



ENERGY STAR® Program Requirements for Commercial Dishwashers

Partner Commitments

Following are the terms of the ENERGY STAR Partnership Agreement as it pertains to the manufacture and labeling of ENERGY STAR qualified products. The ENERGY STAR Partner must adhere to the following partner commitments:

Qualifying Products

1. Comply with current ENERGY STAR Eligibility Criteria, which define performance requirements and test procedures for commercial dishwashers. A list of eligible products and their corresponding Eligibility Criteria can be found at www.energystar.gov/specifications.
2. **Prior to associating the ENERGY STAR name or mark with any product**, obtain written certification of ENERGY STAR qualification from a Certification Body recognized by EPA for commercial dishwashers. As part of this certification process, products must be tested in a laboratory recognized by EPA to perform commercial dishwasher testing. A list of EPA-recognized laboratories and Certification Bodies can be found at www.energystar.gov/testingandverification.

Using the ENERGY STAR Name and Marks

3. Comply with current ENERGY STAR Identity Guidelines, which define how the ENERGY STAR name and marks may be used. Partner is responsible for adhering to these guidelines and ensuring that its authorized representatives, such as advertising agencies, dealers, and distributors, are also in compliance. The ENERGY STAR Identity Guidelines are available at www.energystar.gov/logouse.
4. Use the ENERGY STAR name and marks only in association with qualified products. Partner may not refer to itself as an ENERGY STAR Partner unless at least one product is qualified and offered for sale in the U.S. and/or ENERGY STAR partner countries.
5. Provide clear and consistent labeling of ENERGY STAR qualified commercial dishwashers. The ENERGY STAR mark must be clearly displayed on the top/front of the product, in product literature (i.e., user manuals, spec sheets, etc.), on product packaging, and on the manufacturer's Internet site where information about ENERGY STAR qualified models is displayed.

Verifying Ongoing Product Qualification

6. Participate in third-party verification testing through a Certification Body recognized by EPA for commercial dishwashers, providing full cooperation and timely responses. EPA/DOE may also, at its discretion, conduct tests on products that are referred to as ENERGY STAR qualified. These products may be obtained on the open market, or voluntarily supplied by Partner at the government's request.

Providing Information to EPA

7. Provide unit shipment data or other market indicators to EPA annually to assist with creation of ENERGY STAR market penetration estimates, as follows:
 - 7.1. Partner must submit the total number of ENERGY STAR qualified commercial dishwashers shipped in the calendar year or an equivalent measurement as agreed to in advance by EPA and Partner. Partner shall exclude shipments to organizations that rebrand and resell the shipments (unaffiliated private labelers).

7.2. Partner must provide unit shipment data segmented by meaningful product characteristics (e.g., type, capacity, presence of additional functions) as prescribed by EPA.

7.3. Partner must submit unit shipment data for each calendar year to EPA or an EPA-authorized third party, preferably in electronic format, no later than March 1 of the following year.

Submitted unit shipment data will be used by EPA only for program evaluation purposes and will be closely controlled. If requested under the Freedom of Information Act (FOIA), EPA will argue that the data is exempt. Any information used will be masked by EPA so as to protect the confidentiality of the Partner.

8. Report to EPA any attempts by recognized laboratories or Certification Bodies (CBs) to influence testing or certification results or to engage in discriminatory practices.

9. Notify EPA of a change in the designated responsible party or contacts within 30 days using the My ENERGY STAR Account tool (MESA) available at www.energystar.gov/mesa.

Performance for Special Distinction

In order to receive additional recognition and/or support from EPA for its efforts within the Partnership, the ENERGY STAR Partner may consider the following voluntary measures, and should keep EPA informed on the progress of these efforts:

- Provide quarterly, written updates to EPA as to the efforts undertaken by Partner to increase availability of ENERGY STAR qualified products, and to promote awareness of ENERGY STAR and its message.
- Consider energy efficiency improvements in company facilities and pursue benchmarking buildings through the ENERGY STAR Buildings program.
- Purchase ENERGY STAR qualified products. Revise the company purchasing or procurement specifications to include ENERGY STAR. Provide procurement officials' contact information to EPA for periodic updates and coordination. Circulate general ENERGY STAR qualified product information to employees for use when purchasing products for their homes.
- Feature the ENERGY STAR mark(s) on Partner website and other promotional materials. If information concerning ENERGY STAR is provided on the Partner website as specified by the ENERGY STAR Web Linking Policy (available in the Partner Resources section of the ENERGY STAR website), EPA may provide links where appropriate to the Partner website.
- Ensure the power management feature is enabled on all ENERGY STAR qualified displays and computers in use in company facilities, particularly upon installation and after service is performed.
- Provide general information about the ENERGY STAR program to employees whose jobs are relevant to the development, marketing, sales, and service of current ENERGY STAR qualified products.
- Provide a simple plan to EPA outlining specific measures Partner plans to undertake beyond the program requirements listed above. By doing so, EPA may be able to coordinate, and communicate Partner's activities, provide an EPA representative, or include news about the event in the ENERGY STAR newsletter, on the ENERGY STAR website, etc. The plan may be as simple as providing a list of planned activities or milestones of which Partner would like EPA to be aware. For example, activities may include: (1) increasing the availability of ENERGY STAR qualified products by converting the entire product line within two years to meet ENERGY STAR guidelines; (2) demonstrating the economic and environmental benefits of energy efficiency through special in-store displays twice a year; (3) providing information to users (via the website and user's manual) about energy-saving features and operating characteristics of ENERGY STAR qualified products; and (4) building awareness of the ENERGY STAR Partnership and brand identity by collaborating with EPA on one print advertorial and one live press event.
- Join EPA's SmartWay Transport Partnership to improve the environmental performance of the company's shipping operations. The SmartWay Transport Partnership works with freight carriers, shippers, and other stakeholders in the goods movement industry to reduce fuel consumption,

greenhouse gases, and air pollution. For more information on SmartWay, visit www.epa.gov/smartway.

- Join EPA's Green Power Partnership. EPA's Green Power Partnership encourages organizations to buy green power as a way to reduce the environmental impacts associated with traditional fossil fuel-based electricity use. The partnership includes a diverse set of organizations including Fortune 500 companies, small and medium businesses, government institutions as well as a growing number of colleges and universities. For more information on Green Power, visit www.epa.gov/greenpower.



ENERGY STAR® Program Requirements Product Specification for Commercial Dishwashers

Eligibility Criteria Version 2.0

Note: A clarification has been made to the note under Table 1 (Section 3) regarding the calculation used to determine the gallons per hour (GPH) limit for flight type conveyor machines.

Following is the **Version 2.0** product specification for ENERGY STAR qualified commercial dishwashers. A product shall meet all of the identified criteria if it is to earn the ENERGY STAR.

1) **Definitions**¹: Below are the definitions of the relevant terms in this document.

- A. Dishwashing Machine: A machine designed to clean and sanitize plates, pots, pans, glasses, cups, bowls, utensils, and trays by applying sprays of detergent solution (with or without blasting media granules) and a sanitizing rinse.

Machine Types

- B. Stationary Rack Machine: A dishwashing machine in which a rack of dishes remains stationary within the machine while subjected to sequential wash and rinse sprays. This definition also applies to machines in which the rack revolves on an axis during the wash and rinse cycles.
- a) Under Counter: A stationary rack machine with an overall height of 38 inches or less, designed to be installed under food preparation workspaces. Under counter dishwashers can be either chemical or hot water sanitizing, with an internal or external booster heater for the latter.
- b) Single Tank, Door Type: A stationary rack machine designed to accept a standard 20 inch x 20 inch dish rack which requires the raising of a door to place the rack into the wash/rinse chamber. Closing of the door typically initiates the wash cycle. Subcategories of single tank, stationary door type machines include: single rack, double rack, pot, pan and utensil washers, chemical dump type and hooded wash compartment ("hood type"). Single tank, door type models can be either chemical or hot water sanitizing, with an internal or external booster heater for the latter.
- c) Pot, Pan, and Utensil: A stationary rack, door type machine designed to clean and sanitize pots, pans, and kitchen utensils.
- d) Glasswashing: A stationary rack, under counter machine specifically designed to clean and sanitize glasses.
- C. Conveyor Machine: A dishwashing machine that employs a conveyor or similar mechanism to carry dishes through a series of wash and rinse sprays within the machine.
- a) Single Tank Conveyor: A conveyor machine that includes a tank for wash water followed by a sanitizing rinse (pumped or fresh water). This type of machine does not have a pumped rinse tank. This type of machine may include a prewashing section ahead of the washing section and an auxiliary rinse section, for purposes of reusing the sanitizing rinse water, between the power rinse and sanitizing rinse sections. Single tank conveyor dishwashers can be either chemical or hot water sanitizing, with an internal or external booster heater for the latter.

¹ Additional terms found throughout this document, and related to machine components and operation, are defined in NSF 170-2010.

- b) Multiple Tank Conveyor: A conveyor type machine that includes one or more tanks for wash water and one or more tanks for pumped rinse water, followed by a sanitizing rinse. This type of machine may include a pre-washing section before the washing section and an auxiliary rinse section, for purposes of reusing the sanitizing rinse water, between the power rinse and sanitizing rinse section. Multiple tank conveyor dishwashers can be either chemical or hot water sanitizing, with an internal or external booster heater for the latter.
- c) Flight Type Conveyor: A conveyor machine where the dishes are loaded directly on the conveyor rather than transported within a rack. This machine is also referred to as a rackless conveyor.

Sanitation Methods

- D. Hot Water Sanitizing (High Temp) Machine: A machine that applies hot water to the surfaces of dishes to achieve sanitization.
- E. Chemical Sanitizing (Low Temp) Machine: A machine that applies a chemical sanitizing solution to the surfaces of dishes to achieve sanitization.
- F. Chemical Dump Type Machine: A low temp, stationary rack machine with a pumped recirculated sanitizing rinse.
- G. Dual Sanitizing Machine: A machine designed to operate as either a high temp or low temp machine.

Modes and Metrics

- H. Wash Mode: For stationary rack machines, the dishwasher is in wash mode when it is actively running a cycle and is spraying wash water (i.e., water that is neither part of the sanitizing rinse, post sanitizing rinse, nor the prewashing unit).
- I. Rinse Mode: For stationary rack machines, the dishwasher is in rinse mode when it is at the end of the actively running cycle and is spraying hot water or chemical sanitizing rinse water or a post-sanitizing rinse. If there is a post-sanitizing rinse, it shall be included in rinse mode.
- J. Dwell Mode: For stationary rack machines, the dishwasher is in dwell mode when it is actively running a cycle but is not in wash or rinse modes.
- K. Idle Mode: For all dishwasher types, the dishwasher is in idle mode when it is not actively running but is still powered on and ready to wash dishes at the required temperature.
- L. Energy Saver Mode: A dishwasher is in energy saver mode if the dishwasher is manually converted or, after inactivity, the dishwasher automatically converts to a setting that consumes less energy than it does in idle mode (not all dishwashers have this feature).
- M. Idle Energy Rate: The rate of energy consumed by the dishwasher while “holding” or maintaining wash tank water at the thermostat(s) set point during the time period specified in the ENERGY STAR Test Method for Commercial Dishwashers (Rev. May-2012).

Qualification Terms

- N. Product Family: Variations of one model offered within a single product line with design differences limited to: finish/color; length of pre-wash section, voltage, and orientation (e.g., corner, straight through models). Individual models represented by a product family must have the same sanitizing and post sanitizing rinse water and idle energy consumption.

2) **Scope:**

- A. Included Products: Products that meet the definition of a Commercial Dishwasher as specified herein are eligible for ENERGY STAR qualification, with the exception of products listed in Section 2.B. The following product types are eligible: under counter; single tank, door type; single tank conveyor; multiple tank conveyor and flight type machines. Glasswashing machines; pot, pan, and utensil machines; and dual sanitizing machines are also eligible. Only those under counter machines designed for wash cycles of 10 minutes or less are eligible for ENERGY STAR. This Version 2.0 specification only covers electric models.
- B. Excluded Products: Dishwashers intended for use in residential or laboratory applications are not eligible for ENERGY STAR under this product specification. Steam, gas, and other non-electric models cannot qualify for ENERGY STAR under this Version 2.0.

3) **Qualification Criteria:**

A. Energy and Water Efficiency Requirements:

Table 1: ENERGY STAR Requirements for Commercial Dishwashers				
Machine Type	High Temp Efficiency Requirements		Low Temp Efficiency Requirements	
	Idle Energy Rate*	Water Consumption**	Idle Energy Rate*	Water Consumption**
Under Counter	≤ 0.50 kW	≤ 0.86 GPR	≤ 0.50 kW	≤ 1.19 GPR
Stationary Single Tank Door	≤ 0.70 kW	≤ 0.89 GPR	≤ 0.60 kW	≤ 1.18 GPR
Pot, Pan, and Utensil	≤ 1.20 kW	≤ 0.58 GPSF	≤ 1.00 kW	≤ 0.58 GPSF
Single Tank Conveyor	≤ 1.50 kW	≤ 0.70 GPR	≤ 1.50 kW	≤ 0.79 GPR
Multiple Tank Conveyor	≤ 2.25 kW	≤ 0.54 GPR	≤ 2.00 kW	≤ 0.54 GPR
Single Tank Flight Type	Reported	GPH ≤ 2.975x + 55.00	Reported	GPH ≤ 2.975x + 55.00
Multiple Tank Flight Type	Reported	GPH ≤ 4.96x + 17.00	Reported	GPH ≤ 4.96x + 17.00

* Idle results should be measured with the **door closed** and represent the total idle energy consumed by the machine including all tank heater(s) and controls. Booster heater (internal or external) energy consumption should not be part of this measurement unless it cannot be separately monitored per the ENERGY STAR Test Method referenced in Section 4, below.

** GPR = gallons per rack; GPSF = gallons per square foot of rack; GPH = gallons per hour; **x** = maximum conveyor speed (feet/min as verified through NSF 3 certification) x conveyor belt width (feet).

- B. User-Adjustable Conveyor Machines: Conveyor machines that offer multiple speeds adjustable by the end user must meet the ENERGY STAR requirements using the maximum conveyor speed setting tested to and certified to NSF/ANSI Standard 3. Water consumption values using the maximum conveyor speed setting shall be used for qualification purposes. Water consumption using the slowest conveyor speed shall also be reported to EPA.
- C. Dual Sanitizing Machines: As defined in Section 1, these machines shall meet both the high temp and low temp requirements presented in Table 1, above, to qualify as ENERGY STAR.
- D. Dual Purpose Door Type Machines: Machines designed to be used either as a standard door type machine or a pot, pan, and utensil machine shall meet the performance requirements for both of those sub categories.

- E. Post Sanitizing Machines: Machines offering a post sanitizing rinse will be evaluated for ENERGY STAR qualification with the post sanitizing rinse turned on during testing. The final rinse water consumption will include both sanitizing and post sanitizing rinses.
- F. Industry Standard Certifications: All machines shall be certified to the NSF/ANSI 3-2010 Standard, *Commercial Warewashing Equipment*.
- G. Significant Digits and Rounding:
 - a. All calculations shall be carried out with directly measured (unrounded) values.
 - b. Unless otherwise specified, compliance with specification limits shall be evaluated using directly measured or calculated values without any benefit from rounding.
 - c. Directly measured or calculated values that are submitted for reporting on the ENERGY STAR website shall be rounded to the second decimal place.

4) **Test Requirements:**

- A. Representative Models shall be selected for testing per the following requirements:
 - a. For qualification of an individual product model, the representative model shall be equivalent to that which is intended to be marketed and labeled as ENERGY STAR.
 - b. For qualification of a product family, any model within that product family can be tested and serve as the representative model.
- B. When testing commercial dishwashers, the following test methods shall be used to determine ENERGY STAR qualification:

Table 2: Test Methods for ENERGY STAR Qualification	
ENERGY STAR Requirement	Test Method Reference
Idle Energy Rate, GPH, GPR, and GPSF (all machines)	<i>ENERGY STAR Test Method for Commercial Dishwashers (Rev. May-2012)</i>

- 5) **Effective Date:** The ENERGY STAR Commercial Dishwasher Specification shall take effect on **February 1, 2013**. To qualify for ENERGY STAR, a product model shall meet the ENERGY STAR specification in effect on the model's date of manufacture. The date of manufacture is specific to each unit and is the date on which a unit is considered to be completely assembled.
- 6) **Future Specification Revisions:** EPA reserves the right to change the specification should technological and/or market changes affect its usefulness to consumers, industry, or the environment. In keeping with current policy, revisions to the specification are arrived at through industry discussions. In the event of a specification revision, please note that the ENERGY STAR qualification is not automatically granted for the life of a product model.

ASTM Test Standard Review: EPA will revisit this specification once the revision processes for ASTM F1696 and ASTM F1920 are complete to evaluate new performance requirements that capture total machine energy consumption.



ENERGY STAR[®] Program Requirements Product Specification for Commercial Dishwashers

Test Method (Rev. May-2012)

1 OVERVIEW

The following test method shall be used for determining product compliance with requirements in the ENERGY STAR Eligibility Criteria for Commercial Dishwashers.

Note: Throughout this test method, “may” refers to an action that is voluntary and “shall” refers to an action that is mandatory.

2 APPLICABILITY

This test method is applicable to commercial dishwashers, specifically: under counter; glasswashing; single tank, door type; pot, pan and utensil; dual sanitizing rinse; single tank conveyor; multiple tank conveyor and flight type machines. This test method may also be used to test machines that include a post-sanitizing rinse. This test method is applicable to machines with electric, gas, or steam coil tank heat and electric, gas, or steam booster heat but not for machines with steam injection tank or booster heat.

Note: This test method has not been validated for flight type machines, machines with a post-sanitizing rinse, or machines with steam coil booster heaters.

3 DEFINITIONS

Unless otherwise specified, all terms used in this document are consistent with the definitions in the ENERGY STAR Eligibility Criteria for Commercial Dishwashers Version 2.0.

Note: Dishwashing Machines are referred to as Dishwashers throughout this Test Method.

A) Acronyms, Abbreviations, and Units:

- 1) ANSI: American National Standards Institute
- 2) ASTM: American Society for Testing and Materials
- 3) Btu: British Thermal Units
- 4) cfm: Cubic feet per minute
- 5) DOE: U.S. Department of Energy
- 6) EPA: U.S. Environmental Protection Agency
- 7) °F: Degrees Fahrenheit
- 8) ft: Feet

- 9) ft³: Cubic feet
- 10) h: Hour(s)
- 11) in: Inch(es)
- 12) in. H₂O: Inches water
- 13) in. Hg: Inches mercury
- 14) kW: Kilowatt(s)
- 15) kWh: Kilowatt-hour(s)
- 16) lb: Pound(s)
- 17) min: Minute(s)
- 18) NSF: NSF International
- 19) psi: Pounds per square inch
- 20) psia: Pounds per square inch absolute
- 21) psig: Pounds per square inch gauge
- 22) °R: Degrees Rankine
- 23) s: Second(s)
- 24) UUT: Unit Under Test
- 25) V: Volt(s)
- 26) W: Watt(s)
- 27) Wh: Watt-hour(s)

B) General:

1) Warewashing Machine Terminology

- a) Water heater: Water Heater is defined in NSF International/American National Standards Institute (*NSF/ANSI 170-2010: Glossary of Food Equipment Terminology; Section 3.223*).
- b) Booster Heater: Booster Heater is defined in *NSF/ANSI 170-2010; Section 3.223.1*.
- c) Sanitization: Sanitization is defined in *NSF/ANSI 170-2010; Section 3.176*.
- d) Sanitizing Solution: Sanitizing Solution is defined in *NSF/ANSI 170-2010; Section 3.177*.
- e) Washing: Washing is defined in *NSF/ANSI 170-2010; Section 3.221*.
- f) Fresh Water: Fresh Water is defined in *NSF/ANSI 170-2010; Section 3.83*.

- g) Sanitizing Rinse: Sanitizing Rinse is defined in *NSF/ANSI 170-2010; Section 3.173*.
- h) Chemical Sanitizing Rinse: Chemical Sanitizing Rinse is defined in *NSF/ANSI 170-2010; Section 3.170*.
- i) Hot Water Sanitizing Rinse: Hot Water Sanitizing Rinse is defined in *NSF/ANSI 170-2010; Section 3.171*.
- j) Pumped Rinse: Pumped Rinse is defined in *NSF/ANSI 170-2010; Section 3.152*.
- k) Auxiliary Rinse: Auxiliary rinse is defined in *NSF/ANSI 170-2010; Section 3.5*.
- l) Recirculating Sanitizing Rinse: Recirculating Sanitizing Rinse is defined in *NSF/ANSI 170-2010; Section 3.160*.
- m) Non-recirculating Pumped Sanitizing Rinse: Non-recirculating Pumped Sanitizing Rinse is defined in *NSF/ANSI 170-2010; Section 3.129*.
- n) Post-sanitizing Rinse: Post-sanitizing Rinse is defined in *NSF/ANSI 170-2010; Section 3.172*.
- o) Prewashing Unit: Prewashing Unit is defined in *NSF/ANSI 170-2010; Section 3.148*.
- p) Rack: Rack is defined in *NSF/ANSI 170-2010; Section 3.155*.
- q) User Adjustable: A feature is user adjustable if it may be adjusted by the machine operator without aid from a technician or manufacturer.

2) Test Method Terminology

- a) Ambient Temperature: Ambient Temperature is defined in *NSF/ANSI 170-2010; Section 3.3*.
- b) Flow Pressure: Flow Pressure is defined in *NSF/ANSI 170-2010; Section 3.74*.
- c) Line Pressure: Line Pressure is defined in *NSF/ANSI 170-2010; Section 3.113*.
- d) Rated Temperature: Rated Temperature is defined in *American Society for Testing and Materials (ASTM) F1920-11: Standard Test Method for Performance of Rack Conveyor, Commercial Dishwashing Machines; Section 3.1.7*.
- e) Tank Heater Idle Rate: Tank Heater Idle Rate is defined in *ASTM F1920-11; Section 3.1.9*.
- f) Uncertainty: Uncertainty is defined in *ASTM F1920-11; Section 3.1.10*.

4 TEST CONDUCT

- A) Testing Order: The sanitizing and post-sanitizing rinse water consumption test shall be run before the idle energy consumption test. The Dishwasher shall be operated at the same settings (water level, cycle times, sanitizing mode, etc.) for both the water consumption test and the idle energy consumption tests.
- B) Machines with a post-sanitizing rinse shall separately measure and report the water consumption with the feature turned on and turned off.

- C) Machines designed to be interchangeable in the field from high temp and low temp (i.e. Dual Sanitizing Machines), and vice versa, shall be tested at both settings.
- D) Machines designed to be used either as a Dishwasher or a pot, pan, and utensil washer shall be tested at both settings.
- E) If a machine includes an Energy Saver Mode, it shall be turned off or disabled whether or not it is user adjustable. DOE shall be contacted if this feature cannot be turned off or disabled.
- F) If a Dishwasher includes a prewash tank heater as an option, the model must be tested and reported separately from the same model without the prewash tank heater.
- G) When the test method or referenced test procedures specify to use the nameplate or manufacturer's recommendations, instructions, specifications, or requirements, the information source shall be used in the following order of preference and documented in the test report: nameplate data, user manual, communication with manufacturer.
- H) Since this test method will be used to qualify and/or verify products for ENERGY STAR, any issues that result in a termination of testing will require the test lab to obtain a replacement unit or replacement part. Field servicing of components by technicians is allowed. Component replacements are limited to direct replacements with identical model numbers in cases where the component is rendered defective. If the manufacturer elects to have a unit repaired by servicing or replacing a component, the manufacturer may not request that a new unit be tested unless the unit is inoperable subsequent to the repair. For features that are user adjustable, adjustments may not occur once data collection has started.
- I) Power and energy data may be recorded for longer than the time periods specified. However, data that are used for calculations shall be obtained from as close to the specified time periods or events (e.g. tank heater "on" cycle) as possible.

5 TEST SETUP

A) Water Consumption Test Instrumentation

- 1) Pressure Gauge: The pressure gauge shall be capable of measuring at least 0-60 pounds per square inch gage (psig) with a resolution of at least 1 psig and a maximum uncertainty of 1% of the measured value.
- 2) Scale: The scale shall be capable of measuring at least 0-100 pounds (lb) with a resolution of at least 0.1 lb and an accuracy of at least +/- 0.1 lb.
- 3) Stopwatch: The stopwatch shall have a resolution of at least 0.1 seconds (s) and an accuracy of at least +/- 2% of the time period being measured.
- 4) Vessel: The vessel for capturing the sanitizing and post-sanitizing rinse water shall be large enough (depending on the tank volume) to capture the water consumed during the entire water consumption test.

B) Idle Energy Consumption Test Instrumentation

- 1) For all instruments, the specifications may be better than specified. Values provided are intended to be the minimum or maximum (depending on which is the worst case for the parameter) allowable.

2) Meters

- a) Watt-hour Meters: For Dishwashers with electric tank or booster heat, the watt-hour meters for measuring the energy consumption of the Dishwasher and booster heater separately shall meet the requirements in *ASTM F1920-11; Section 6.1* with the following revisions.
 - i. The maximum uncertainty shall be no greater than 10% of the measured value.
- b) Gas Meters: For Dishwashers with gas tank or booster heat, the gas meters for measuring the gas consumption of the Dishwasher and booster heater separately shall meet the requirements in *ASTM F1920-11; Section 6.2* with the following revision and additions.
 - i. The requirement that the pilot light gas meter shall have a maximum uncertainty of at least 0.01 cubic feet (ft³) shall be excluded.
 - ii. The tank heater gas meters shall be capable of measuring flows between at least 0 ft³/hour (h) and 250 ft³/h and the pilot light gas meters shall be capable of measuring flows between at least 0 ft³/h and 10 ft³/h.
- c) Steam Flow Meters: For Dishwashers with steam coil tank or booster heat, the steam flow meters shall meet the requirements in *ASTM F1920-11; Section 6.3* with the following addition.
 - i. The steam flow meters shall be capable of measuring flows between at least 0 ft³/h and 50 ft³/h and shall be capable of recording data at least as frequently as every second.
- d) Water Flow Meters: For conveyor Dishwashers, the calibrated flow meters shall have a resolution of at least 0.1 gallons per minute, an accuracy of +/- 1.5% of the flow rate being measured, and shall be capable of measuring flows between at least 0 gallons per minute and 6 gallons per minute.

3) Pressure Gauges

- a) Gas Pressure Gauge: For Dishwashers with gas tank heat, the gas pressure gauges shall meet the requirements in *ASTM F1920-11; Section 6.6*.
- b) Steam Pressure Gauge: For Dishwashers with steam coil tank or booster heat, the steam pressure gauges shall meet the requirements in *ASTM F1920-11; Section 6.4* with the following addition.
 - i. The steam pressure gauges shall be capable of measuring pressures between at least 0 psig and 100 psig.

4) Ventilation

- a) Stationary Rack: For Dishwashers that are classified as stationary rack types, ventilation shall meet the requirements in *ASTM F1696-07: Standard Test Method for Energy Performance of Single-Rack, Door-Type Commercial Dishwashing Machines; Section 6.5*.
- b) Conveyors: For Dishwashers that are classified as conveyor types, ventilation shall meet the requirements in *ASTM F1920-11; Section 6.5* with the following revision.
 - i. Vent cowl exhaust ducts shall operate in accordance with the manufacturer's recommendation, if applicable, or at a nominal 200 cubic feet per minute (cfm) on the

entrance side of the Dishwasher and 400 cfm on the exit side if the manufacturer does not provide recommendations.

5) Thermocouple Probes and Temperature Sensors

- a) Thermocouple Probes: For all Dishwashers, the thermocouple probes shall meet the requirements in *ASTM F1920-11; Section 6.12* with the following revision and additions.
 - i. "Dishwater" shall be replaced with "Dishwasher".
 - ii. The thermocouple probes shall have a response time of less than 2 seconds.
 - iii. For Dishwashers with steam coil tank or booster heat, the thermocouple probes shall be used for measuring the condensate water outlet temperature.
- b) Ambient Air: For all Dishwashers, the temperature sensor for measuring ambient air temperatures in the range of 50 degrees Fahrenheit (°F) to 100 °F shall have a resolution of at least 0.5 °F and a maximum uncertainty of +/- 1 °F.
- c) Gas: For Dishwashers with gas tank heat, the temperature sensor for measuring natural gas temperatures shall meet the requirements in *ASTM F1920-11; Section 6.7*.
- d) Steam: For Dishwashers with steam coil tank or booster heat, the temperature sensor for measuring steam temperatures in the range of 200 °F to 300 °F shall have a resolution of at least 0.5 °F and a maximum uncertainty of +/- 1 °F.

6) Additional Requirements

- a) Stop Watch: For all Dishwashers, the stop watch shall meet the requirements in *ASTM F1920-11; Section 6.10*. The stop watch shall have an accuracy of +/- 2% of the time period being measured.
- b) Barometer: For Dishwashers with natural gas tank heat, a barometer shall be used if the gas flow meter does not correct for pressure. For Dishwashers with steam coil tank or booster heat, a barometer shall be used for calculating absolute pressure from gage pressure if the pressure gauge does not correct for atmospheric pressure. The barometer shall meet the requirements in *ASTM F1920-11; Section 6.8*.
- c) Dishrack: Metro Mdl P2MO, 20 in. x 20 in., peg-type, commercial or acceptable equivalent.

C) Commercial Dishwasher Installation

- 1) Commercial Dishwashers shall be installed per manufacturer's installation instructions. All packing material and protective packaging shall be removed.
- 2) Drain connections shall be accessible with sufficient space to allow capture vessel to be positioned beneath.
- 3) For steam coil tank or booster heat Dishwashers, install instruments to provide dry superheated steam to the Dishwasher. Adjust the steam supply pressure to within +/- 2.5% of the operating pressure specified by the manufacturer. Install instrumentation to record the pressure, temperature, and volumetric flow rate of the steam supplied to the Dishwasher tank heater (and booster heater separately, if applicable), the pressure and temperature of the condensate exiting the Dishwasher tank heater (and booster heater separately, if applicable), and the barometric

pressure during each test so that the measured gage pressures can be corrected to absolute pressure.

- 4) Stationary Rack Type: For Dishwashers that are classified as stationary rack types, the Dishwasher setup shall meet the requirements in *ASTM F1696-07; Sections 9.1-9.10* with the following revisions and additions.
 - a) In Section 9.3, the supply of water shall be within the range of the manufacturer-specified input temperatures (not to exceed 140 +/- 2 °F). For testing purposes, the Dishwasher may be connected to a source of water that is at the manufacturer specified sanitizing rinse temperature in lieu of an external booster heater.
 - b) In Section 9.4, the watt-hour meters shall be connected so that all idle energy (including tank heater, motors, and controls) is monitored. For steam coil or gas Dishwashers, electric energy consumption shall be simultaneously monitored with steam or gas energy consumption. The Dishwasher and booster shall not be monitored as one energy load. For the idle energy test, internal booster heaters shall be monitored separately and the booster idle energy shall be reported separately from the total idle energy.
 - c) In Section 9.5, instrumentation to record both the pressure and temperature of the gas supplied to the Dishwasher and the barometric pressure is only necessary if the gas flow meter does not already correct for pressure and temperature.
- 5) Conveyors: For Dishwashers that are classified as conveyors, the Dishwasher setup shall meet the requirements in *ASTM F1920-11; Sections 9.1-9.11* with the following revisions and additions.
 - a) In Section 9.3, the supply of water shall be within the range of the manufacturer-specified input temperatures (not to exceed 140 +/- 2 °F). For testing purposes, the Dishwasher may be connected to a source of water that is at the manufacturer specified sanitizing rinse temperature in lieu of an external booster heater.
 - b) In Section 9.4, the watt-hour meters shall be connected so that all idle energy (including tank heater(s), motors, and controls) is monitored. For steam coil or gas Dishwashers, electric energy consumption shall be simultaneously monitored with steam or gas energy consumption. The Dishwasher and booster shall not be monitored as one energy load. For the idle energy test, internal booster heaters shall be monitored separately and the booster idle energy shall be reported separately from the total idle energy.
 - c) In Section 9.5, instrumentation to record both the pressure and temperature of the gas supplied to the Dishwasher and the barometric pressure is only necessary if the gas flow meter does not already correct for pressure and temperature.

D) Test Settings

1) Water Consumption Test Settings:

- a) Fresh Water Sanitizing or Post-Sanitizing Rinse Stationary Rack Type Machines
 - i. If multiple cycle times are available, the Dishwasher shall be tested at the shortest time setting.
 - ii. If the water consumption including post-sanitizing rinse is being measured, turn on the post-sanitizing rinse feature and ensure it remains on during testing.

- iii. Based on manufacturer instructions, set the sanitizing or post-sanitizing rinse flow pressure based on the following:
 - For machines marked for sanitizing or post-sanitizing rinse pressure ratings of 20 +/- 5 psig, the test shall be run at 20 +/- 1 psig.
 - For machines marked for sanitizing or post-sanitizing rinse pressure ratings other than 20 +/- 5 psig, and a marked pressure range of greater than 5 psig, the test shall be run with the sanitizing or post-sanitizing rinse pressure set at both the minimum and maximum ratings marked on the unit +/- 1 psig.
 - For machines marked for sanitizing or post-sanitizing rinse pressure ratings other than 20 +/- 5 psig, and a marked pressure range of less than or equal to 5 psig, the test shall be run with the sanitizing or post-sanitizing rinse pressure set at the minimum rating marked on the unit +/- 1 psig.
- b) Pumped Water Sanitizing or Post-Sanitizing Rinse Stationary Rack Type Machines
 - i. If multiple cycle times are available, the Dishwasher shall be tested at the shortest time setting.
 - ii. If the water consumption including post-sanitizing rinse is being measured, turn on the post-sanitizing rinse feature and ensure it remains on during testing.
 - iii. The machine shall be filled to the manufacturer's recommended level. The same water level shall be used for the water consumption and idle energy tests for consistency.
- c) Fresh Water Sanitizing or Post-Sanitizing Rinse Conveyor Type Machines
 - i. If the conveyor speed is user adjustable, set to maximum conveyor speed and report the conveyor speed. If it is not user adjustable, retain the factory setting and report the conveyor speed.
 - ii. If the water consumption including post-sanitizing rinse is being measured, turn on the post-sanitizing rinse feature and ensure it remains on during testing.
 - iii. Based on manufacturer instructions, set the rinse flow pressure based on the following:
 - For machines marked for sanitizing or post-sanitizing rinse pressure ratings of 20 +/- 5 psig, the test shall be run at 20 +/- 1 psig.
 - For machines marked for sanitizing or post-sanitizing rinse pressure ratings other than 20 +/- 5 psig, and a marked pressure range of greater than 5 psig, the test shall be run with the sanitizing or post-sanitizing rinse pressure set at both the minimum and maximum ratings marked on the unit +/- 1 psig.
 - For machines marked for sanitizing or post-sanitizing rinse pressure ratings other than 20 +/- 5 psig, and a marked pressure range of less than or equal to 5 psig, the test shall be run with the sanitizing or post-sanitizing rinse pressure set at the minimum rating marked on the unit +/- 1 psig.
- d) Pumped Water Sanitizing or Post-Sanitizing Rinse Conveyor Type Machines

- i. If the conveyor speed is user adjustable, set to maximum conveyor speed and report the conveyor speed. If it is not user adjustable, retain the factory setting and report the conveyor speed.
- ii. If the water consumption including post-sanitizing rinse is being measured, turn the post-sanitizing rinse feature on and ensure it remains on during testing.

6 TEST METHODS FOR ALL PRODUCTS

6.1 Sanitizing and Post-Sanitizing Rinse Water Consumption

1) Fresh Water Sanitizing or Post-Sanitizing Rinse Stationary Rack Type Machines

- a) Completely dry and weigh the capture vessel.
- b) Operate the machine through three cycles. Verify that the wash, rinse (including post-sanitizing rinse if this feature is included), and dwell times are within 1 second of the manufacturer's specified values and that the water pressure is within 1 psig of the manufacturer's specified value. If they are not, make adjustments and operate the machine through additional cycles until they are (i.e. steady state is achieved). If the specified times are not reached, terminate testing.
- c) Using the weighed capture vessel, catch all water that is sent to the drain during a complete cycle, including any water from a post-sanitizing rinse if the water consumption including post-sanitizing rinse is being measured. Record the exact wash, rinse, and dwell times. It may take longer than the duration of the cycle for all of the water to drain; thus the vessel shall remain in place until the water flow from the cycle ceases.
- d) Weigh the filled vessel after the cycle, subtracting the weight of the capture vessel to calculate the weight of the water.
- e) Repeat steps a) through d) five times. Completely dry the vessel after each cycle.

2) Pumped Water Sanitizing or Post-Sanitizing Rinse Stationary Rack Type Machines

- a) Completely dry and weigh the capture vessel.
- b) Operate the machine through three cycles. Verify that the wash, rinse, and dwell times are within one second of the manufacturer's specified values and that the water is within 0.25 inch (in.) of the water fill line. If it is not, adjust the water pressure until the water is within 0.25 in. of the water fill line. If the water is still not within 0.25 in. of the water fill line, the wash, rinse, and dwell times may be adjusted, but the new times shall be recorded. If the specified times and/or water fill level are not reached, terminate testing.
- c) Using the weighed capture vessel, catch all water that is sent to the drain during a complete cycle, including any water from a post-sanitizing rinse if the water consumption including post-sanitizing rinse is being measured. Record the exact wash, rinse, and dwell times. It may take longer than the duration of the cycle for all of the water to drain; thus the vessel shall remain in place until the water flow from the cycle ceases.
- d) Weigh the filled vessel after the cycle, subtracting the weight of the capture vessel to calculate the weight of the water.
- e) Repeat steps a) through d) five times. Completely dry the vessel after each cycle.

3) Fresh Water Sanitizing or Post-Sanitizing Rinse Conveyor Type Machines

- a) Activate the sanitizing rinse solenoid (and the post-sanitizing rinse solenoid if the water consumption including post-sanitizing rinse is being measured) for 5 minutes (min). Do not activate any other component(s) of the Dishwasher that sends water to the drain. If there is a lever that actuates the sanitizing rinse solenoid or post-sanitizing rinse solenoid, the lever may be held down to simulate operation. Verify that the water pressure is within 1 psig of the manufacturer's specified value. If it is not, make adjustments and operate the machine until it is (i.e. steady state is achieved).
- b) Using a flow meter, measure all water that is sent to the drain during 1 min +/- 1 second of continuous operation of the sanitizing rinse solenoid (and post-sanitizing rinse solenoid if the water consumption including post-sanitizing rinse is being measured). Record the exact time. Do not activate any other component(s) of the Dishwasher that sends water to the drain. If there is a lever that actuates the sanitizing rinse solenoid or post-sanitizing rinse solenoid, the lever may be held down to simulate operation.
- c) Repeat steps a) and b) five times.

4) Pumped Water Sanitizing or Post-Sanitizing Rinse Conveyor Type Machines

- a) Activate the sanitizing rinse (and the post-sanitizing rinse if the water consumption including post-sanitizing rinse is being measured) for 5 min. Do not activate any other component(s) of the Dishwasher that sends water to the drain. If there is a lever that actuates the sanitizing rinse or post-sanitizing rinse, the lever may be held down to simulate operation. Verify that the pumped sanitizing rinse and post-sanitizing rinse operate correctly. If they do not, terminate testing.
- b) Using a flow meter, measure all water that is sent to the drain during 1 min +/- 1 second of continuous operation of the sanitizing rinse (and post-sanitizing rinse if the water consumption including post-sanitizing rinse is being measured). Record the exact time. Do not activate any other component(s) of the Dishwasher that sends water to the drain. If there is a lever that actuates the sanitizing rinse or post-sanitizing rinse, the lever may be held down to simulate operation.
- c) Repeat steps a) and b) five times.

6.2 Idle Energy Consumption for Stationary Rack Type Machines

- 1) General measurements shall be taken and recorded as specified in *ASTM F1696-07; Section 10.1* with the following revisions and additions.
 - a) Steam coil units shall also be included in Section 10.1.1.
 - b) Section 10.1.1.2 shall be disregarded.
 - c) The higher heating value shall be measured for all tests with a gas powered tank heater or booster. The other measurements specified in Section 10.1.2 shall only be taken if the gas meter does not already correct the gas volume based on temperature and pressure. Section 10.1.2.6 shall be disregarded.
 - d) Section 10.1.4 shall be replaced with "For Dishwashers that use steam coils for tank or booster heat, the steam temperature, pressure, and volumetric flow rate at Dishwasher inlet, water temperature and pressure at Dishwasher outlet, and barometric pressure

shall be recorded at no greater than 1 second of every test. Make any necessary corrections to the measurements as required by the instruments (i.e. correction for elevation of pressure gauge above pressure line, etc.).”

- e) Section 10.1.5 shall be disregarded.
- 2) For Dishwashers with steam coil tank or booster heat, allow the Dishwasher tank or booster heater to idle for one “on” cycle, with the exterior service door(s) closed. As the tank or booster heater cycles on for the second time, record the amount of time between steam entering the volumetric flow meter and exiting as condensate with a stopwatch as t_{delay} (seconds). This time delay is used to compare the data from the inlet to the corresponding data from the outlet. Adjust testing times so that there is enough data to account for this delay. Alternately, if the time delay cannot be determined using this method, it may be estimated by dividing the volume of the heat exchanger by the average flow during the first complete heater “on” cycle.
- 3) If there is a booster heater for high temperature machines, the booster temperature shall be calibrated as follows:
 - a) *For external booster heaters*, while monitoring the water inlet of the booster heater *or water source* and Dishwasher (rinse manifold) temperature, initiate a Dishwasher cycle. Adjust the booster heater *or water source* to the manufacturer's recommended *sanitizing* rinse temperature ± 2 °F, if *user* adjustable. If the manufacturer does not have a recommended external booster heater setting, then set the booster heater thermostat such that the average temperature of water at the Dishwasher manifold (measured only during the rinse) is *between 180 °F and 195 °F*. If the machine is supplied with an internal booster heater, retain the factory setting of the thermostat.
 - b) *Run two machine cycles with an empty dishrack placed in the machine to confirm that the stabilized flowing sanitizing rinse temperature is above the manufacturer's rated sanitizing rinse temperature minus 1 °F (or above 180 °F if the manufacturer does not provide a rated rinse temperature). If the stabilized flowing sanitizing rinse temperature is below the manufacturer's nameplate rated sanitizing rinse temperature minus 1 °F (or below 180 °F if the manufacturer does not provide a rated sanitizing rinse temperature), adjust the thermostat per the manufacturer's instructions if it is user adjustable.*
- 4) The wash tank temperature shall be set as specified in *ASTM F1920-11; Section 10.6* with the following revisions and additions.
 - a) “Dishwater” shall be replaced with “Dishwasher”. Verify that the minimum tank heater temperature during the three consecutive heater cycles is above the manufacturer's recommended setting minus 1 °F and the maximum temperature is not more than 15 °F higher than the minimum measured temperature. Repeat for all actively heated tanks.
 - b) Run two machine cycles with an empty dishrack placed in the machine to confirm that the minimum tank temperature(s) during the test is above the manufacturer's recommended setting minus 1 °F and the maximum temperature is not more than 15 °F higher than the minimum measured temperature. If the tank temperature(s) is not correct, adjust the thermostat per the manufacturer's instructions if it is user adjustable.
- 5) The tank heater “maximum energy input rate” (i.e. maximum power) shall be measured and reported as specified in *ASTM F1696-07; Section 10.2* with the following revisions and additions.
 - a) The maximum energy input rate determination is used to verify that the dishwasher is operating within manufacturer specifications. If there is a nameplate rating or a rating printed on the heating element for the tank heater, follow the steps below. If the tank

heater is included as part of a total power consumption nameplate rating, follow the steps below while monitoring the total power consumption for all components included in the rating.

- b) Section 10.2.1 shall be disregarded.
 - c) Section 10.2.2 shall be replaced with the following:
 - i. Instruments shall be connected so that only the energy (for steam and gas tank heat) or power (for electric tank heat) consumption of the tank heater is measured. Fill the Dishwasher tank with water.
 - ii. For electric tank heaters, commence monitoring the power of the tank heater when the tank heater cycles on. Stop monitoring the power when the tank heater cycles off. Record the maximum power value as the “maximum energy input rate”.
 - iii. For gas tank heaters, allow the tank heater to idle for one “on” cycle to allow the burner orifices to heat up. Commence monitoring the elapsed time and energy consumption of the tank heater when the tank heater cycles on for the second time. Stop monitoring the elapsed time and energy consumption of the tank heater when the tank heater cycles off. Record the time and energy consumption of the tank heater during the complete “on” cycle.
 - iv. For steam coil tank heaters, commence monitoring the elapsed time and energy consumption of the tank heater when the tank heater cycles on. Stop monitoring the elapsed time and energy consumption of the tank heater when the tank heater cycles off. Record the time and energy consumption of the tank heater during the complete “on” cycle.
 - d) Section 10.2.3 shall be followed as written with the following revision.
 - i. The tank heater “maximum energy input rate” (i.e. maximum power) for the Dishwasher under test shall be determined in accordance with Section 7.6 of this test method.
 - ii. If the difference between the recorded value and the nameplate rating or rating printed on the heating element is greater than 5%, testing shall be terminated.

Note: ASTM F1696-07 specifies that the manufacturer may make appropriate changes or adjustments to the dishwasher. See Test Conduct Section 4H) for ENERGY STAR requirements.
 - e) For machines with steam coil tank heat, using an appropriately sized vessel that is completely dry, catch all water from the outlet during the test. Weigh the filled vessel, subtracting the weight of the capture vessel to calculate the weight of the water. Calculate the total mass of the inlet steam during the test and confirm that it is within 5% of the mass of water measured from the outlet stream. If the difference is greater than 5%, adjust the quality of the steam until the difference is less than 5% and rerun the tank heater “maximum energy input rate” (i.e. maximum power) test.
- 6) If there is a booster heater, the booster heater maximum energy input rate shall be measured and reported as specified in *ASTM F1696-07; Section 10.3* with the following revisions and additions.

- a) If there is a nameplate rating or a rating printed on the heating element for the booster heater, follow the steps below. If the booster heater is included as part of a total power consumption nameplate rating, follow the steps below while monitoring the total power consumption for all components included in the rating.
- b) Section 10.3.1 shall be replaced with the following:
 - i. Instruments shall be connected so that only the energy (for gas or steam booster heat) or power (for electric booster heat) consumption of the booster heater is measured. Fill the booster heater with water.
 - ii. For electric booster heaters, commence monitoring the power of the booster heater when the booster heater cycles on. Stop monitoring the power when the booster heater cycles off. Record the maximum power value as the “maximum energy input rate”.
 - iii. For gas booster heaters, allow the tank heater to idle for one “on” cycle to allow the burner orifices to heat up. Commence monitoring the elapsed time and energy consumption of the booster heater when the booster heater cycles on for the second time. Stop monitoring the elapsed time and energy consumption of the booster heater when the booster heater cycles off. Record the time and energy consumption of the booster heater during the complete “on” cycle.
 - iv. For steam coil booster heaters, commence monitoring the elapsed time and energy consumption of the booster heater when the booster heater cycles on. Stop monitoring the elapsed time and energy consumption of the booster heater when the tank heater cycles off. Record the time and energy consumption of the booster heater during the complete “on” cycle.
- c) Section 10.3.2 shall be followed as written with the following revision.
 - i. The booster heater “maximum energy input rate” (i.e. maximum power) for the Dishwasher under test shall be determined in accordance with Section 7.6 of this test method.
 - ii. If the difference between the recorded value and the nameplate rating or rating printed on the heating element is greater than 5%, testing shall be terminated.

Note: ASTM F1696-07 specifies that the manufacturer may make appropriate changes or adjustments to the dishwasher. See Test Conduct Section 4H) for ENERGY STAR requirements.
- d) For machines with steam coil booster heat, using an appropriately sized vessel that is completely dry, catch all water from the outlet during the test. Weigh the filled vessel, subtracting the weight of the capture vessel to calculate the weight of the water. Calculate the total mass of the inlet steam during the test and confirm that it is within 5% of the mass of water measured from the outlet stream. If the difference is greater than 5%, adjust the quality of the steam until the difference is less than 5% and rerun the booster heater “maximum energy input rate” (i.e. maximum power) test.

7) The idle energy rate (i.e. power) shall be measured as follows:

- a) If the Dishwasher does not have an internal booster heater:
 - i. Allow the Dishwasher to fill and energize the tank heater.

- ii. With the door(s) closed, allow the Dishwasher tank to idle for at least *1 hour for stabilization*. Commence monitoring elapsed time, *tank* temperature, and *total* energy consumption of the Dishwasher *when* the tank heater “on” cycles for the *first time after the 1 hour stabilization period*.
 - iii. Allow the Dishwasher to idle for 3 hours. *If there have not been ten distinct heater cycles during the 3 hour period, continue to run the test and record data. Stop the test the tenth time that the heater cycles off.* Record the final *elapsed* time and energy consumption *of the Dishwasher*.
 - iv. Record the minimum tank temperature during the test and confirm that it is at or above the *manufacturer’s specified* minimum tank temperature minus 1 °F, as applicable. If the minimum tank temperature during the idle energy test is below the manufacturer’s specified tank temperature *minus 1 °F*, the test is invalid and must be repeated. *If the tank temperature exceeds 15 °F of the measured minimum tank temperature, the test is invalid and must be repeated.* Adjust the thermostat per the manufacturer’s instructions *if it is user adjustable* and repeat the steps in i through iii.
- b) If the Dishwasher has an internal booster heater:
- i. Allow the Dishwasher to fill and energize the tank heater and booster heater.
 - ii. With the door(s) closed, allow the Dishwasher tank and booster heater to idle for at least 1 hour for stabilization. Commence monitoring elapsed time, tank temperature, and total energy consumption of the Dishwasher when the tank heater cycles “on” for the first time after the 1 hour stabilization period.
 - iii. Allow the Dishwasher to idle for 3 hours. If there have not been ten distinct heater cycles during the 3 hour period, continue to run the test and record data. Stop the test the tenth time that the heater cycles off. Record the final elapsed time and energy consumption of the Dishwasher.
 - iv. The booster idle energy consumption shall be reported separately from the total idle energy consumption.
 - If possible, sub-monitor the idle energy consumption of the booster heater during the Dishwasher idle energy test described in steps i through iii above.
 - If the booster heater idle energy cannot be simultaneously measured with the Dishwasher idle energy, the booster heater idle energy may be monitored at a different time; however, the number of booster heater “on” cycles in the separate test must be equivalent to the number of booster heater “on” cycles in the Dishwasher idle energy. Repeat steps i through iii above, but record the energy consumption of the booster heater instead of the total Dishwasher energy consumption.
 - If the booster heater cannot be separately monitored or sub-monitored, the booster heater idle energy consumption shall be included as part of the total idle energy consumption.
 - v. Record the minimum tank temperature during the test(s) and confirm that it is at or above the manufacturer’s specified minimum tank temperature minus 1 °F, as

applicable. If the minimum tank temperature during the idle energy test is below the manufacturer's specified tank temperature minus 1 °F, then the test is invalid and must be repeated. If the tank temperature exceeds 15 °F of the measured minimum tank temperature, the test is invalid and must be repeated. Adjust the thermostat per the manufacturer's instructions if it is user adjustable and repeat the steps in i through iv.

6.3 Idle Energy Consumption for Conveyor Type Machines

- 1) General measurements shall be taken and recorded as specified in *ASTM F1920-11; Section 10.1* with the following revisions and additions.
 - a) Steam coil units shall also be included in Section 10.1.1.
 - b) Section 10.1.1.2 shall be disregarded.
 - c) The higher heating value shall be measured for all tests with a gas powered tank heater or booster. The other measurements specified in Section 10.1.2 shall only be taken if the gas meter does not already correct the gas volume based on temperature and pressure. Section 10.1.2.6 shall be disregarded.
 - d) Section 10.1.4 shall be replaced with "For Dishwashers that use steam coils for tank or booster heat, the steam temperature, pressure, and volumetric flow rate at Dishwasher inlet, water temperature and pressure at Dishwasher outlet, and barometric pressure shall be recorded at no greater than 1 second of every test. Make any necessary corrections to the measurements as required by the instruments (i.e. correction for elevation of pressure gauge above pressure line, etc.)."
 - e) Section 10.1.5 shall be disregarded.
- 2) For Dishwashers with steam coil tank or booster heat, with the exterior service door(s) closed, allow the Dishwasher tank or booster to idle for one "on" cycle. As the tank or booster heater cycles on for the second time, record the amount of time between steam entering the volumetric flow meter and exiting as condensate with a stopwatch as t_{delay} (seconds). This time delay is used to compare the data from the inlet to the corresponding data from the outlet. Adjust testing times so that there is enough data to account for this delay. Alternately, if the time delay cannot be determined using this method, it may be estimated by dividing the volume of the heat exchanger by the average flow during the first complete heater "on" cycle.
- 3) If there is a booster heater for high temperature machines, the booster temperature shall be calibrated as follows:
 - a) *For external booster heaters*, while monitoring the water inlet of the booster heater *or water source* and Dishwasher (rinse manifold) temperature, initiate a Dishwasher cycle. Adjust the booster heater *or water source* to the manufacturer's recommended *sanitizing* rinse temperature ± 2 °F, if *user* adjustable. If the manufacturer does not have a recommended external booster heater setting, then set the booster heater thermostat such that the average temperature of water at the Dishwasher manifold (measured only during the rinse) is *between 180 °F and 195 °F*. If the machine is supplied with an internal booster heater, retain the factory setting of the thermostat.
 - b) *Run two empty dishracks through the machine to confirm that the stabilized flowing sanitizing rinse temperature is above the manufacturer's rated sanitizing rinse temperature minus 1 °F (or above 180 °F if the manufacturer does not provide a rated*

sanitizing rinse temperature). If the stabilized flowing sanitizing rinse temperature is below the manufacturer's nameplate rated sanitizing rinse temperature minus 1 °F (or below 180 °F if the manufacturer does not provide a rated rinse temperature), adjust the thermostat per the manufacturer's instructions if it is user adjustable.

- 4) The tank temperature(s) shall be calibrated as specified in *ASTM F1920-11; Section 10.6* with the following revisions and additions.
 - a) "Dishwater" should be replaced with "Dishwasher". Verify that the minimum tank heater temperature during the three consecutive heater cycles is above the manufacturer's recommended setting minus 1 °F and the maximum temperature is not more than 15 °F higher than the measured minimum temperature. Repeat for all actively heated tanks.
 - b) Run two empty dishracks through the machine to confirm that the minimum tank temperature(s) during the test is above the manufacturer's recommended setting minus 1 °F and the maximum temperature is not more than 15 °F higher than the measured minimum temperature. If the tank temperature(s) is not correct, adjust the thermostat per the manufacturer's instructions if it is user adjustable.
- 5) The wash tank pump and conveyor motor shall be calibrated as specified in *ASTM F1920-11; Section 10.7* with the following revision.
 - a) Section 10.7.1 is applicable to all pumps (not just the wash pump).
- 6) The tank heater "maximum energy input rate" (i.e. maximum power) shall be measured and reported as specified in *ASTM F1920-11; Section 10.2* with the following revisions and additions.
 - a) The maximum energy input rate determination is used to verify that the dishwasher is operating within manufacturer specifications. If there is a nameplate rating or a rating printed on the heating element for the tank heater(s), follow the steps below. If the tank heater(s) are included as part of a total power consumption nameplate rating, follow the steps below while monitoring the total power consumption for all components included in the rating.
 - b) Section 10.2.1 shall be replaced with the following:
 - i. Instruments shall be connected so that only the energy (for steam and gas tank heat) or power (for electric tank heat) consumption of the tank heater(s) is measured. Fill the Dishwasher tank with water.
 - ii. For electric tank heaters, commence monitoring the power of the tank heater when the tank heater cycles on. Stop monitoring the power when the tank heater cycles off. Record the maximum power value as the "maximum energy input rate".
 - iii. For gas tank heaters, allow the tank heater to idle for one "on" cycle to allow the burner orifices to heat up. Commence monitoring the elapsed time and energy consumption of the tank heater when the tank heater cycles on for the second time. Stop monitoring the elapsed time and energy consumption of the tank heater when the tank heater cycles off. Record the time and energy consumption of the tank heater during the complete "on" cycle.
 - iv. For steam coil tank heaters, commence monitoring the elapsed time and energy consumption of the tank heater when the tank heater cycles on. Stop monitoring the elapsed time and energy consumption of the tank heater when the tank

heater cycles off. Record the time and energy consumption of the tank heater during the complete “on” cycle.

- c) Section 10.2.2 shall be followed as written with the following revision.
 - i. The tank heater “maximum energy input rate” (i.e. maximum power) for the Dishwasher under test shall be determined in accordance with Section 7.6 of this test method.
 - ii. If the difference between the recorded value and the nameplate rating or rating printed on the heating element is greater than 5%, testing shall be terminated.

Note: ASTM F1696-07 specifies that the manufacturer may make appropriate changes or adjustments to the dishwasher. See Test Conduct Section 4H) for ENERGY STAR requirements.

- d) For machines with steam coil tank heat, using an appropriately sized vessel that is completely dry, catch all water from the outlet during the test. Weigh the filled vessel, subtracting the weight of the capture vessel to calculate the weight of the water. Calculate the total mass of the inlet steam during the test and confirm that it is within 5% of the mass of water measured from the outlet stream. If the difference is greater than 5%, adjust the quality of the steam until the difference is less than 5% and rerun the tank heater “maximum energy input rate” (i.e. maximum power) test.
- 7) If there is a booster heater, the booster heater maximum energy input rate shall be measured and reported as specified in *ASTM F1920-11; Section 10.3* with the following revisions and additions.
- a) If there is a nameplate rating or a rating printed on the heating element for the booster heater, follow the steps below. If the booster heater is included as part of a total power consumption rating, follow the steps below while monitoring the total power consumption for all components included in the rating.
 - b) Section 10.3.1 shall be replaced with the following:
 - i. Instruments shall be connected so that only the energy (for gas or steam booster heat) or power (for electric booster heat) consumption of the booster heater is measured. Fill the booster heater with water.
 - ii. For electric booster heaters, commence monitoring the power of the booster heater when the booster heater cycles on. Stop monitoring the power when the booster heater cycles off. Record the maximum power value as the maximum energy input rate.
 - iii. For gas booster heaters, allow the tank heater to idle for one “on” cycle to allow the burner orifices to heat up. Commence monitoring the elapsed time and energy consumption of the booster heater when the booster heater cycles on for the second time. Stop monitoring the elapsed time and energy consumption of the booster heater when the booster heater cycles off. Record the time and energy consumption of the booster heater during the complete “on” cycle.
 - iv. For steam coil booster heaters, commence monitoring the elapsed time and energy consumption of the booster heater when the booster heater cycles on. Stop monitoring the elapsed time and energy consumption of the booster heater when the tank heater cycles off. Record the time and energy consumption of the booster heater during the complete “on” cycle.

- c) Section 10.3.2 shall be followed as written with the following revision.
- i. The booster heater “maximum energy input rate” (i.e. maximum power) for the Dishwasher under test shall be determined in accordance with Section 7.6 of this test method.
 - ii. If the difference between the recorded value and the nameplate rating or rating printed on the heating element is greater than 5%, testing shall be terminated.

Note: ASTM F1696-07 specifies that the manufacturer may make appropriate changes or adjustments to the dishwasher. See Test Conduct Section 4H) for ENERGY STAR requirements.

- d) For machines with steam coil booster heat, using an appropriately sized vessel that is completely dry, catch all water from the outlet during the test. Weigh the filled vessel, subtracting the weight of the capture vessel to calculate the weight of the water. Calculate the total mass of the inlet steam during the test and confirm that it is within 5% of the mass of water measured from the outlet stream. If the difference is greater than 5%, adjust the quality of the steam until the difference is less than 5% and rerun the booster heater “maximum energy input rate” (i.e. maximum power) test.

8) The idle energy rate (i.e. power) shall be measured as follows:

- a) If the Dishwasher does not have an internal booster heater:
- i. Allow the Dishwasher to fill and energize the tank heater(s).
 - ii. *For single tank machines, with the exterior service door(s) closed, allow the Dishwasher tank to idle for at least 1 hour for stabilization. Commence monitoring elapsed time, tank temperature, and total energy consumption of the Dishwasher when the tank heater on “cycles” for the first time after the 1 hour stabilization period.*
 - iii. *For multiple tank machines, with the exterior service door(s) closed, allow the Dishwasher tanks to idle for at least 1 hour for stabilization. Commence monitoring the elapsed time and total energy consumption of the Dishwasher and the temperature of all the tanks when one of the tank heaters “on” cycles again after the 1 hour stabilization period.*
 - iv. Allow the Dishwasher to idle for 3 hours. *If there have not been ten distinct tank heater cycles for all tank heaters during the 3 hour period, continue to run the test and record data. Stop the test when one of the tank heaters cycles off again after all tank heaters have “on” cycled ten times. Record the final elapsed time and energy consumption of the Dishwasher.*
 - v. *Record each tank’s minimum tank temperature during the test and confirm that it is at or above the manufacturer’s specified minimum tank temperature(s) minus 1 °F, as applicable. If the minimum tank temperature(s) during the idle energy test was below the manufacturer’s specified tank temperature(s) minus 1 °F, the test is invalid and must be repeated. If the tank temperature(s) exceeds 15 °F of the measured minimum tank temperature(s), the test is invalid and must be repeated. Adjust the thermostat per the manufacturer’s instructions if it is user adjustable and repeat the steps in i through iv.*

- b) If the Dishwasher has an internal booster heater:
- i. Allow the Dishwasher to fill and energize the tank heater(s).
 - ii. For single tank machines, with the exterior service door(s) closed, allow the Dishwasher tank to idle for at least 1 hour for stabilization. Commence monitoring elapsed time, tank temperature, and total energy consumption of the Dishwasher when the tank heater cycles “on” for the first time after the 1 hour stabilization period.
 - iii. For multiple tank machines, with the exterior service door(s) closed, allow the Dishwasher tanks to idle for at least 1 hour for stabilization. Commence monitoring the elapsed time and total energy consumption of the Dishwasher and the temperature of all the tanks when one of the tank heaters “on” cycles again after the 1 hour stabilization period.
 - iv. Allow the Dishwasher to idle for 3 hours. If there have not been ten distinct tank heater cycles for all tank heaters during the 3 hour period, continue to run the test and record data. Stop the test when one of the tank heaters cycles off again after all tank heaters have “on” cycled ten times. Record the final elapsed time and energy consumption of the Dishwasher.
 - v. The booster idle energy rate shall be reported separately from the total idle energy rate.
 - If possible, sub-monitor the idle energy rate of the booster heater during the Dishwasher idle energy test described in steps i through iv above.
 - If the booster heater idle energy cannot be simultaneously measured with the Dishwasher idle energy, the booster heater idle energy may be monitored at a different time; however, the number of booster heater “on” cycles in the separate test must be equivalent to the number of booster heater “on” cycles in the Dishwasher idle energy test. Repeat steps i through iv above, but record the energy consumption of the booster heater instead of the total Dishwasher energy consumption.
 - If the booster heater cannot be separately monitored or sub-monitored, the booster heater idle energy shall be included as part of the total idle energy.
 - vi. Record each tank’s minimum tank temperature during the test(s) and confirm that it is at or above the manufacturer’s specified minimum tank temperature(s) minus 1 °F, as applicable. If the minimum tank temperature(s) during the idle energy test is below the manufacturer’s specified tank temperature(s) minus 1 °F, then the test is invalid and must be repeated. If the tank temperature(s) exceeds 15 °F of the measured minimum tank temperature(s), the test is invalid and must be repeated. Adjust the thermostat per the manufacturer’s instructions if it is user adjustable and repeat the steps in i through v.

7 CALCULATIONS

7.1 Racks per Hour

A) Fresh Water or Pumped Water Sanitizing or Post-Sanitizing Rinse Stationary Type Machines

Equation 1: Racks per Hour for Stationary Type Machines

$$\text{Racks per Hour} = \frac{3600 \text{ seconds} \times NR}{(WT + RT + DT + LT)(\text{seconds})}$$

Where:

Racks per Hour = Number of racks washed per hour, truncated to the next lowest whole number

NR = Number of racks washed per cycle

WT = Wash time (i.e. amount of time spent in wash mode) in seconds as recorded during test
RT = Rinse time (i.e. amount of time spent in rinse mode, including a post-sanitizing rinse) in seconds as recorded during test

DT = Dwell time (i.e. amount of time spent in dwell mode) in seconds as recorded during test

LT = Load time (30 seconds for under counter Dishwashers, 5 seconds for straight through door-type Dishwashers, 7 seconds for corner door-type Dishwashers, 30 seconds for front load/unload door-type Dishwashers)

- B) Fresh Water or Pumped Water Sanitizing or Post-Sanitizing Rinse Conveyor Type (excluding Flight Type) Machines

Equation 2: Racks per Hour for Conveyor Type Machines

$$\text{Racks per Hour} = \frac{CS \times \frac{60 \text{ minutes}}{\text{hour}}}{RL \times \frac{1 \text{ ft}}{12 \text{ in}}}$$

Where:

Racks per Hour = Number of racks washed per hour, truncated to the next lowest whole number

RL = Rack length (use 20 inches)

CS = Manufacturer specified maximum conveyor speed in feet per minute

7.2 Sanitizing and Post-Sanitizing Rinse Water Consumption (Gallons per Hour, GPH)

- A) Fresh Water or Pumped Water Sanitizing or Post-Sanitizing Rinse Stationary Type Machines

Equation 3: Gallons per Hour for Stationary Type Machines

$$\text{Gallons per Hour} = \frac{\sum_{n=1}^5 \frac{\text{Measured Weight of water for cycle } n \text{ (lbs)}}{5 \text{ cycles}}}{\frac{8.34 \text{ lbs}}{\text{gal}}} \times \frac{\text{Racks per Hour}}{NR}$$

Where:

Racks per Hour = Number of racks washed per hour, truncated to the next lowest whole number, as calculated in Section 7.1

NR = Number of racks washed per cycle

- B) Fresh Water or Pumped Water Sanitizing or Post-Sanitizing Rinse Conveyor Type (including Flight Type) Machines

Equation 4: Gallons per Hour for Conveyor Type Machines

$$\text{Gallons per Hour} = \frac{\sum_{n=1}^5 \text{Measured Flow of water for test run } n \text{ (gallons per minute)}}{5 \text{ test runs} \times \frac{1 \text{ hour}}{60 \text{ minutes}}}$$

Where:

Measured Flow of water for test run n = Flow of water measured by flow meter from one minute of sanitizing rinse activation (and post-sanitizing rinse solenoid activation if the water consumption including post-sanitizing rinse is being measured).

7.3 Sanitizing and Post-Sanitizing Rinse Water Consumption

- A) Fresh Water or Pumped Water Sanitizing or Post-Sanitizing Rinse Stationary Rack Type Machines

Equation 5: Gallons per Rack for Stationary Type Machines

$$\text{Gallons per Rack} = \frac{\text{Gallons per Hour}}{\text{Racks per Hour}}$$

Where:

Gallons per Hour= Water use in gallons per hour, as calculated in Section 7.2

Racks per Hour= Number of racks washed per hour, truncated to the next lowest whole number, as calculated in Section 7.1

- B) Fresh Water or Pumped Water Sanitizing and Post-Sanitizing Rinse Conveyor Type (excluding Flight Type) Machines

Equation 6: Gallons per Rack for Conveyor Type Machines

$$\text{Gallons per Rack} = \frac{\text{Gallons per Hour}}{\text{Racks per Hour}}$$

Where:

Gallons per Hour= Water use in gallons per hour, as calculated in Section 7.2

Racks per Hour= Number of racks washed per hour, truncated to the next lowest whole number, as calculated in Section 7.1

- C) Pot, Pan, and Utensil Type Machines

Equation 7: Gallons per Square Foot for Pot, Pan, and Utensil Type Machines

$$\text{Gallons per Square Foot} = \frac{\text{Gallons per Rack}}{\text{Square foot of rack}}$$

Where:

Gallons per Rack= Water use in gallons per hour, as calculated in Section 7.3A)

Square foot of rack= Manufacturer specified rack area in ft² for machine tested

7.4 Gas Energy Consumption

- A) The gas energy consumption rate shall be calculated as specified in *ASTM F1920-11; Section 11.3* with the following revision.
- 1) Equation (2) shall only be used to calculate V if the gas meter does not already correct the gas volume based on temperature and pressure using the same standard values for temperature and pressure that were used to calculate the higher heating value in *ASTM F1920-11; Section 10.1.2*.

7.5 Steam Coil Energy Consumption

- A) Inlet Steam Mass Flow Rate
- 1) Find the measured pressure and temperature values for the inlet stream for each data point in the superheated or saturated steam tables¹ (depending on the state of the steam) and record the listed density (ρ_{Steam}). If the exact pressure and temperature are not listed in the table, interpolate between the two closest pressure and temperature values to calculate the density.
 - 2) Calculate the mass flow rate for each data point as follows:

Equation 8: Inlet Steam Mass Flow Rate for Steam Coil Machines

$$\dot{M}_{Steam} = \dot{V}_{Steam} \times \rho_{Steam}$$

Where:

\dot{M}_{Steam} = Mass flow rate of steam (pounds (lb)/h)
 \dot{V}_{Steam} = Measured volumetric flow rate of steam (ft³/h)
 ρ_{Steam} = Density of steam (lb/ft³), calculated from steam tables

- B) Inlet Steam Total Mass

Equation 9: Inlet Steam Total Mass for Steam Coil Machines

$$M_{Total} = \sum_{i=1}^N (\dot{M}_{Steam,i} \times t_i) \times \frac{1 \text{ hour}}{3600 \text{ seconds}}$$

Where:

M_{Total} = Total steam consumption during time period (lb)
 $\dot{M}_{Steam,i}$ = Instantaneous steam mass flow rate for each data point (lb/h)
 N = Total number of data points during time period, excluding extra data to account for t_{delay}
 t_i = Time interval of each data point (seconds)

¹ "Steam tables" throughout this test procedure refers to any steam table source based on the International Association for the Properties of Water and Steam Formulation 1997 for the Thermodynamic Properties of Water and Steam for Industrial Use.

C) Inlet Stream Enthalpy

- 1) Find the measured pressure and temperature values for the inlet steam for each data point in the superheated or saturated steam tables (depending on the state of the steam) and record the listed enthalpy (H_{Inlet}). If the exact pressure and temperature are not listed in the table, interpolate between the two closest pressure and temperature values to calculate the enthalpy.

D) Outlet Water Enthalpy

- 1) Find the pressure value for the outlet water for each data point in the saturated steam tables. Record the listed saturated liquid enthalpy value ($H_{Saturated}$) and saturated temperature value ($T_{Saturated}$). If the exact pressure is not listed in the table, interpolate between the two closest pressure values to calculate the enthalpy.
- 2) Calculate the enthalpy of the outlet water for each data point as follows:

Equation 10: Outlet Water Enthalpy for Steam Coil Machines

$$H_{Outlet} = H_{Saturated} - (C_p \times (T_{Saturated} - T_{Measured}))$$

Where:

H_{Outlet} = Enthalpy of Dishwasher outlet stream (British thermal units (Btu)/lb)

$H_{Saturated}$ = Saturated liquid enthalpy value listed in steam tables (Btu/lb)

C_p = Heat capacity of water (1 Btu/lb °F)

$T_{Saturated}$ = Saturated liquid temperature value listed in steam tables (°F)

$T_{Measured}$ = Recorded temperature of liquid water outlet stream during test (°F)

E) Instantaneous Energy Consumption

- 1) Calculate the energy for each data point as follows:

Equation 11: Instantaneous Energy Consumption for Steam Coil Machines

$$E_i = \dot{M}_{Steam,i} \times (H_{Inlet,i} - H_{Outlet,i+t_{delay}}) \times t_i \times \frac{1 \text{ hour}}{3600 \text{ seconds}}$$

Where:

E_i = Instantaneous energy consumption for each data point (Btu)

$\dot{M}_{Steam,i}$ = Calculated mass flow rate of steam for each data point (lb/h)

$H_{Inlet,i}$ = Enthalpy of Dishwasher inlet steam for each data point (Btu/lb)

$H_{Outlet,i+t_{delay}}$ = Enthalpy of Dishwasher outlet water for each data point (Btu/lb)

t_{delay} = Measured time between steam entering the flow meter and exiting as water (seconds)

t_i = Time interval of each data point (seconds)

F) Total Energy Consumption

Equation 12: Total Energy Consumption for Steam Coil Machines

$$E_{Total} = \sum_{i=1}^N (E_i) + E_{Electric}$$

Where:

E_{Total} = Total energy consumption during test (active or idle) (Btu)

E_i = Instantaneous energy consumption for each data point (Btu)

$E_{Electric}$ = Electric energy consumption during test (Btu)

N = Total number of data points, excluding extra data to account for t_{delay}

7.6 Booster and Tank Heater Maximum Power

- A) The idle energy input rate (i.e. maximum power) shall be calculated as specified in *ASTM F1920-11; Section 11.4* if a direct measurement of power was not taken.
- 1) The value 60 provided in the equation is a conversion factor from minute to hours.
 - 2) This calculation shall also be used for steam.

7.7 Idle Energy Rate (Power)

- A) The idle energy rate (i.e. power) shall be calculated as specified in *ASTM F1920-11; Section 11.5* with the following clarification, and additions.
- 1) The value 60 provided in the equation is a conversion factor from minute to hours.
 - 2) This calculation shall also be used for steam.
 - 3) If the idle energy rate (i.e. power) is reported in Btu/h, convert it to kilowatts (kW) based on the following equation:

Equation 13: Idle Energy Rate Conversion

$$E_{Idle\ rate} (kW) = E_{Idle\ rate} \left(\frac{Btu}{h} \right) \times \frac{kW}{3412\ Btu/h}$$

7.8 Internal Booster Heater Idle Energy Rate (Power)

- A) The booster heater idle energy rate (i.e. power) shall be calculated using the same equation as specified in *ASTM F1920-11; Section 11.5* for the tank heater idle energy rate with the following clarification and addition.
- 1) The value 60 provided in the equation is a conversion factor from minute to hours.
 - 2) This calculation shall also be used for steam.
 - 3) If the internal booster heater idle energy rate (i.e. power) is reported in Btu/h, convert it to kW based on the following equation:

Equation 14: Internal Booster Heater Idle Energy Rate Conversion

$$E_{Idle\ rate} (kW) = E_{Idle\ rate} \left(\frac{Btu}{h} \right) \times \frac{kW}{3412\ Btu/h}$$

8 REFERENCES

- A) ASTM F857-07. Standard Specification for Hot Water Sanitizing Commercial Dishwashing Machines, Stationary Rack Type. Published April 2007.
- B) ASTM F858-07. Standard Specification for Hot Water Sanitizing Commercial Dishwashing Machines, Single Tank, Conveyor Rack Type. Published April 2007.
- C) ASTM F1920-11. Standard Test Method for Performance of Rack Conveyor, Commercial Dishwashing Machines. Published July 2011.
- D) ASTM F1696-07. Standard Test Method for Energy Performance of Single-Rack, Door-Type Commercial Dishwashing Machines. Published November 2007.
- E) NSF/ANSI 3-2010. Commercial Warewashing Equipment. November 2, 2010. NSF/ANSI 170-2010. Glossary of Food Equipment Terminology. April 6, 2011.
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