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An American National Standard

Standard Test Method for Performance of Conveyor Broilers[1]

This standard is issued under the fixed designation F2239; 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.

~~ε[1] NOTE—Sections 2.2 and 9.4 were editorially corrected in February 2005.~~

1. Scope

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

~~1.2This test method is applicable to gas, electric, and hybrid gas/electric conveyor broilers.~~

1.2 This test method is applicable to gas, electric, and hybrid gas/electric conveyorized broilers. This test method covers both units with continuously operating conveyors and batch-style units with intermittently operating conveyors.

1.3 The conveyor broiler can be evaluated with respect to the following (where applicable):

1.3.1 Energy input rate (see 10.2),

1.3.2 Preheat energy consumption and time (see 10.3),

1.3.3 Idle energy rate and temperature uniformity (see 10.4),

1.3.4 Pilot energy rate (if applicable) (see 10.5), and

1.3.5 Cooking energy efficiency, cooking uniformity and production capacity (see 10.8 and 10.9).

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

1.4 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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

2.2 *ANSI Standard:*[3]

ANSI Z83.11 American National Standard for Gas Food Service Equipment

2.3 *AOAC Documents:*[4]

AOAC Official Action 950.46 Air Drying to Determine Moisture Content of Meat and Meat Products

AOAC Official Action 960.39 Fat (Crude) or Ether Extract in Meat

2.4 *ASHRAE Standard:*[5]

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

3. Terminology

~~3.1*Definitions:*~~

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *broiler cavity*, *n*—that portion of the conveyor broiler in which food products are heated or cooked.

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[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 *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

[4] Available from Association of Official Analytical Chemists, 1111 N. 19th Street, Arlington, VA 22209.

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

3.1.2 ~~*conveyor broiler*~~continuous conveyor, *n*~~—a device, with a continuous belt and a heat source above and below the belt, for cooking food by high heat, usually by direct or radiant heat. Conveyor broilers are used primarily, but not exclusively, for cooking meats.~~ —broiler with a belt or chain that moves constantly through the broiler cavity and does not halt during the cooking process.

3.1.3 *conveyor broiler*, *n*—device, with a continuous belt and a heat source above and below the belt, for cooking food by high heat, usually by direct or radiant heat. Conveyor broilers are used primarily, but not exclusively, for cooking meats.

3.1.4 *cooking energy efficiency*, *n*—quantity of energy imparted to the specified food product, expressed as a percentage of energy consumed by the conveyor broiler during the cooking event.

~~3.1.4~~

3.1.5 *cooking energy rate*, *n*—average rate of energy consumption (Btu/h or kW) during the cooking energy efficiency tests. Refers to both loading scenarios (heavy, light).

~~3.1.5~~

3.1.6 *cooking lane*, *n*—segment of broiler that food product passed through as it cooks. Each position on the conveyor where food product is placed represents a cooking lane.

~~3.1.6~~

3.1.7 *cooking uniformity*, *n*—calculated variation in cooked food product.

~~3.1.7~~

3.1.8 *energy input rate*, *n*—peak rate at which a conveyor broiler consumes energy (Btu/h or kW).

~~3.1.8~~

3.1.9 *idle energy rate*, *n*~~—the conveyor broiler's rate of energy consumption (kW or Btu/h), when empty, required to maintain the broiler's temperature at the specified thermostat set point.~~

~~3.1.9~~*—conveyor broiler's rate of energy consumption (kW or Btu/h), when empty, required to maintain the broiler's temperature at the specified thermostat set point.*

3.1.10 *intermittent conveyor*, *n*—broiler that operates the belt or chain only at the beginning or conclusion of a cooking cycle to move a batch of product through the broiler cavity.

3.1.11 *pilot energy rate*, *n*—rate of energy consumption (Btu/h) by a conveyor broiler's continuous pilot (if applicable).

~~3.1.10~~

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

~~3.1.11~~

3.1.13 *preheat time*, *n*—time (min.) required for the conveyor broiler cavity to preheat from ambient temperature to the specified thermostat set point.

~~3.1.12~~

3.1.14 *production capacity*, *n*—maximum rate (lb/h) at which a conveyor broiler can bring the specified food product to a specified "cooked" condition.

~~3.1.13~~

3.1.15 *production rate*, *n*—rate (lb/h) at which a conveyor broiler brings the specified food product to a specified "cooked" condition. It does not necessarily refer to maximum rate. Production rate varies with the amount of food being cooked.

~~3.1.14*temperature infinity*~~

3.1.16 *temperature uniformity*, *n*—measured variation in broiler cavity temperature.

~~3.1.15~~

3.1.17 *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 conveyor broiler is operating within 5 % of the nameplate energy input rate. For gas and hybrid gas/electric conveyor broilers, the pilot energy rate and control energy rates are also determined (if applicable).

4.2 Preheat energy and time are determined.

4.3 Idle energy rate and temperature uniformity of each broiler cavity is determined while operating at manufacturer's recommended temperature setting.

4.4 Cooking energy efficiency is determined during light-load cooking tests using prefrozen hamburger patties as a food product.

4.5 Cooking energy efficiency, cooking uniformity, and production rate are determined during heavy-load cooking tests using prefrozen hamburger patties as a food product.

5. Significance and Use

5.1 The energy input rate test is used to confirm that the conveyor broiler is operating properly prior to further testing.

5.2 Preheat energy and time can be useful to food service operators to manage power demands and to know how quickly the conveyor broiler 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 Temperature uniformity of the broiler cavity may be used by food service operators to understand the heat distribution throughout the broiler cavity and select a conveyor broiler that matches their required temperature characteristics.

5.5 Cooking energy efficiency is a precise indicator of conveyor broiler energy performance while cooking a typical food product under various loading conditions. If energy performance information is desired using a food product other than the specified test food, the test method could be adapted and applied. Energy performance information allows an end user to better understand the operating characteristics of a conveyor broiler.

5.6 Cooking uniformity of the broiler may be used by food service operates to select a conveyor broiler that provides a uniformly cooked product.

5.7 Production capacity information can help an end user to better understand the production capabilities of a conveyor broiler 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.

6. Apparatus

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

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

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

6.4 *Convection Drying Oven*, temperature controlled at 215 to 220°F (101 to 104°C), used to determine moisture content of both the raw and the cooked food product.

6.5 *Data Acquisition System*, for measuring energy and temperatures, capable of multiple channel displays updating at least every 5 s.

6.6 *Gas Meter*, for measuring the gas consumption of a conveyor broiler, shall be a positive displacement type with a resolution of at least 0.01 ft^3 and a maximum uncertainty no greater than 1 % of the measured value for any demand greater than 2.2 ft^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 and a maximum uncertainty no greater than 2 % of the measured value.

6.7 *Pressure Gage*, for monitoring natural gas pressure. It shall have a range of 0 to 10 in. water, a resolution of 0.5 in. water, and a maximum uncertainty of 1 % of the measured value.

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

6.9 *Temperature Sensor*, for measuring natural gas temperature in the range of 50 to 100°F with an uncertainty of ±1°F.

6.10 *Thermocouple(s)*, high temperature (>1200°F) fiberglass insulated, 24 gage, type K thermocouple wire, welded and calibrated.

6.11 *Watt-Hour Meter*, for measuring the electrical energy consumption of a conveyor broiler, shall have a resolution of at least 10 Wh and a maximum uncertainty no greater than 1.5 % of the measured value for any demand greater than 100 W. For any demand less than 100 W, the meter shall have a resolution of at least 10 Wh and a maximum uncertainty no greater than 10 %.

7. Reagents and Materials

7.1 *Drip Rack*, large enough to hold a full load of hamburger patties in a single layer (25 patties for a 30 in. nominal width broiler), for dripping hamburger patties.

7.2 *Freezer Paper*, waxed commercial grade, 18 in. (460 mm) wide, for use in packaging hamburger patties.

7.3 *Half-Size Sheet Pans*, measuring 18 by 13 by 1 in. (460 by 130 by 25 mm), for use in packaging hamburger patties.

7.4 *Hamburger Patties* shall be prefrozen, four per pound, 20 ± 2 % fat (by weight), finished grind, pure beef patties with a moisture content between 58 and 62 % of the total hamburger weight. The patties shall be machine prepared to produce ⅜-in. (9.5 mm) thick patties with a nominal diameter of 5 in. (127 mm).

NOTE 1—It is important to confirm by laboratory tests that the hamburger patties are within the above specifications because these specifications impact directly on cook time and cooking energy consumption.

7.5 *Permanent Marker*, felt-tip, for labeling plastic bags.

7.6 *Plastic Bags*, self-sealing, 1 gal (3.79 L) size, for collecting cooked hamburger patties.

7.7 *Plastic Wrap*, commercial grade, 18 in. (460 mm) wide, for use in packaging hamburger patties.

7.8 *Tongs*, commercial grade, metal construction, for handling hot hamburger patties.

8. Sampling and Test Units

8.1 *Conveyor Broiler*—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 conveyor broiler 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