Designation: F2022 – 01 (Reapproved 2019)

An American National Standard

Standard Test Method for Performance of Booster Heaters[1]

This standard is issued under the fixed designation F2022; 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 energy efficiency, energy consumption and water heating performance of booster heaters. The food service operator can use this evaluation to select a booster heater and understand its energy consumption.

1.2 This test method is applicable to electric, gas, and steam powered booster heaters.

1.3 The booster heater can be evaluated with respect to the following (where applicable):

1.3.1 Energy input rate (9.2).

1.3.2 Pilot energy rate (9.3).

1.3.3 Flow capacity rate, energy rate, and energy efficiency with 110°F (43.3°C) and 140°F (60.0°C) supply to the booster heater inlet (9.4).

1.3.4 Thermostat calibration (9.5).

1.3.5 Energy rate and energy efficiency at 50% of flow capacity rate with 110°F (43.3°C) and 140°F (60.0°C) supply to the booster heater inlet (9.6).

1.3.6 Preheat energy and time (9.7). The preheat test is not applicable to booster heaters built without water storage and will not have auxiliary water storage connected to the booster heater to complete the water heating system.

1.3.7 Idle (standby) energy rate (9.8).

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

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

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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

2.2 *ANSI Standard:*[3]

ANSI Z223.1-1996 National Fuel Gas Code

2.3 *ASHRAE Handbook:*[4]

ASHRAE 1993 Fundamentals Handbook

2.4 *ASHRAE Guideline:*[4]

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

2.5 *NSF Standards:*[5]

NSF Listing—Food Equipment and Related Components and Material

ANSI/NSF 3-1996 Commercial Spray-Type Dishwashing Machines and Glasswashing Machines

ANSI/NSF 5-1992 Water Heaters, Hot Water Supply Boilers, and Heat Recovery Equipment

ANSI/NSF 26-1980 Pot, Pan, and Utensil Washers

3. Terminology

3.1 *Definitions:*

3.1.1 *booster heater, n*—a water heater that raises the booster heater inlet water supply temperature (typically 110°F to 140°F (43.3°C to 60°C)) to 180°F (82.2°C) or more to provide high temperature sanitizing rinse water for a dishwasher machine.

3.1.2 *dishwasher machine, n*—(hereafter referred to as dishwasher) machine that uniformly washes, rinses, and heat sanitizes eating and drinking utensils. The machine shall be

[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.

Current edition approved May 1, 2019. Published June 2019. Originally approved in 2001. Last previous edition approved in 2013 as F2022 – 01 (2013). DOI: 10.1520/F2022-01R19.

[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, http://www.ansi.org.

[4] Available from American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), 1791 Tullie Circle, NE, Atlanta, GA 30329, http://www.ashrae.org.

[5] Available from NSF International, P.O. Box 130140, 789 N. Dixboro Rd., Ann Arbor, MI 48113-0140, http://www.nsf.org.

capable of removing physical soil from properly racked and pre-scraped items, and sanitizing multi-use eating and drinking utensils.

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *batch water flow*—intermittent mode of water delivery at specified flow rate and elapse time. This is the typical style of water delivery of a booster heater supplying final rinse water to a door type dishwasher machine.

3.2.2 *booster heater energy efficiency*—quantity of energy imparted to the water while heating, expressed as a percentage of total amount of energy consumed by the booster heater during the capacity tests.

3.2.3 *booster heater inlet*—the point of connection on the booster heater for the water line from the primary supply to the booster heater.

3.2.4 *booster heater outlet*—the point of connection on the booster heater for the water line from the booster heater to the dishwasher.

3.2.5 *continuous water flow*—uninterrupted water delivery by a booster heater at a specified flow rate. This is a typical mode of water delivery of a booster heater supplying water to a conveyor or rack-less conveyor (flight) type dishwasher machine.

3.2.6 *energy rate*—average rate of energy consumption (Btu/h or kW, (kJ/h)) during the continuous flow tests.

3.2.7 *energy input rate*—peak rate at which a booster heater consumes energy (Btu/h or kW, (kJ/h)).

3.2.8 *flow capacity energy rate*—peak rate at which a booster heater consumes energy (Btu/h or kW, (kJ/h)) during the flow capacity tests. Refers to maximum energy rate while maximum flow capacity rate is supplied.

3.2.9 *flow capacity*—maximum water flow rate (gal/min, gal/h, (L/h)) at which the booster heater can heat water from a specified inlet temperature to an outlet temperature of 183 ± 3°F (83.9 ± 1.7°) during the continuous flow capacity test.

3.2.10 *pilot energy rate*—average rate of energy consumption (Btu/h) by a booster heater's continuous pilot (if applicable).

3.2.11 *primary supply*—the service water heater system that supplies water to the booster heater under test.

3.2.12 *thermal efficiency, n*—quantity of energy imparted to the water, expressed as a percentage of energy consumed by the element(s), gas burner(s), steam coil(s), and steam injector(s) during the flow capacity tests. Thermal efficiency data is collected during the continuous flow capacity tests.

4. Summary of Test Method

NOTE 1—An energy supply meeting the manufacturer's specification shall be provided for the gas, electric, or steam booster heater under test.

4.1 The booster heater under test is connected to the appropriate metered energy supply. The measured energy input rate is determined and checked against the rated input before continuing with testing.

4.2 Pilot energy rate is determined, when applicable, for gas booster heaters.

4.3 Flow capacity, energy rate and energy efficiency of the booster for continuous water flow is determined with the booster heater inlet water supplied at 110 $^{+0}/_{-3}$ °F (43.3 $^{+0}/_{-1.7}$ °C) and 140 $^{+0}/_{-3}$ °F (60.0 $^{+0}/_{-1.7}$ °C).

4.4 Flow rate, energy rate and energy efficiency of the booster for continuous water flow at 50% of flow capacity is determined with the booster heater inlet water supplied at 110 $^{+0}/_{-3}$ °F (43.3 $^{+0}/_{-1.7}$ °C) and 140 $^{+0}/_{-3}$ °F (60.0 $^{+0}/_{-1.7}$ °C).

4.5 The preheat energy consumption and time and idle/standby energy consumption rate are determined while the booster heater is operating with the thermostat(s) set at the calibrated setting(s) to deliver 183 ± 3 °F at the booster heater outlet. The booster heater is supplied with 110 $^{+0}/_{-3}$ °F (43.3 $^{+0}/_{-1.7}$ °C) and 140 $^{+0}/_{-3}$ °F (60.0 $^{+0}/_{-1.7}$ °C) water at the booster inlet.

5. Significance and Use

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

5.2 Booster heater flow capacity is an indicator of the booster heater's ability to supply hot water for sanitation. The booster heater's flow capacity can be used by the operator to determine the appropriate size booster heater for their operation. Booster heater energy rate is an indicator of the booster heater's energy consumption during continuous water flow. The energy rate can be used by food service operators to estimate the energy consumption of the booster heater. Booster heater energy efficiency is a precise indicator of a booster heater's energy performance during the continuous flow test. This information enables the food service operator to consider energy performance when selecting a booster heater.

5.3 Booster heater flow capacity at 50 % of the maximum capacity is an indicator of the booster heater's ability to provide hot water for sanitation at this reduce flow rate condition. Booster heater energy efficiency at a flow rate of 50 % of maximum capacity is an indicator of a booster heater's energy performance at this flow rate. The booster heater outlet temperature during the capacity test at a flow rate of 50 % of maximum capacity is an indicator of the booster heater's temperature response at this reduced flow rate.

5.4 Preheat energy and time can be useful to food service operators to manage power demands and to know how quickly the booster heater can be ready for operation.

5.5 Idle energy rate and pilot energy rate can be used to estimate energy consumption during standby periods.

6. Apparatus

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

6.2 *Exhaust Hood,* (if applicable) some gas booster heaters may require an exhaust hood for exhausting gas combustion products. Follow manufacturer's venting specifications.

6.3 *Flowmeter,* for measuring total water consumption of the booster heater. Shall have 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). Shall be designed to operate with water temperatures between 50°F to 195°F. The flowmeter shall be calibrated at both 110°F and 140°F booster heater inlet temperatures and their corresponding test flow rates and booster heater outlet temperatures.

6.4 *Gas Meter,* for measuring the gas consumption of the booster heater (if applicable). Shall have 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 pilot lights, it shall have a resolution of at least 0.01 ft^3 (0.0003 m^3) and have a maximum uncertainty no greater than 2 % of the measured value.

6.5 *Insulation,* for insulating all exterior fittings and plumbing. The insulation shall have a thermal insulation value (R value) of at least 4 (h × ft^2 × °F)/Btu (5.67 (m^2 × °C)/W).

6.6 *Pressure Gage,* for monitoring natural gas pressure. Shall have a range of 0 to 10 in. H_2O, a resolution of 0.5 in. H_2O, and a maximum uncertainty of 1 % of the measured value.

6.7 *Pressure Gage,* for monitoring water pressure supplied to and from the booster heater. The pressure gage on the downstream side of the booster heater shall have a range of 15 to 25 psi, a resolution of ±1 psi, and a maximum uncertainty of 1 % of the measured value. The pressure gage on the upstream side of the booster heater shall have a range of 0 to 200 psi, a resolution of ±5 psi, and a maximum uncertainty of 1 % of the measured value.

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

6.9 *Temperature Sensor,* for measuring natural gas temperature in the range of 50°F to 100°F (10°C to 37.8°C), with a resolution of 0.5°F (0.3°C) and an uncertainty of ±1°F (0.6°C).

6.10 *Thermocouple Probe,* industry standard Type T or Type K thermocouples capable of immersion with a range of 50°F to 200°F (10°C to 93.3°C) and an uncertainty of ±1°F.

6.11 *Watt-Hour Meter,* for measuring the electrical energy consumption of a booster heater. 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 %.

6.12 *Water Pressure Regulator,* for controlling the water line pressure to and from the booster heater. Two regulators are required. Adjustable within a range of 10 to 30 psi for the regulator downstream of the booster heater. Adjustable within a range of 10 to 200 psi for the regulator upstream of the booster heater.

6.13 *Solenoid Valve,* for regulating water flow from the booster heater. Sized to booster heater manufacturer's pipe diameter specifications.

6.14 *Tempering Valve or Equivalent Temperature Control Device,* for regulating the temperature of the water being supplied to the booster heater inlet. Tempering valve shall be capable of operating within the delivered water temperature range from 100°F (37.8°C) to 150°F (65.6°C) and capable of maintaining ±1.5°F (±0.8°C) of any specific delivery temperature set point within this range.

6.15 *Steam Flowmeters,* for measuring the flow of steam to the booster heater (if applicable). Shall have a resolution of 0.01 ft^3 (0.0003 m^3) and a maximum uncertainty of 1 % of the measured value.

6.16 *Calibrated Exposed Junction Thermocouple Probes,* industry standard Type T or Type K thermocouple with a range from 50°F to 200°F (10 to 93.3°C), a resolution of 0.2°F (0.1°C), and an uncertainty of 1.0°F (0.5°C), for measuring temperature at the booster heater inlet and outlet connections. Calibrated Type K or Type T 24 GA thermocouple wire with stainless steel sheath and ceramic insulation is the recommended choice for measuring the booster heater inlet and outlet temperatures. The thermocouple probe shall be fed through a compression fitting so as to submerse the exposed junction in booster heater water inlet and outlet.

6.17 *Temperature and Pressure Relief Valve(s),* sized to handle the maximum energy input of the booster heater with automatic reset and capable of releasing at temperatures and pressures above the booster heater maximum working conditions. The relief valve can be integral with both temperature and pressure relief capacity or separate valves for temperature and pressure control.

6.18 *Hammer Arrestor (Shock Absorber),* to eliminate water hammer caused by the quick closing of the solenoid valve.

6.19 *Throttling Valve,* to adjust the water flow rate (gal/min and gal/h) from the booster heater. Maximum water flow through throttling valve shall be large enough to accommodate the largest water flow requirements of the booster heater. Throttling valve shall be gate type or equivalent industry standard. Valve shall be sized to booster heater manufacturer's pipe diameter specifications.

6.20 *Primary Supply,* water heating system capable of supplying water at each of the following temperature ranges of 110 $^{+0}_{-3}$ °F (43.3 $^{+0}_{-1.7}$ °C) or 140 $^{+0}_{-3}$ °F (60.0 $^{+0}_{-1.7}$ °C) for all water flow rates required by the booster heater.

6.21 *One Way Check Valve,* water valve that allows water flow in one direction only. Valves to be installed in water lines where flow should be directional.

6.22 *Platform Balance Scale,* or appropriate load cells, used to measure the collected booster heater outlet discharge during capacity tests. Shall have the capacity to accommodate the total weight of the water discharged during the test with resolution of 0.2 lb (10 g) and an uncertainty of 0.2 lb (10 g) .