Designation: F 2143 – 01

An American National Standard

Standard Test Method for Performance of Refrigerated Buffet and Preparation Tables[1]

This standard is issued under the fixed designation F 2143; 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 evaluation of the energy consumption and refrigeration performance of refrigerated buffet and preparation tables. The food service operator can use this evaluation to select a refrigerated buffet and preparation table and understand its energy performance.

1.2 This test method is applicable to electric self-contained refrigerators used for holding and displaying refrigerated food in an open area.

1.3 The refrigerated buffet and preparation table can be evaluated with respect to the following (where applicable):

1.3.1 Maximum energy input rate, or maximum current draw (10.1),

1.3.2 Thermostat calibration (10.4), and

1.3.3 Holding energy rate (10.5).

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 *NSF Standard:*[2]

NSF, Listing-Food Equipment and Related, Components and Material

ANSI/NSF 7-1997 Commercial Refrigerators and Freezers

2.2 *ASHRAE Guideline:*[3]

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

2.3 *ANSI/ASHRAE Standards:*[4]

ANSI/ASHRAE 117 Method of Testing Closed Refrigerators

ANSI/ASHRAE 72 Method of Testing Open Refrigerators for Food Stores

2.4 *Food and Drug Administration, U.S. Public Health Service Regulation:*[5]

Food Code, 1999

3. Terminology

3.1 *Definitions:*

3.1.1 *box car average*, *n*—a location's thermocouple temperature averaged over a 1-h period. During the 4-h holding energy rate test, thermocouple temperatures are recorded at 5-min intervals. The first box car average is the average of readings 1 through 12. The second box car average is the average of temperature readings 2 through 13, and so on.[6]

3.1.2 *energy input rate*, *n*—peak rate at which a refrigerated buffet and preparation table consumes energy (kW).

3.1.3 *holding energy rate*, *n*—average rate of energy consumption (kW) during the holding energy efficiency tests. Refers to energy rate with synthetic food load.

3.1.4 *production capacity*, *n*—maximum volumetric storage capacity [ft^3(m^3)] at which the refrigerated buffet and preparation table's open display area can hold using a specified container filled to ½ in. of the container rim.

3.1.5 *refrigerated buffet and preparation table*, *n*—buffet/preparation table herein.

3.1.6 *refrigerated buffet table or unit*, *n*—equipment designed with mechanical refrigeration that is intended to receive refrigerated food and maintain food product temperatures and is intended for customer service such as a salad bar. A unit may or may not be equipped with a lower refrigerated compartment.[6]

3.1.7 *refrigerated food preparation unit*, *n*—equipment designed with a refrigerated open top or open condiment rail such as refrigerated sandwich units, pizza preparation tables, and similar equipment. The unit may or may not be equipped with a lower refrigerated compartment.[6]

3.1.8 *self-contained refrigerator*, *n*—a refrigerator whose condensing unit is attached as an integral component of the unit.[6]

[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 NSF International, P.O. Box 130140, Ann Arbor, MI 48113-0140.

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

[4] Available from American National Standards Institute, 1819 L St., NW, Ste 600, Washington, DC 20036

[5] Available from National Technical Information Services, 5285 Port Royal Road, Springfield, VA 22161.

[6] Based on ANSI/NSF 7, available from NSF International, P.O. Box 130140, Ann Arbor, MI 48113-0140.

3.1.9 *storage refrigerator or freezer*, *n*—a refrigerator or freezer designed for cold storage of nonfrozen or frozen foods.

3.1.10 *storage capacity*, *n*—maximum volumetric storage capacity [ft^3(m^3)] as determined by the manufacturer at which the refrigerated buffet or preparation table's storage component can hold food.

3.1.11 *test method*, *n*—a definitive procedure for the identification, measurement, and evaluation of one or more qualities, characteristics, or properties of a material, product, system, or service that produces test results.

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 Energy input rate is determined to confirm that the buffet/preparation table is operating within 5 % of the nameplate energy input rate.

4.2 Holding energy rate is determined.

4.3 Production capacity is determined.

5. Significance and Use

5.1 The energy input rate test is used to confirm that the buffet/preparation table is operating properly prior to further testing.

5.2 Holding energy rate is a precise indicator of buffet/preparation table energy performance under the test loading condition. This information enables the food service operator to consider energy performance when selecting a buffet/preparation table.

5.3 Production capacity is used by food service operators to choose a buffet/preparation table that matches their food output requirements.

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.

6.2 *Electric Mixer*, for mixing ingredients of the synthetic food. Mixer can be handheld or stand mounted. The synthetic food is used to evaluate the performance of the open top section of the refrigeration equipment.

6.3 *Hotel Pans*, for holding synthetic food and water loads. Both standard 4-in.–deep half-size and full-size pans or manufacturer specified pans are used in this standard. Pans are to be constructed of stainless steel (unless manufacturer specifies an alternative) with nominal dimensions of 12 × 20 × 4 in. (300 × 500 × 102 mm) or 122 × 10 × 4 in. (300 × 250 × 102 mm) solid pans. The buffet/preparation table manufacturer may provide alternative pans if table is designed to be used with alternative pans. Pans for holding water loads for preconditioning the appliance must be equipped with a thermocouple for water temperature measurement. An example of a typical setup using Type T thermocouple probes with a stainless-steel protective sheath is 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 lead is long enough to allow connection to the monitoring device while the pans are in the refrigerator.

6.4 *Hydrometer*, for measuring the atmospheric humidity within the test environment.

6.5 *Platform Balance Scale*, or appropriate load cells, to be used for weighing synthetic food to determine the production capacity of table. The scale shall have the capacity to accommodate the total weight of the hotel pans when loaded with synthetic food.

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

6.7 *Thermocouple Probe*, capable of immersion with a range of 30° to 50°F and an uncertainty of ± 1°F. Preferably industry standard type T or type K thermocouples.

6.8 *Watt-Hour Meter*, for measuring the electrical energy consumption of a buffet/preparation table, shall have a resolution of at least 1 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 1 W·h and a maximum uncertainty no greater than 10 %.

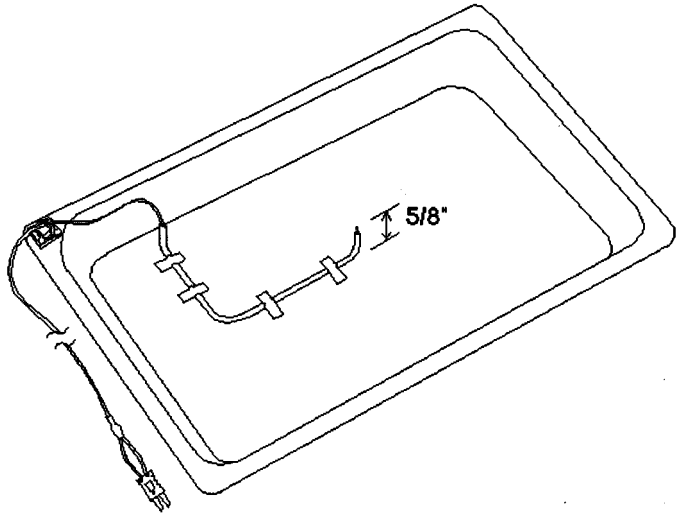

FIG. 1 Hotel Pan With Thermocouple Probe for Preconditioning Load

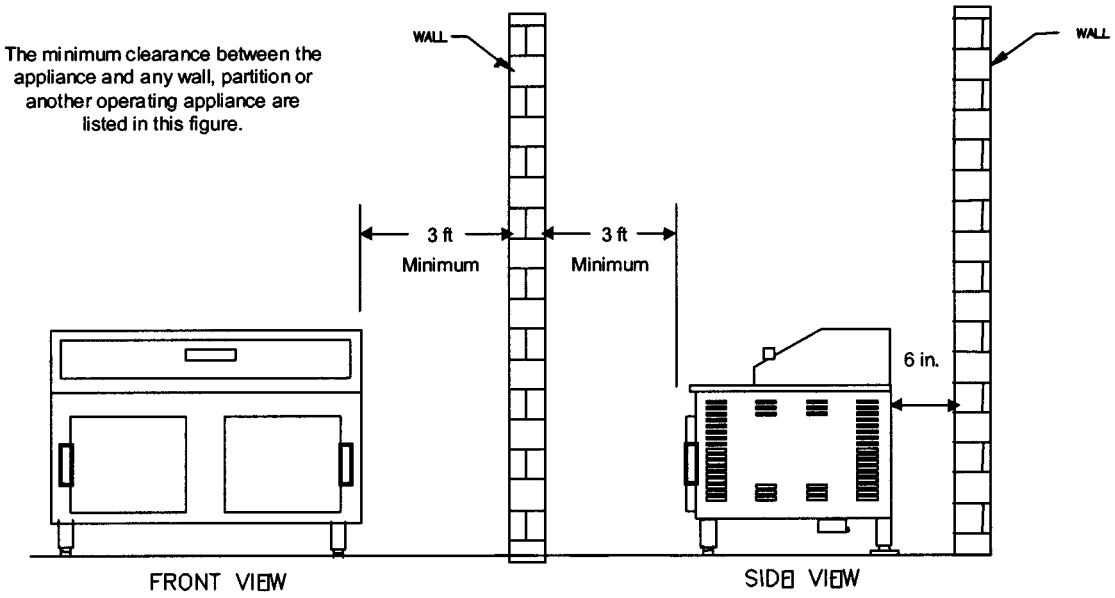

FIG. 2 Example of Appliance Placement

6.9 *Velocity Meter*, for measuring air velocity around the buffet/preparation table.

NOTE 1—Pacific Gas and Electric Company found 10-ft (3-m) sensor leads allowed for flexibility in test equipment setup while still being manageable (tangle free).

7. Reagents and Materials

7.1 *Water* used shall have a maximum hardness of 3 grains per gallon. Distilled water may be used.

7.2 Sodium chloride (salt).

7.3 Hydroxypropyl methylcellulose[7].

8. Sampling, Test Units

8.1 *Buffet/Preparation Table*—Select a representative production model for performance testing.

9. Preparation of Apparatus [6]

9.1 Install the buffet/preparation table according to the manufacturer's instructions. Position the buffet/preparation table so that there is 6 in. clearance maintained between a back wall and the back vertical plane of the buffet/preparation table. In addition, both sides of the buffet/preparation table shall be a minimum of 3 ft from any side wall, side partition, or other operating buffet/preparation table (see Fig. 2). Walls can be portable or suspended from ceiling. There shall be a minimum of 3 ft of clearance between the front vertical plane of the buffet/preparation table and any wall or partition. If manufacturer's instructions require additional clearance between buffet/preparation table and walls, then use the manufacturer's clearance recommendations in place of clearances listed above. Report appliance placement relative to test room walls in results reporting section. The associated heating or cooling system shall be capable of maintaining an ambient temperature of 73 ± 3°F (22 ± 2°C) during preconditioning of the buffet/preparation table and 86 ± 2°F (30 ± 1°C) during energy tests within the testing environment.

9.2 The testing environment during energy tests shall be maintained as per ANSI/NSF 7 standard section on performance for refrigerated buffet units and refrigerated food preparation units room (test chamber) specifications. ANSI/NSF 7-1999 test room conditions are ambient temperature of 86 ± 2°F (30 ± 1°C), no vertical temperature gradient exceeding 1.5°F/ft (2.5°C/m), maximum relative humidity of 50 % and maximum air current velocity of 50 ft/min (0.25 m/s) across the surfaces of the test pans.

9.3 Connect the buffet/preparation table 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.

9.4 Confirm (while the buffet/preparation table compressor(s) 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.

9.5 Instrument hotel pans to be loaded in open display area as described in 10.2. The manufacturer may supply other pans to be used in energy test, these pans must also be instrumented with thermocouples as specified in 10.2.

NOTE 2—It is the intent of the testing procedure herein to evaluate the performance of a buffet/preparation table at its rated voltage. If a unit is rated for 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 buffet/preparation table is designed to operate at two voltages without a change in components, the performance of the unit (for example, holding energy rate) may differ at the two voltages.

9.6 If the buffet/preparation table is equipped with a refrigerated compartment, the compartment air temperature shall be

[7] The sole source of supply of hydroxypropyl methylcellulose known to the committee at this time is METHOCEL K4M (standard grade), available from Dow Chemical, 2040 Willard H. Dow Circle, Midland, MI 48674. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsibl technical committee, which you may attend.

monitored to evaluate the buffet/preparation table's ability to maintain the air temperature between 33°F (1°C) and 40°F (4°C). The compartment shall be empty, and three thermocouples shall be used to monitor air temperatures. If the buffet/preparation table is not equipped with a refrigerated compartment then skip steps 9.6.1-9.6.3.

9.6.1 For buffet/preparation tables with refrigerated compartments position thermocouple no. 1 when viewed from the front of the refrigerated table 5 ± 0.25 in (127 ± 6 mm) from the left interior wall. Center the thermocouple in the compartment relative to the front and the back. For refrigerated compartments with overhead cooling, position the thermocouple 2 ± 0.25 in. (51 ± 6 mm) above the bottom horizontal plane of the compartment. For units where the evaporator is not suspended from the ceiling, the thermocouple shall be placed 5 ± 0.25 in. (127 ± 6 mm) down from the ceiling.

9.6.2 Position thermocouple no. 2 centered front-to-back, top-to-bottom, and left-to-right.

9.6.3 Position thermocouple no. 3 when viewed from the front of the refrigerated table 5 ± 0.25 in. (127 ± 6 mm) from the right interior wall and 5 ± 0.25 in. (127 ± 6 mm) above the internal floor of the compartment. Center the thermocouple in the compartment relative to the front and the back.

10. Procedure

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

10.1 *General*:

10.1.1 Record the following for each test run: (*1*) voltage while compressor(s) are energized and (*2*) energy input rate while the compressor(s) are energized.

10.1.2 For each test run, confirm that the peak instantaneous amperage draw rate is below the rated nameplate maximum amperage. If the measured instantaneous amperage is greater than the rated nameplate maximum amperage, terminate testing and contact the manufacturer. The manufacturer may make appropriate changes or adjustments to the buffet/preparation table.

10.2 *Preparation of Synthetic Food*:

10.2.1 Determine whether standard half or full-sized hotel pans or manufacturer specified pans will be used to hold synthetic food in the display (rail) area of the buffet/preparation table. During the holding energy test, thermocouples will measure the temperature of the synthetic food in the pans. Place the pans in display area (rail) of the buffet/preparation table to determine thermocouple placement. Later, when the synthetic food is prepared, the pans will be filled with synthetic food to within ½ in. (13 mm) of the pan's top rim. Note where ½ in. (13 mm) is from the pan's top rim for determining placement of thermocouples. Determine which pans will be placed in the corners of the display area (rail). Place two thermocouples in each of the corner pans and two thermocouples in the pan located in the center of the display area (rail). The two thermocouples in each corner will be positioned no more than ½ in. (13 mm) from the side walls or end walls of the pan. One of the corner thermocouples shall be 1 in. (25 mm) below the surface of the synthetic food while the other thermocouple will be positioned ⅛ in. (3 mm) above the bottom surface of the pan. Position the two center thermocouples as close to the center of the open display area as possible (in the center pan) with one thermocouple at a depth of 1 in. (25 mm) below the surface of the synthetic food and the other thermocouple positioned ⅛ in. (3 mm) above the bottom surface of the pan. Position each center thermocouple no more than ½ in. (13 mm) from the sidewalls or endwalls of the pan. Thermocouple leads should be firmly attached to the pan to prevent movement. The thermocouple leads should be long enough to allow connection to the monitoring device while the pans are in a cooler for conditioning and while they are in the buffet/perparation table. See Fig. 3 for an example of manufacturer-supplied pans with thermocouple probes.

10.2.2 Calculate the test capacity of the pans. The usable test capacity of a pan is the volume measured from the pan bottom to within ½ in. of the rim.

10.2.3 Prepare enough synthetic food to fill standard half-size or full-size hotel pans or the manufacturer-specified pans to within ½ in. of the rim. The following steps and material quantities will produce approximately 4.75 gal (18L) of synthetic food.

10.2.3.1 Dissolve 3.0 oz (93 g) of sodium chloride into 1.59 gal (6 L) of deionized water in a stainless steel kettle. Heat and maintain the solution between 176°F (80°C) and 194°F (90°C).

10.2.3.2 Slowly add 17.94 oz (558 g) of hydroxypropyl methylcellulose to the salt solution while stirring with a paddle or large spoon. Use an electric hand mixer to disperse any lumps that form.

10.2.3.3 When all the hydroxypropyl methylcellulose is dispersed, slowly add 3.33 gal (12.6 L) of cold deionized water to the suspension and stir until the mixture appears smooth and homogenous. An electric mixer may be used at low speed to mix the synthetic food until it appears smooth and homogenous.

10.2.3.4 As soon as the synthetic food is finished mixing, pour into the instrumented pans. Fill the pans to ½ in. (13 mm) of the rim. If the pans are to be used in a tilted display, fill the pans so that when tilted, the synthetic food at the bottom of the pan is ½ in. (13 mm) below the rim. Cover each pan and refrigerate. Maintain the synthetic food temperature at 35 ± 2°F (2 ± 1°C) until loading the pans into the test unit.

10.3 *Preconditioning Buffet/Preparation Table for the Holding Energy Test*[6]:

10.3.1 Fill the 4-in. (100 mm) deep half-size or full-sized hotel pans at least half full with cold water. Refrigerate and maintain the hotel pans at 35 ± 2°F (2 ± 1°C).

10.3.2 Place the buffet/preparation table in a test environment (test chamber) maintained at 73 ± 3°F (22 ± 2°C).

10.3.3 Place the chilled hotel pans filled with water into the open display area of the buffet/preparation table. If the unit is equipped with cover(s) for the display area, the cover(s) shall be closed.

10.3.4 Allow the unit to cycle on and off at least two full cycles.

10.4 *Thermostat Calibration*:

10.4.1 If the buffet/preparation table has not been preconditioned, then complete 10.3 first; if the table has been preconditioned, then move to step 10.4.2.

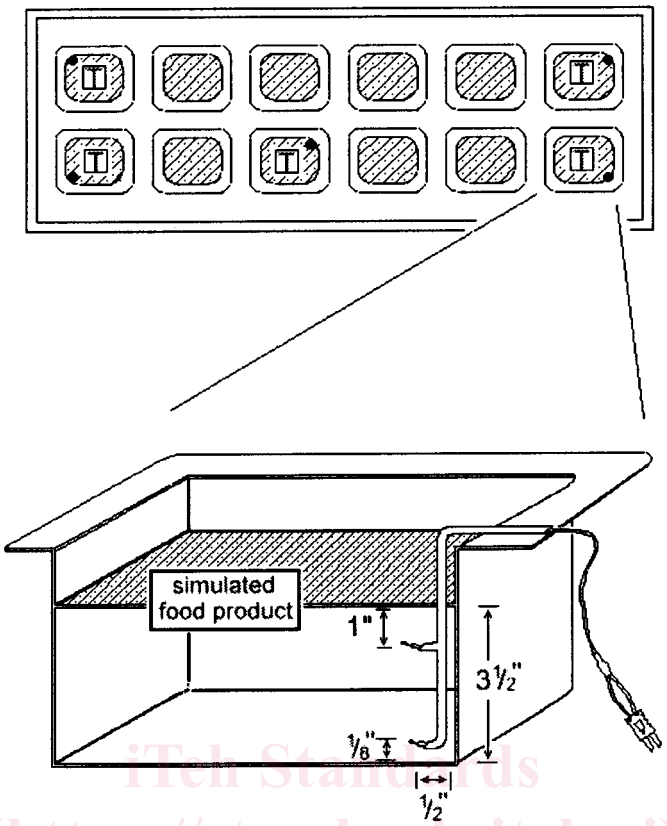

FIG. 3 Example of Manufacturer-Supplied Pan With Thermocouple Probes

10.4.2 Record the water temperature of the pans placed in the open section as the unit cycles on and off for two complete cycles. If the highest water temperature during the two cycles is below 41°F (5°C) and above 39°F (3.9°C), then pre-calibration of thermostat is done. If the highest water temperature during the two cycles is not between 39°F (3.9°C) and 41°F (5°C), then adjust the thermostat accordingly. Repeat adjustment of the thermostat until the highest water temperature during two consecutive complete cycles is between 39°F (3.9°C) and 41°F (5°C). If the highest water temperature during refrigeration cycling is not between 39°F (3.9°C) and 41°F (5°C) after repeated thermostat adjustment, then stop thermostat calibration and contact the manufacturer for assistance.

10.5 *Holding Energy Test*[6]:

10.5.1 Establish and maintain the test room (test chamber) conditions of 86 ± 2°F (30 ± 1°C) ambient temperature, no vertical temperature gradient exceeding 1.5°F/ft (2.5°C/m), maximum relative humidity of 50 % and maximum air current velocity of 50 ft/min (0.25 m/s) across the surfaces of the test pans.

10.5.2 Place the refrigerated pans of synthetic food in the display area (rail) and ensure that thermocouples in the pans are positioned as described in 10.2. If the unit is equipped with cover(s) for the display area, then test the unit with the cover(s) in an open position or, if the cover(s) are not designed to remain open, then remove the cover(s) for the duration of the test. Close all refrigerated compartment doors, excluding the display area.

10.5.3 Start the test when the temperature of the synthetic food is verified to be 35 ± 2°F (2 ± 1°C) at each of thermocouples located 1 in. (25 mm) below the surface.

NOTE 4—Stirring the synthetic food in the pans prior to the start of the holding energy test can eliminate temperature stratification within the pan.

10.5.4 Record the temperature of the ten thermocouples in the synthetic food every 5 min over the 4-h test period. For each thermocouple location, its box car average must be above 33°F (1°C) and below 41°F (5°C) for the duration of the test. If the temperature of any box car average records outside of the 33°F (1°C) to 40°F (4°C) temperature range, then adjust the thermostat accordingly and repeat test. Record the unit's compressor on-time during the 4-h test period. Refer to 11.6 to calculated percent compressor run time. Refer to 11.7 to calculate box car averages.

10.5.5 Record the temperature of each of the three thermocouples in the empty refrigerated compartment (if unit is equipped with a refrigerated compartment) every 5 min over the 4-h test period. Each thermocouple must be above 33°F (1°C) and below 40°F (4°C) for the duration of the test. If the temperature of any of the thermocouples records outside of the 33°F (1°C) to 40°F (4°C) temperature range then adjust the thermostat accordingly and repeat the test.

11. Calculation and Report

11.1 *Test Buffet/Preparation Table*:

11.1.1 Summarize the physical and operating characteristics of the buffet/preparation table. 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.

11.3.2 Calculate and report the measured energy input rate (kW) based on the energy consumed by the buffet/preparation table 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 *Holding Energy Rate*:

11.4.1 Report the average holding energy rate based on a minimum of three test runs.

11.4.2 Calculate and report the holding energy rate based on:

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

where:

$q_{holding}$ = holding energy rate, kW,
E = energy consumed during the test period, kWh, and
t = test period, min.

11.4.3 Describe the thermocouple locations in the refrigerated display area (rail) and the refrigerated compartment (if applicable).

11.5 *Production Capacity*:

11.5.1 Calculate production capacity (ft^3) based on:

$$PC = V \times n \quad (3)$$

where:

PC = production capacity of the buffet/preparation table, $ft^3(m^3)$,
V = total volume of the test pan when filled to within ½ in. of the rim, $ft^3(m^3)$, and
n = total number of pans held in the display area (rail) of the buffet/preparation table.

11.6 *Compressor Run Time*[6]:

11.6.1 Calculate and report compressor run time based on:

$$R = d/D \times 100 \quad (4)$$

where:

R = compressor run time, %,
d = the elapsed time that the compressor is operating during whole number of cycles, min, and
D = the total elapsed time during a whole number of cycles, min.

11.7 *Average Box Car Temperatures*:

11.7.1 Calculate and report average temperatures of the thermocouples in synthetic food.

11.7.2 Each of the 10 thermocouple locations in the synthetic food will be reported as a separate 1-h, moving average called a box car average. Each box car average includes 12 data points (temperature readings). For each thermocouple location, the first 12 collected data points (data points 1 through 12) shall be averaged together to obtain the locations first reported box car average no. 1. The second reported box car average temperature for a location is calculated from averaging its data points 2 through 13; the third reported box car average will be calculated from data points 3 through 14 and so on. Continue to summarize box car averages till the last box car no. 37 (data points 37-48) is calculated. For each of the 10 thermocouple locations, all 37 calculated box car averages shall not exceed 41°F (5°C) nor shall they be less than 33°F (1°C). If the any of the box car averages exceeds 41°F (5°C) or is less than 33°F (1°C), then adjust the thermostat accordingly and retest the buffet/preparation table. If after two retests any of the box car averages still exceeds 41°F (5°C) or is less than 33°F (1°C), stop testing and contact manufacturer for assistance with thermostat calibration.

11.7.3 Report the average temperatures in the refrigerated compartment (if applicable).

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 buffet table; display; energy; energy rate; open refrigeration; performance; preparation table; production capacity; rail; refrigeration; table; test method