the food service operator to estimate energy consumption during operating periods.

5.4 Energy consumption (idle energy rate) with the water device can be used by the food service operator to estimate energy consumption during operating periods with the humidity device.

5.5 The relative humidity percentage can be used by operators to select a hot food holding cabinet that will meet their food-holding needs.

5.6 The temperature uniformity can be used by operators to choose a hot food cabinet that meets their food-holding needs.

6. Apparatus

6.1 *Data Acquisition System*, for measuring energy and temperatures, capable of multiple channel displays updating at least every 2 s.

6.2 *Humidity Measuring Device*, with an operating temperature range of 60 to 180°F, with an accuracy of ± 2 % relative humidity.

6.3 *Stop Watch*, with a 1-s resolution.

6.4 *Thermocouple(s)*, industry standard type T or type K thermocouple wire connected at the exposed ends by tightly twisting or soldering the two wires together, with a range of 0 to 250°F and an uncertainty of ± 1°F.

6.5 *Watt-Hour Meter*, for measuring the electrical energy consumption of a hot food holding cabinet, shall have a resolution of at least 10 W·h 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 W·h and a maximum uncertainty no greater than 10 %.

7. Reagents and Materials

7.1 *Aluminum Sheet Pans*, measuring 18 × 26 × 1 in. for the idle tests. (Pans measuring 13 × 18 × 1 in. may be used for smaller units if the larger pans do not fit).

8. Sampling, Test Units

8.1 *Hot Food Holding Cabinet*—Select a representative production model for performance testing.

9. Preparation of Apparatus

9.1 Install the hot food holding cabinets 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. The associated heating or cooling system for the space shall be capable of maintaining an ambient temperature of 75 ± 2.5°F within the testing environment.

9.2 Connect the hot food holding cabinet to a calibrated energy test meter. 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 Confirm (while the 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 1—It is the intent of the testing procedure herein to evaluate the performance of a hot food holding cabinet at its rated 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 and/or tester shall be reported. If a hot food holding cabinet 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 Assure that the hot food holding cabinet's vent (if applicable) is closed for all tests.

9.5 For the preheat test and the idle test, each tested cabinet will have a minimum of three thermocouples regardless of the physical size of the unit. All thermocouple placements are to be centered front to back and side to side. These three minimum thermocouple locations are: 5 ± ½ in. from the top, 5 ± ½ in. from the bottom, and in the geometric center (± ½ in.) of the cabinet. See example in Fig. 1.

NOTE 2—The thermocouple placement in 9.5 is in accordance with NSF Standard 4.

9.5.1 For the idle energy consumption rate test, additional temperatures shall be measured with no more than 12 in. vertically between adjacent measuring points, centered side to side and front to back.

NOTE 3—For example, a hot food holding cabinet (measured approximately 58 in. inside the cavity, top to bottom) will have the initial minimum three thermocouples per 9.5. This leaves a 24-in. space between both the top and/or bottom thermocouples and the center thermocouple. Dividing the space (24 in.) by 12 in. results in 2 sections of 12 in. where the additional thermocouples can be placed (1 additional thermocouple in each 24-in. section) . Installing additional thermocouples results in thermocouple placement every 12 in., for a total of 5 thermocouples in a full-size hot food holding cabinet. A half-size hot food holding cabinet (measured approximately 24 in. inside the cavity, top to bottom) will have the minimum of three thermocouples. Since the space between either the top or bottom thermocouples and the center thermocouple is already 7 in., it does not require additional thermocouples.

9.5.2 For the idle energy consumption test, install a relative humidity sensor in the geometric center of the hot food holding cabinet.

9.6 The idle energy consumption test will use sheet pans. One sheet pan is to be placed in the cabinet for each vertical

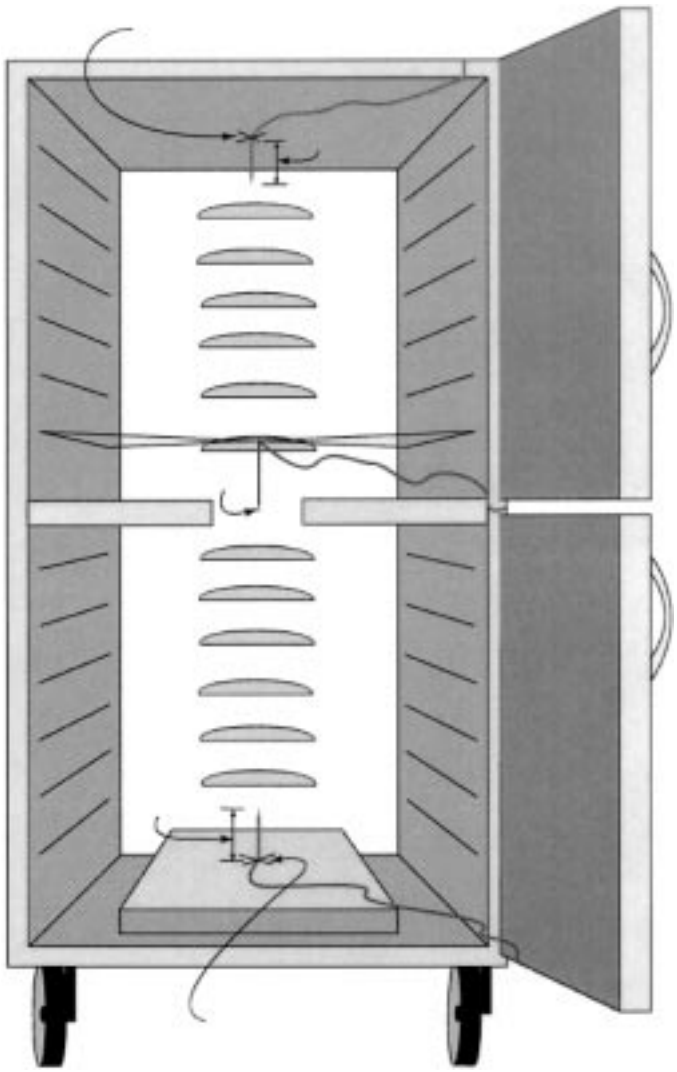

FIG. 1 Placement of Thermocouples

foot. Measure the inside of the cavity from top to bottom and divide by 12. This will determine the number of sheet pans required for the idle energy test.

10. Procedure

10.1 *General*:

10.1.1 For the hot food holding cabinets, record the following for each test run:

10.1.1.1 Voltage while elements are energized,

10.1.1.2 Ambient temperature, and

10.1.1.3 Energy input rate during or immediately prior to each test run.

10.1.2 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 hot food holding cabinet.

10.2 *Energy Input Rate*:

10.2.1 Set the temperature controls to 150°F and turn on the hot food holding cabinet.

10.2.2 Start recording time and energy consumption when the elements are energized and stop recording when the elements commence cycling (not when the hot food holding cabinet's ready light comes on).

NOTE 4—A cabinet's ready light is an indication that the cabinet is up to temperature and not an indication of whether the elements are on or drawing power. It is the intent of this Energy Input Rate procedure to monitor the energy during a continuous period when the elements are energized.

10.3 *Temperature Calibration*:

10.3.1 Install a thermocouple at the geometric center of the hot food holding cabinet.

10.3.2 Set the controls to maintain a cabinet temperature of 150°F and turn the unit on. Stabilize for 60 min after the elements commence cycling at the thermostat set point.

NOTE 5—If the temperature dial does not have a temperature scale (for example, 70 to 200°F), but instead has a numbered setting dial (for example, 1 to 10) use a best guess estimate at what may be 150°F for the initial thermostat calibration setting and adjust as necessary thereafter.

10.3.3 Monitor and record the cavity temperature every 30 s for a minimum of 1 h. Average these recorded temperatures.

10.3.4 As required (as indicated by the average temperature), adjust the temperature control(s) to attain an actual

holding cavity temperature of 150 ± 5°F. Repeat 10.3.3 to confirm that the cavity temperature is 150 ± 5°F.

10.3.5 To facilitate further testing, mark on the dial the exact position of the thermostat control(s) that corresponds to an average holding cavity temperature of 150 ± 5°F . Record the final control setting.

10.4 *Preheat Energy Consumption and Time*:

NOTE 6—The preheat test should be conducted as the first appliance operation on the day of the test, starting with the holding cavity at room temperature (75 ± 2.5°F).

10.4.1 Assure that there are no sheet pans in the cabinet.

NOTE 7—The preheat test requires that no sheet pans are in the hot food holding cabinet.

10.4.2 Record oven cavity temperature and ambient temperature at the start of the test. The cavity temperature shall be 75 ± 2.5°F at the start of the test.

10.4.3 Turn the unit on with control(s) set to maintain 150°F at each thermocouple, as determined in 10.3.5.

10.4.4 Record the cavity temperature over a minimum of 5-s intervals during the course of preheat.

10.4.5 Record the energy and time to preheat the hot food holding cabinet. Preheat is judged complete when the temperature at the geometric center of the cabinet reaches 150°F, as indicated by the thermocouple.

10.5 *Energy Consumption (Idle Energy Rate—Dry)*:

NOTE 8—The idle test may be conducted immediately following the preheat test (10.4). In addition, testing at Pacific Gas and Electric's Food Service Technology Center has determined that the ambient temperature during the idle energy consumption test can affect the energy usage; therefore, it is important to record the average ambient temperature during testing.

10.5.1 Preheat the hot food holding cabinet to 150°F.

10.5.2 Place the sheet pans as determined in 9.6 into the predetermined positions and center front to back and side to side (if applicable).

10.5.3 Stabilize the hot food holding cabinet for 2 h after the sheet pans have been inserted.

10.5.4 Begin recording the hot food holding cabinet's temperature and energy consumption for an additional 3 h while the hot food holding cabinet is operated in this condition with the sheet pans.

NOTE 9—Idle energy consumption rate can be used to calculate real-world energy usage. It has been determined at Pacific Gas and Electric's Food Service Technology Center that the energy consumption of an empty hot food holding cabinet and a fully loaded (with food) cabinet are very similar.

10.6 *Energy Consumption (Idle Energy Rate—Wet)*:

10.6.1 Preheat the hot food holding cabinet to 150°F.

10.6.2 Place the sheet pans as determined in 9.6 into the predetermined positions and center front to back and side to side (if applicable).

10.6.3 Fill the water device (humidity pan) with 70 ± 2°F water to the full mark (if applicable) or to 90 % of the pan capacity. If the unit being tested has a separate control for humidity generation, turn the control to the highest setting.

10.6.4 Stabilize the hot food holding cabinet for 2 h after the sheet pans have been inserted and the water-generating device has been activated and filled with water.

10.6.5 Begin recording the hot food holding cabinet's temperature, humidity, and energy consumption for an additional 3 h while the hot food holding cabinet is operated in this condition with the sheet pans and water generating device.

11. Calculation and Report

11.1 *Test Hot Food Holding Cabinet*:

11.1.1 Summarize the physical and operating characteristics of the hot food holding cabinet. If needed, describe other design or operating characteristics that may facilitate interpretation of the test results.

11.2 *Apparatus and Procedure*:

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

11.2.2 Report the voltage for each test.

11.3 *Energy Input Rate*:

11.3.1 Report the manufacturer's nameplate energy input rate in kW for the electric hot food holding cabinet.

11.3.2 For the hot food holding cabinets, calculate and report the measured energy input rate (kW) based on the energy consumed by the hot food holding cabinet during the period of peak energy input according to the following relationship:

$$q_{input} = \frac{E \times 60}{t} \quad (1)$$

where:

q_{input} = measured peak energy input rate, kW,
E = energy consumed during period of peak energy input, kW·h, and
t = period of peak energy input, min.

11.3.3 Calculate and report the percent difference between the manufacturer's nameplate energy input rate and the measured energy input rate.

11.4 *Temperature Calibration*:

11.4.1 For the as-received condition, report the holding cavity temperature (at the geometric center of the cabinet) that corresponds to the 150°F setting on the hot food cabinet's thermostat control.

11.4.2 Report any discrepancies greater than 5°F between the temperature indicated by the hot food cabinet's control and the 150°F hot food cabinet cavity temperature.

11.5 *Preheat Energy and Time*:

11.5.1 Report the preheat energy consumption (kWh) and preheat time (min).

11.5.2 Calculate and report the average preheat rate (°F/min) based on the preheat period. Also report the starting temperature of the holding cavity.

11.5.3 Generate a graph showing the holding cavity temperature versus time based on the preheat period.

11.6 *Energy Consumption (Idle Energy Rate) With and Without Humidity*:

11.6.1 Calculate and report the idle energy consumption rate (kW) based on:

$$q_{idle} = \frac{E \times 60}{t} \quad (2)$$

where:

q_{idle} = energy consumption (idle energy rate), kW,
E = energy consumed during the test period, kW·h, and
t = test period, min.

11.6.2 Calculate and report the idle energy consumption rate (kW) with water in the humidity pan (water device) based on:

$$q_{idle,w} = \frac{E \times 60}{t} \quad (3)$$

where:
$q_{idle,w}$ = energy consumption (idle energy rate) with water in the humidity vessel, kW,
E = energy consumed during the test period, kW·h, and
t = test period, min.

11.6.3 Report the number of thermocouples used in the idle energy consumption rate test. Also report the number of sheet pans used in the idle energy consumption rate test stratification.

11.6.4 Report the greatest temperature differences between the thermocouples during the idle energy consumption rate test.

11.6.5 Report the average relative humidity from the 36 measurements taken.

12. Precision and Bias

12.1 *Precision*

12.1.1 *Repeatability* (within laboratory, same operator and equipment).

12.1.1.1 The repeatability for each reported parameter is being determined.

12.1.2 *Reproducibility* (multiple laboratories).

12.1.2.1 The interlaboratory precision of the procedure in this test method for measuring each reported parameter is being determined.

12.2 *Bias*

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

13. Keywords

13.1 hot food holding cabinet; idle energy consumption; preheat time and energy consumption

APPENDIX

(Nonmandatory Information)

X1. RESULTS REPORTING SHEETS

X1.1

Manufacturer _____
Model _____
Date _____
Test Reference Number (optional ____

Section 11.1 Test Hot Food Holding Cabinet

Description of operational characteristics:

_____
_____
_____
_____
_____
_____
_____

Section 11.2 Apparatus

_____ Check if testing apparatus conformed to specifications in Section 6.
Deviations:

_____
_____
_____
_____
_____
_____

Section 11.3 Energy Input Rate

Test Voltage (V) _____
Measured (kW) _____
Rated (kW) _____
Percent Difference between Measured and Rated (%) _____

Section 11.4 Thermostat Calibration

As-Received:
Temperature Control Setting (°F) 150
Cavity Temperature (°F) _____
As-Adjusted:
Temperature Control Setting (°F) _____
Cavity Temperature (°F) _____

Section 11.5 Preheat Energy and Time

Test Voltage (V) _____
Starting Temperature (°F) _____
Energy Consumption (kW h) _____
Duration (min) _____
Preheat rate (°F/min) _____

FIG. X1.1 Results Reporting Sheet

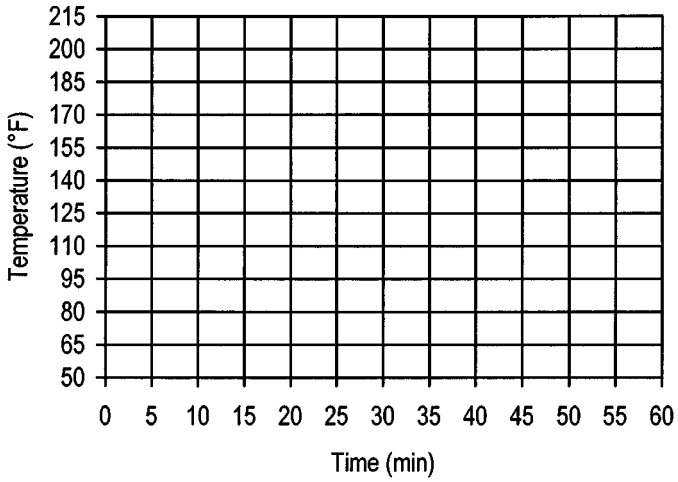

FIG. X1.2 Preheat Curve

Section 11.6 Energy Consumption (Idle Energy Rate)

	Without Water	With Water
Test Voltage (V)		
Energy Consumption @ 150°F (kW)		
Ambient Temperature for Energy Consumption Test (°F)		
Number of Thermocouples		
Number of Sheet Pans		
Average Temperature at Top of Cabinet (°F)		
Average Temperature at Center of Cabinet (°F)		
Average Temperature at Bottom of Cabinet (°F)		
Additional Average Temperatures (°F)		
Maximum Temperature Difference (°F)		
Average Relative Humidity (%)	N/A	

Fig. X1.3 Idle Energy Results Table