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

Final Draft Test Method (Rev. Apr-2012)

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8 **1 OVERVIEW**

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

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

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15 **2 APPLICABILITY**

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

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22 **Note:** This test method has not been validated for flight type machines; however, laboratories have
23 indicated that the conveyor test method is applicable to flight type machines so they are included.

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25 A test method was developed and is included for machines with a post-sanitizing rinse; however, the
26 method has not been validated for either in a laboratory.

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28 The test method for steam coil booster heaters has not been validated; however, stakeholder feedback
29 indicated that the method should be the same as the steam coil tank heat method, but applied to the
30 booster heater instead. Models that use steam injection tank or booster heaters are excluded from this
31 test method, These designs represent a small share of the marketplace and without additional data, DOE
32 and EPA cannot identify a consistent method for measuring performance. These product types may be
33 considered under a future version if more information can be obtained on these designs.

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35 **3 DEFINITIONS**

36 **Note:** DOE and EPA will combine the Test Method and Eligibility Criteria when they are finalized, so the
37 definitions will only be in one document.

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39 A) Acronyms, Abbreviations, and Units:

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41 1) ANSI: American National Standards Institute

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43 2) ASTM: American Society for Testing and Materials

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45 3) Btu: British Thermal Units

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47 4) cfm: Cubic feet per minute

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49 5) DOE: U.S. Department of Energy
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51 6) EPA: U.S. Environmental Protection Agency
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53 7) °F: Degrees Fahrenheit
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55 8) ft: Feet
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57 9) ft³: Cubic feet
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59 10) h: Hour(s)
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61 11) in: Inch(es)
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63 12) in. H₂O: Inches water
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65 13) in. Hg: Inches mercury
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67 14) kW: Kilowatt(s)
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69 15) kWh: Kilowatt-hour(s)
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71 16) lb: Pound(s)
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73 17) min: Minute(s)
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75 18) NSF: NSF International
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77 19) psi: Pounds per square inch
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79 20) psia: Pounds per square inch absolute
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81 21) psig: Pounds per square inch gauge
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83 22) °R: Degrees Rankine
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85 23) s: Second(s)
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87 24) UUT: Unit Under Test
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89 25) V: Volt(s)
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91 26) W: Watt(s)
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93 27) Wh: Watt-hour(s)

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95 B) General:

- 96
97 1) Dishwashing Machine: A machine designed to clean and sanitize plates, pots, pans, glasses,
98 cups, bowls, utensils, and trays by applying sprays of detergent solution (with or without blasting
99 media granules) and a sanitizing rinse.

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

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2) Machine Types:

a) 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.

i. 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.

Note: The definition for under counter machine has been updated to include designs that use external booters.

ii. Single Tank, Door Type: A machine designed to accept a standard nominal 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.

iii. Pot, Pan, and Utensil: A stationary rack, door type machine designed to clean and sanitize pots, pans, and kitchen utensils.

iv. Glasswashing: A stationary rack, under counter machine specifically designed to clean and sanitize glasses.

b) 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.

i. 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.

Note: The words “pumped or fresh water” have been added to the first sentence in the single tank conveyor definition, as additional descriptors of the sanitizing rinse, to address a manufacturer’s concern that machines with an air gap and pumped final rinse may be miscategorized as multi-tank machines.

ii. 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.

156 iii. Flight Type Conveyor: A conveyor machine where the dishes are loaded directly on the
157 conveyor rather than transported with a rack. This machine is also referred to as a
158 rackless conveyor.
159

160 c) Sanitation Methods:

161
162 i. Hot Water Sanitizing (High Temp) Machine: A machine that applies hot water to the
163 surfaces of dishes to achieve sanitization.
164

165 ii. Chemical Sanitizing (Low Temp) Machine: A machine that applies a chemical sanitizing
166 solution to the surfaces of dishes to achieve sanitization.
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168 iii. Chemical Dump Type Machine: A low temp, stationary rack machine with a pumped
169 recirculated sanitizing rinse.
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171 iv. Dual Sanitizing Machine: A machine designed to operate as either a high temp or low
172 temp machine.
173

174 3) Warewashing Machine Terminology
175

176 a) Product Family: Variations of one model offered within a single product line with design
177 differences limited to: finish/color; length of pre-wash section, voltage, and orientation (e.g.,
178 corner, straight through models). Individual models represented by a product family must
179 have the same sanitizing and post-sanitizing rinse water and idle energy consumption.
180

181 b) Water heater: Water Heater is defined in NSF International/American National Standards
182 Institute (*NSF/ANSI 170-2010: Glossary of Food Equipment Terminology*; Section 3.223.
183

184 c) Booster Heater: Booster Heater is defined in *NSF/ANSI 170-2010*; Section 3.223.1.
185

186 d) Sanitization: Sanitization is defined in *NSF/ANSI 170-2010*; Section 3.176.
187

188 e) Sanitizing Solution: Sanitizing Solution is defined in *NSF/ANSI 170-2010*; Section 3.177.
189

190 f) Washing: Washing is defined in *NSF/ANSI 170-2010*; Section 3.221.
191

192 g) Fresh Water: Fresh Water is defined in *NSF/ANSI 170-2010*; Section 3.83.
193

194 h) Sanitizing Rinse: Sanitizing Rinse is defined in *NSF/ANSI 170-2010*; Section 3.173.
195

196 i) Chemical Sanitizing Rinse: Chemical Sanitizing Rinse is defined in *NSF/ANSI 170-2010*;
197 Section 3.170.
198

199 j) Hot Water Sanitizing Rinse: Hot Water Sanitizing Rinse is defined in *NSF/ANSI 170-2010*;
200 Section 3.171.
201

202 k) Pumped Rinse: Pumped Rinse is defined in *NSF/ANSI 170-2010*; Section 3.152.
203

204 l) Auxiliary Rinse: Auxiliary rinse is defined in *NSF/ANSI 170-2010*; Section 3.5.
205

206 m) Recirculating Sanitizing Rinse: Recirculating Sanitizing Rinse is defined in *NSF/ANSI 170-*
207 *2010*; Section 3.160.
208

209 n) Non-recirculating Pumped Sanitizing Rinse: Non-recirculating Pumped Sanitizing Rinse is
210 defined in *NSF/ANSI 170-2010*; Section 3.129.

- 211
212 o) Post-sanitizing Rinse: Post-sanitizing Rinse is defined in *NSF/ANSI 170-2010; Section 3.172*.
213
214 p) Prewashing Unit: Prewashing Unit is defined in *NSF/ANSI 170-2010; Section 3.148*.
215
216 q) Rack: Rack is defined in *NSF/ANSI 170-2010; Section 3.155*.
217
218 r) User Adjustable: A feature is user adjustable if it may be adjusted by the machine operator
219 without aid from a technician or manufacturer.
220

221 **Note:** DOE and EPA welcome stakeholder comments on the newly proposed definition for “User
222 Adjustable”.

223
224 4) Mode Definitions

- 225
226 a) Wash Mode: For stationary rack machines, the dishwasher is in wash mode when it is
227 actively running a cycle and is spraying wash water (water that is neither part of the sanitizing
228 rinse, post-sanitizing rinse, nor the prewashing unit).
229
230 b) Rinse Mode: For stationary rack machines, the dishwasher is in rinse mode when it is at the
231 end of the actively running cycle and is spraying hot water or chemical sanitizing rinse water
232 or a post-sanitizing rinse.
233
234 c) Dwell Mode: For stationary rack machines, the dishwasher is in dwell mode when it is actively
235 running a cycle but is not in wash mode or rinse mode.
236
237 d) Idle Mode: For all dishwasher types, the dishwasher is in idle mode when it is not actively
238 running but is still powered on and ready to wash dishes at the required temperature.
239
240 e) Energy Saver Mode: A dishwasher is in energy saver mode if the dishwasher is manually
241 converted or, after inactivity, the dishwasher automatically converts to a setting that
242 consumes less energy than it does in idle mode (not all dishwashers include this feature).
243

244 **Note:** In response to stakeholder feedback, the Energy Saver Mode definition has been updated to
245 account for units that enter Energy Saver Mode either automatically or manually.

246
247 5) Test Method Terminology

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249 a) Ambient Temperature: Ambient Temperature is defined in *NSF/ANSI 170-2010; Section 3.3*.
250
251 b) Flow Pressure: Flow Pressure is defined in *NSF/ANSI 170-2010; Section 3.74*.
252
253 c) Line Pressure: Line Pressure is defined in *NSF/ANSI 170-2010; Section 3.113*.
254
255 d) Rated Temperature: Rated Temperature is defined in *American Society for Testing and*
256 *Materials (ASTM) F1920-11: Standard Test Method for Performance of Rack Conveyor,*
257 *Commercial Dishwashing Machines; Section 3.1.7*.
258
259 e) Tank Heater Idle Rate: Tank Heater Idle Rate is defined in *ASTM F1920-11; Section 3.1.9*.
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261 f) Uncertainty: Uncertainty is defined in *ASTM F1920-11; Section 3.1.10*.
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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.

Note: This clarification has been added so that the water consumption from the post-sanitizing rinse may be separately evaluated from the sanitizing rinse water consumption.

- 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.

Note: DOE and EPA acknowledge stakeholders' desire to measure and promote the energy reductions that are capable through the use of Energy Saver Modes. Typically, EPA and DOE have required that products meet ENERGY STAR requirements "as shipped" to the end user. However, given that these Energy Saver Modes are adjustable and dependent on operation, it is important that the end user is assured of ENERGY STAR performance in a worst case scenario. EPA and DOE believe that the Dishwasher must meet idle energy requirements for the entire duration of the idle energy test without the Energy Saver Mode activated. Therefore, a requirement that the Energy Saver Mode be disabled during testing has been added above.

- 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.

Note: In response to stakeholder feedback, instructions for field servicing and component replacements have been added.

- 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.

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Note: This clarification has been added because laboratories often record more data than necessary and perform data analysis on a portion of that data.

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.

Note: In response to stakeholder feedback, the scale resolution has been changed from at least 0.01 lb to 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.

Note: In response to stakeholder feedback, the stopwatch accuracy has been changed from +/- 0.2% to +/- 2%

- 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

Note: ASTM is in the process of revising ASTM F1920-11. DOE has discussed the proposed revisions in this test method with ASTM. Once the revised ASTM standard is published, it will include many of the revisions specified in this test method.

- 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.

- 368 ii. The tank heater gas meters shall be capable of measuring flows between at least
369 0 ft³/hour (h) and 250 ft³/h and the pilot light gas meters shall be capable of measuring
370 flows between at least 0 ft³/h and 10 ft³/h.
371
- 372 c) Steam Flow Meters: For Dishwashers with steam coil tank or booster heat, the steam flow
373 meters shall meet the requirements in *ASTM F1920-11; Section 6.3* with the following
374 addition.
375
- 376 i. The steam flow meters shall be capable of measuring flows between at least 0 ft³/h and
377 50 ft³/h and shall be capable of recording data at least as frequently as every second.
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379
- 380 d) Water Flow Meters: For conveyor Dishwashers, the flow meters shall have a resolution of at
381 least 0.1 gallons per minute, an accuracy of +/- 1.5% of the flow rate being measured, and
382 shall be capable of measuring flows between at least 0 gallons per minute and 6 gallons per
383 minute.
384

385 **Note:** In response to stakeholder feedback, the water consumption test method for conveyor
386 Dishwashers has been changed from a catch and weigh method to a flow meter method. DOE and EPA
387 propose adding these requirements for water flow meters used to measure the water consumption of
388 conveyor Dishwashers.

389
390 3) Pressure Gauges

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- 392 a) Gas Pressure Gauge: For Dishwashers with gas tank heat, the gas pressure gauges shall
393 meet the requirements in *ASTM F1920-11; Section 6.6*.
394
- 395 b) Steam Pressure Gauge: For Dishwashers with steam coil tank or booster heat, the steam
396 pressure gauges shall meet the requirements in *ASTM F1920-11; Section 6.4* with the
397 following addition.
398
- 399 i. The steam pressure gauges shall be capable of measuring pressures between at least
400 0 psig and 100 psig.
401

402 4) Ventilation

- 403
- 404 a) Stationary Rack: For Dishwashers that are classified as stationary rack types, ventilation shall
405 meet the requirements in *ASTM F1696-07: Standard Test Method for Energy Performance of*
406 *Single-Rack, Door-Type Commercial Dishwashing Machines; Section 6.5*.
407
- 408 b) Conveyors: For Dishwashers that are classified as conveyor types, ventilation shall meet the
409 requirements in *ASTM F1920-11; Section 6.5* with the following revision.
410
- 411 i. Vent cowl exhaust ducts shall operate in accordance with the manufacturer's
412 recommendation, if applicable, or at a nominal 200 cubic feet per minute (cfm) on the
413 entrance side of the Dishwasher and 400 cfm on the exit side if the manufacturer does
414 not provide recommendations.
415

416 5) Thermocouple Probes and Temperature Sensors

- 417
- 418 a) Thermocouple Probes: For all Dishwashers, the thermocouple probes shall meet the
419 requirements in *ASTM F1920-11; Section 6.12* with the following revision and additions.
420
- 421 i. "Dishwater" shall be replaced with "Dishwasher".
422

- 423 ii. The thermocouple probes shall have a response time of less than 2 seconds.
424
425 iii. For Dishwashers with steam coil tank or booster heat, the thermocouple probes shall be
426 used for measuring the condensate water outlet temperature.
427
428 b) Ambient Air: For all Dishwashers, the temperature sensor for measuring ambient air
429 temperatures in the range of 50 degrees Fahrenheit (°F) to 100 °F shall have a resolution of
430 at least 0.5 °F and a maximum uncertainty of +/- 1 °F.
431
432 c) Gas: For Dishwashers with gas tank heat, the temperature sensor for measuring natural gas
433 temperatures shall meet the requirements in *ASTM F1920-11; Section 6.7*.
434
435 d) Steam: For Dishwashers with steam coil tank or booster heat, the temperature sensor for
436 measuring steam temperatures in the range of 200 °F to 300 °F shall have a resolution of at
437 least 0.5 °F and a maximum uncertainty of +/- 1 °F.
438

439 6) Additional Requirements

- 440
441 a) Stop Watch: For all Dishwashers, the stop watch shall meet the requirements in *ASTM*
442 *F1920-11; Section 6.10*. The stop watch shall have an accuracy of +/- 2% of the time period
443 being measured.
444

445 **Note:** DOE and EPA propose adding an accuracy requirement for the stop watch that is used in the idle
446 energy test for consistency with the requirements of the stop watch that is used in the water consumption
447 test.

- 448
449 b) Barometer: For Dishwashers with natural gas tank heat, a barometer shall be used if the gas
450 flow meter does not correct for pressure. For Dishwashers with steam coil tank or booster
451 heat, a barometer shall be used for calculating absolute pressure from gage pressure if the
452 pressure gauge does not correct for atmospheric pressure. The barometer shall meet the
453 requirements in *ASTM F1920-11; Section 6.8*.
454

- 455 c) Dishrack: Metro Mdl P2MO, 20 in. x 20 in., peg-type, commercial or acceptable equivalent.
456

457 **Note:** DOE and EPA propose adding the ASTM requirement for dishrack type since a dishrack is used in
458 the test method and specifying the dishrack type improves test consistency.

459
460 C) Commercial Dishwasher Installation

- 461
462 1) Commercial Dishwashers shall be installed per manufacturer's installation instructions. All
463 packing material and protective packaging shall be removed.
464
465 2) Drain connections shall be accessible with sufficient space to allow capture vessel to be
466 positioned beneath.
467
468 3) For steam coil tank or booster heat Dishwashers, install instruments to provide dry superheated
469 steam to the Dishwasher. Adjust the steam supply pressure to within +/- 2.5% of the operating
470 pressure specified by the manufacturer. Install instrumentation to record the pressure,
471 temperature, and volumetric flow rate of the steam supplied to the Dishwasher tank heater (and
472 booster heater separately, if applicable), the pressure and temperature of the condensate exiting
473 the Dishwasher tank heater (and booster heater separately, if applicable), and the barometric
474 pressure during each test so that the measured gage pressures can be corrected to absolute
475 pressure.
476

477 4) Stationary Rack Type: For Dishwashers that are classified as stationary rack types, the
478 Dishwasher setup shall meet the requirements in *ASTM F1696-07; Sections 9.1-9.10* with the
479 following revisions and additions.

480
481 a) In Section 9.3, the supply of water shall be within the range of the manufacturer-specified
482 input temperatures (not to exceed 140 +/- 2 °F). For testing purposes, the Dishwasher may
483 be connected to a source of water that is at the manufacturer specified sanitizing rinse
484 temperature in lieu of an external booster heater.
485

486 **Note:** In response to stakeholder feedback, the water supply temperature requirement has been modified
487 to allow manufacturer-specified input temperature ranges.

488
489 b) In Section 9.4, the watt-hour meters shall be connected so that all idle energy (including tank
490 heater, motors, and controls) is monitored. For steam coil or gas Dishwashers, electric
491 energy consumption shall be simultaneously monitored with steam or gas energy
492 consumption. The Dishwasher and booster shall not be monitored as one energy load. For
493 the idle energy test, internal booster heaters shall be monitored separately and the booster
494 idle energy shall be reported separately from the total idle energy.
495

496 c) In Section 9.5, instrumentation to record both the pressure and temperature of the gas
497 supplied to the Dishwasher and the barometric pressure is only necessary if the gas flow
498 meter does not already correct for pressure and temperature.
499

500 5) Conveyors: For Dishwashers that are classified as conveyors, the Dishwasher setup shall meet
501 the requirements in *ASTM F1920-11; Sections 9.1-9.11* with the following revisions and additions.
502

503 a) In Section 9.3, the supply of water shall be within the range of the manufacturer-specified
504 input temperatures (not to exceed 140 +/- 2 °F). For testing purposes, the Dishwasher may
505 be connected to a source of water that is at the manufacturer specified sanitizing rinse
506 temperature in lieu of an external booster heater.
507

508 **Note:** In response to stakeholder feedback, the water supply temperature requirement has been modified
509 to allow manufacturer-specified input temperature ranges.

510
511 b) In Section 9.4, the watt-hour meters shall be connected so that all idle energy (including tank
512 heater(s), motors, and controls) is monitored. For steam coil or gas Dishwashers, electric
513 energy consumption shall be simultaneously monitored with steam or gas energy
514 consumption. The Dishwasher and booster shall not be monitored as one energy load. For
515 the idle energy test, internal booster heaters shall be monitored separately and the booster
516 idle energy shall be reported separately from the total idle energy.
517

518 c) In Section 9.5, instrumentation to record both the pressure and temperature of the gas
519 supplied to the Dishwasher and the barometric pressure is only necessary if the gas flow
520 meter does not already correct for pressure and temperature.
521

522 D) Test Settings

523
524 1) Water Consumption Test Settings:
525

526 **Note:** In response to stakeholder feedback, the water temperature requirement has been removed for all
527 machine types since it may be dangerous for test operators. A water temperature requirement is not
528 needed because the water consumption calculations provide a density value to normalize results to a cold
529 water temperature.
530

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

532
533 i. If multiple cycle times are available, the Dishwasher shall be tested at the shortest time
534 setting.
535

536 **Note:** DOE and EPA acknowledge that the longest cycle time results in the worst-case water
537 consumption value. However, for consistency with sanitation testing, the shortest time setting will
538 continue to be specified.

539
540 ii. If the water consumption including post-sanitizing rinse is being measured, turn on the
541 post-sanitizing rinse feature and ensure it remains on during testing.
542

543 iii. Based on manufacturer instructions, set the sanitizing or post-sanitizing rinse flow
544 pressure based on the following:
545

546 • For machines marked for sanitizing or post-sanitizing rinse pressure ratings of 20 +/-
547 5 psig, the test shall be run at 20 +/- 1 psig.
548

549 • For machines marked for sanitizing or post-sanitizing rinse pressure ratings other
550 than 20 +/- 5 psig, and a marked pressure range of greater than 5 psig, the test shall
551 be run with the sanitizing or post-sanitizing rinse pressure set at both the minimum
552 and maximum ratings marked on the unit +/- 1 psig.
553

554 • For machines marked for sanitizing or post-sanitizing rinse pressure ratings other
555 than 20 +/- 5 psig, and a marked pressure range of less than or equal to 5 psig, the
556 test shall be run with the sanitizing or post-sanitizing rinse pressure set at the
557 minimum rating marked on the unit +/- 1 psig.
558

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

560
561 i. If multiple cycle times are available, the Dishwasher shall be tested at the shortest time
562 setting.
563

564 **Note:** DOE and EPA acknowledge that the longest cycle time results in the worst-case water
565 consumption value. However, for consistency with sanitation testing, the shortest time setting will
566 continue to be specified.

567
568 ii. If the water consumption including post-sanitizing rinse is being measured, turn on the
569 post-sanitizing rinse feature and ensure it remains on during testing.
570

571 iii. The machine shall be filled to the manufacturer's recommended level. The same water
572 level shall be used for the water consumption and idle energy tests for consistency.
573

574 c) Fresh Water Sanitizing or Post-Sanitizing Rinse Conveyor Type Machines

575
576 i. If the conveyor speed is user adjustable, set to maximum conveyor speed and report the
577 conveyor speed. If it is not user adjustable, retain the factory setting and report the
578 conveyor speed.
579

580 ii. If the water consumption including post-sanitizing rinse is being measured, turn on the
581 post-sanitizing rinse feature and ensure it remains on during testing.
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583 iii. Based on manufacturer instructions, set the rinse flow pressure based on the following:
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- 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.

607 **6 TEST METHODS FOR ALL PRODUCTS**

608 **6.1 Sanitizing and Post-Sanitizing Rinse Water Consumption**

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- 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

638 0.25 inch (in.) of the water fill line. If it is not, adjust the water pressure until the water is
639 within 0.25 in. of the water fill line. If the water is still not within 0.25 in. of the water fill
640 line, the wash, rinse, and dwell times may be adjusted, but the new times shall be
641 recorded. If the specified times and/or water fill level are not reached, terminate testing.
642

643 c) Using the weighed capture vessel, catch all water that is sent to the drain during a
644 complete cycle, including any water from a post-sanitizing rinse if the water consumption
645 including post-sanitizing rinse is being measured. Record the exact wash, rinse, and
646 dwell times. It may take longer than the duration of the cycle for all of the water to drain;
647 thus the vessel shall remain in place until the water flow from the cycle ceases.
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649 d) Weigh the filled vessel after the cycle, subtracting the weight of the capture vessel to
650 calculate the weight of the water.
651

652 e) Repeat steps a) through d) five times. Completely dry the vessel after each cycle.
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654 3) Fresh Water Sanitizing or Post-Sanitizing Rinse Conveyor Type Machines 655

656 a) Activate the sanitizing rinse solenoid (and the post-sanitizing rinse solenoid if the water
657 consumption including post-sanitizing rinse is being measured) for 5 minutes (min). Do
658 not activate any other component(s) of the Dishwasher that sends water to the drain. If
659 there is a lever that actuates the sanitizing rinse solenoid or post-sanitizing rinse
660 solenoid, the lever may be held down to simulate operation. Verify that the water
661 pressure is within 1 psig of the manufacturer's specified value. If it is not, make
662 adjustments and operate the machine until it is (i.e. steady state is achieved).
663

664 b) Using a flow meter, measure all water that is sent to the drain during 1 min +/- 1 second
665 of continuous operation of the sanitizing rinse solenoid (and post-sanitizing rinse solenoid
666 if the water consumption including post-sanitizing rinse is being measured). Record the
667 exact time. Do not activate any other component(s) of the Dishwasher that sends water
668 to the drain. If there is a lever that actuates the sanitizing rinse solenoid or post-sanitizing
669 rinse solenoid, the lever may be held down to simulate operation.
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671 c) Repeat steps a) and b) five times.
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673 **Note:** In response to stakeholder feedback, the test method for water consumption of conveyor
674 Dishwashers has been changed from a catch and weigh method to a flow meter method since catch and
675 weigh is difficult for large volumes of water and a flow meter measures all the water that enters the
676 Dishwasher.

677 4) Pumped Water Sanitizing or Post-Sanitizing Rinse Conveyor Type Machines 678 679

680 a) Activate the sanitizing rinse solenoid (and the post-sanitizing rinse solenoid if the water
681 consumption including post-sanitizing rinse is being measured) for 5 min. Do not activate
682 any other component(s) of the Dishwasher that sends water to the drain. If there is a
683 lever that actuates the sanitizing rinse solenoid or post-sanitizing rinse solenoid, the lever
684 may be held down to simulate operation. Verify that the pumped sanitizing rinse and
685 post-sanitizing rinse operate correctly. If they do not, terminate testing.
686

687 b) Using a flow meter, measure all water that is sent to the drain during 1 min +/- 1 second
688 of continuous operation of the sanitizing rinse solenoid (and post-sanitizing rinse solenoid
689 if the water consumption including post-sanitizing rinse is being measured). Record the
690 exact time. Do not activate any other component(s) of the Dishwasher that sends water
691 to the drain. If there is a lever that actuates the sanitizing rinse solenoid or post-sanitizing
692 rinse solenoid, the lever may be held down to simulate operation.

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c) Repeat steps a) and b) five times.

Note: In response to stakeholder feedback, the test method for water consumption of conveyor Dishwashers has been changed from a catch and weigh method to a flow meter method since catch and weigh is difficult for large volumes of water and a flow meter measures all the water that enters the Dishwasher.

6.2 Idle Energy Consumption for Stationary Rack Type Machines

DOE and EPA propose removing the time tolerance on measurements. Clarifying language has been added to the Test Conduct section that specifies that “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 time periods or events (e.g. tank heater “on” cycle) specified as possible.

- 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.

Note: DOE and EPA propose disregarding Section 10.1.5 because the maximum energy input rate tests include the same instructions.

- 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.

Note: Stakeholder feedback indicated that the time delay for steam coil units may be difficult to measure. DOE and EPA propose an alternative method for estimating the time delay.

- 3) If there is a booster heater for high temperature machines, the booster temperature shall be calibrated as follows:

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Note: This section is a modified version of ASTM F1920-11 Section 10.5. There are enough changes to the original text that the full paragraph is provided for clarity. Proposed changes are italicized below. The conveyor method is used in this section for stationary rack machines because it is more up to date than ASTM F1696-07.

- 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 $\pm 2\text{ }^{\circ}\text{F}$, 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.

Note: DOE and EPA propose changing the tolerance on the sanitizing rinse temperature from $\pm 1\text{ }^{\circ}\text{F}$ to $\pm 2\text{ }^{\circ}\text{F}$ to align with current practice. Additionally, DOE and EPA propose that the average temperature should be between 180 °F and 195 °F to be consistent with realistic operation. DOE and EPA also propose clarifying that the rinse is the sanitizing rinse.

- 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.

Note: In addition to the italicized language above, DOE and EPA propose changing the order of the test steps so that the calibration steps are done before the maximum energy input rate steps.

- 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.

- 800 b) Section 10.2.1 shall be disregarded.
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802 c) Section 10.2.2 shall be replaced with the following:
803
804 i. Instruments shall be connected so that only the energy (for steam and gas tank
805 heat) or power (for electric tank heat) consumption of the tank heater is
806 measured. Fill the Dishwasher tank with water.
807
808 ii. For electric tank heaters, commence monitoring the power of the tank heater
809 when the tank heater cycles on. Stop monitoring the power when the tank heater
810 cycles off. Record the maximum power value as the “maximum energy input
811 rate”.
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813 iii. For gas tank heaters, allow the tank heater to idle for one “on” cycle to allow the
814 burner orifices to heat up. Commence monitoring the elapsed time and energy
815 consumption of the tank heater when the tank heater cycles on for the second
816 time. Stop monitoring the elapsed time and energy consumption of the tank
817 heater when the tank heater cycles off. Record the time and energy consumption
818 of the tank heater during the complete “on” cycle.
819
820 iv. For steam coil tank heaters, commence monitoring the elapsed time and energy
821 consumption of the tank heater when the tank heater cycles on. Stop monitoring
822 the elapsed time and energy consumption of the tank heater when the tank
823 heater cycles off. Record the time and energy consumption of the tank heater
824 during the complete “on” cycle.
825
826 d) Section 10.2.3 shall be followed as written with the following revision.
827
828 i. The tank heater “maximum energy input rate” (i.e. maximum power) for the
829 Dishwasher under test shall be determined in accordance with Section 7.6 of this
830 test method.
831
832 ii. If the difference between the recorded value and the nameplate rating or rating
833 printed on the heating element is greater than 5%, testing shall be terminated.
834
835 *Note: ASTM F1696-07 specifies that the manufacturer may make appropriate*
836 *changes or adjustments to the dishwasher. See Test Conduct Section 4H) for*
837 *ENERGY STAR requirements.*
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839 e) For machines with steam coil tank heat, using an appropriately sized vessel that is
840 completely dry, catch all water from the outlet during the test. Weigh the filled vessel,
841 subtracting the weight of the capture vessel to calculate the weight of the water.
842 Calculate the total mass of the inlet steam during the test and confirm that it is within 5%
843 of the mass of water measured from the outlet stream. If the difference is greater than
844 5%, adjust the quality of the steam until the difference is less than 5% and rerun the tank
845 heater “maximum energy input rate” (i.e. maximum power) test.
846
847 6) If there is a booster heater, the booster heater maximum energy input rate shall be measured and
848 reported as specified in *ASTM F1696-07; Section 10.3* with the following revisions and additions.
849
850 a) If there is a nameplate rating or a rating printed on the heating element for the booster
851 heater, follow the steps below. If the booster heater is included as part of a total power
852 consumption nameplate rating, follow the steps below while monitoring the total power
853 consumption for all components included in the rating.
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- 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.

Note: In response to stakeholder feedback, a test method for steam coil booster heaters has been added.

- 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:

Note: This section is a modified version of ASTM F1696-07 Section 10.8. There are enough changes to the original text that the full text is provided for clarity.

Proposed changes to the original procedure are italicized in section a) below.

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In response to stakeholder feedback, DOE and EPA propose including a 1 hour stabilization period to ensure that the surrounding metal parts of the machine have completely heated up before measurements are taken.

- 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 test must include the same number of booster heater “on” cycles that were in the Dishwasher idle energy test. Repeat steps i through iii above, but record the energy consumption of the booster heater instead of the total Dishwasher energy consumption.

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- 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

DOE and EPA propose removing the time tolerance on measurements. Clarifying language has been added to the Test Conduct section that specifies that "power and energy data may be recorded for longer than the time periods specified. However, data that is used for calculations shall be obtained from as close to the time periods or events (e.g. tank heater "on" cycle) specified as possible.

- 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.

Note: DOE and EPA propose disregarding Section 10.1.5 because the maximum energy input rate tests include the same instructions.

- 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.

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Note: Stakeholder feedback indicated that the time delay for steam coil units may be difficult to measure. DOE and EPA propose an alternative method for estimating the time delay.

- 3) If there is a booster heater for high temperature machines, the booster temperature shall be calibrated as follows:

Note: This section is a modified version of ASTM F1920-11 Section 10.5. There are enough changes to the original text that the full paragraph is provided for clarity. Proposed changes are italicized below.

- 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.

Note: DOE and EPA propose changing the tolerance on the sanitizing rinse temperature from +/- 1 °F to +/- 2 °F to align with current practice. Additionally, DOE and EPA propose that the average temperature should be between 180 °F and 195 °F to be consistent with realistic operation. DOE and EPA also propose clarifying that the rinse is the sanitizing rinse.

- 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).

Note: DOE and EPA propose changing the order of the test steps so that the calibration steps are done before the maximum energy input rate steps.

- 1070 6) The tank heater “maximum energy input rate” (i.e. maximum power) shall be measured and
1071 reported as specified in *ASTM F1920-11; Section 10.2* with the following revisions and additions.
1072
- 1073 a) The maximum energy input rate determination is used to verify that the dishwasher is
1074 operating within manufacturer specifications. If there is a nameplate rating or a rating
1075 printed on the heating element for the tank heater(s), follow the steps below. If the tank
1076 heater(s) are included as part of a total power consumption nameplate rating, follow the
1077 steps below while monitoring the total power consumption for all components included in
1078 the rating.
1079
- 1080 b) Section 10.2.1 shall be replaced with the following:
1081
- 1082 i. Instruments shall be connected so that only the energy (for steam and gas tank
1083 heat) or power (for electric tank heat) consumption of the tank heater(s) is
1084 measured. Fill the Dishwasher tank with water.
1085
- 1086 ii. For electric tank heaters, commence monitoring the power of the tank heater
1087 when the tank heater cycles on. Stop monitoring the power when the tank heater
1088 cycles off. Record the maximum power value as the “maximum energy input
1089 rate”.
1090
- 1091 iii. For gas tank heaters, allow the tank heater to idle for one “on” cycle to allow the
1092 burner orifices to heat up. Commence monitoring the elapsed time and energy
1093 consumption of the tank heater when the tank heater cycles on for the second
1094 time. Stop monitoring the elapsed time and energy consumption of the tank
1095 heater when the tank heater cycles off. Record the time and energy consumption
1096 of the tank heater during the complete “on” cycle.
1097
- 1098 iv. For steam coil tank heaters, commence monitoring the elapsed time and energy
1099 consumption of the tank heater when the tank heater cycles on. Stop monitoring
1100 the elapsed time and energy consumption of the tank heater when the tank
1101 heater cycles off. Record the time and energy consumption of the tank heater
1102 during the complete “on” cycle.
1103
- 1104 c) Section 10.2.2 shall be followed as written with the following revision.
1105
- 1106 i. The tank heater “maximum energy input rate” (i.e. maximum power) for the
1107 Dishwasher under test shall be determined in accordance with Section 7.6 of this
1108 test method.
1109
- 1110 ii. If the difference between the recorded value and the nameplate rating or rating
1111 printed on the heating element is greater than 5%, testing shall be terminated.
1112
- 1113 *Note: ASTM F1696-07 specifies that the manufacturer may make appropriate*
1114 *changes or adjustments to the dishwasher. See Test Conduct Section 4H) for*
1115 *ENERGY STAR requirements.*
1116
- 1117 d) For machines with steam coil tank heat, using an appropriately sized vessel that is
1118 completely dry, catch all water from the outlet during the test. Weigh the filled vessel,
1119 subtracting the weight of the capture vessel to calculate the weight of the water.
1120 Calculate the total mass of the inlet steam during the test and confirm that it is within 5%
1121 of the mass of water measured from the outlet stream. If the difference is greater than
1122 5%, adjust the quality of the steam until the difference is less than 5% and rerun the tank
1123 heater “maximum energy input rate” (i.e. maximum power) test.
1124

1125 7) If there is a booster heater, the booster heater maximum energy input rate shall be measured and
1126 reported as specified in *ASTM F1920-11; Section 10.3* with the following revisions and additions.
1127

1128 a) If there is a nameplate rating or a rating printed on the heating element for the booster
1129 heater, follow the steps below. If the booster heater is included as part of a total power
1130 consumption rating, follow the steps below while monitoring the total power consumption
1131 for all components included in the rating.
1132

1133 b) Section 10.3.1 shall be replaced with the following:
1134

1135 i. Instruments shall be connected so that only the energy (for gas or steam booster
1136 heat) or power (for electric booster heat) consumption of the booster heater is
1137 measured. Fill the booster heater with water.
1138

1139 ii. For electric booster heaters, commence monitoring the power of the booster
1140 heater when the booster heater cycles on. Stop monitoring the power when the
1141 booster heater cycles off. Record the maximum power value as the maximum
1142 energy input rate.
1143

1144 iii. For gas booster heaters, allow the tank heater to idle for one “on” cycle to allow
1145 the burner orifices to heat up. Commence monitoring the elapsed time and
1146 energy consumption of the booster heater when the booster heater cycles on for
1147 the second time. Stop monitoring the elapsed time and energy consumption of
1148 the booster heater when the booster heater cycles off. Record the time and
1149 energy consumption of the booster heater during the complete “on” cycle.
1150

1151 iv. For steam coil booster heaters, commence monitoring the elapsed time and
1152 energy consumption of the booster heater when the booster heater cycles on.
1153 Stop monitoring the elapsed time and energy consumption of the booster heater
1154 when the tank heater cycles off. Record the time and energy consumption of the
1155 booster heater during the complete “on” cycle.
1156

1157 **Note:** In response to stakeholder feedback, a test method for steam coil booster heaters has been added.

1158 c) Section 10.3.2 shall be followed as written with the following revision.
1159

1160 i. The booster heater “maximum energy input rate” (i.e. maximum power) for the
1161 Dishwasher under test shall be determined in accordance with Section 7.6 of this
1162 test method.
1163

1164 ii. If the difference between the recorded value and the nameplate rating or rating
1165 printed on the heating element is greater than 5%, testing shall be terminated.
1166

1167 *Note: ASTM F1696-07 specifies that the manufacturer may make appropriate*
1168 *changes or adjustments to the dishwasher. See Test Conduct Section 4H) for*
1169 *ENERGY STAR requirements.*
1170

1171 d) For machines with steam coil booster heat, using an appropriately sized vessel that is
1172 completely dry, catch all water from the outlet during the test. Weigh the filled vessel,
1173 subtracting the weight of the capture vessel to calculate the weight of the water.
1174 Calculate the total mass of the inlet steam during the test and confirm that it is within 5%
1175 of the mass of water measured from the outlet stream. If the difference is greater than
1176 5%, adjust the quality of the steam until the difference is less than 5% and rerun the
1177 booster heater “maximum energy input rate” (i.e. maximum power) test.
1178
1179

1180 8) The idle energy rate (i.e. power) shall be measured as follows:
1181

1182 **Note:** This section is a modified version of ASTM F1920-11 Section 10.9. There are enough changes to
1183 the original text that the full text is provided for clarity.

1184 Proposed changes to the original procedure are italicized in section a) below.
1185

1186 In response to stakeholder feedback, DOE and EPA propose including a 1 hour stabilization period to
1187 ensure that the surrounding metal parts of the machine have completely heated up before measurements
1188 are taken.
1189

1190 a) If the Dishwasher does not have an internal booster heater:
1191

1192 i. Allow the Dishwasher to fill and energize the tank heater(s).
1193

1194 ii. *For single tank machines, with the exterior service door(s) closed, allow the*
1195 *Dishwasher tank to idle for at least 1 hour for stabilization. Commence monitoring*
1196 *elapsed time, tank temperature, and total energy consumption of the Dishwasher*
1197 *when the tank heater on “cycles” for the first time after the 1 hour stabilization*
1198 *period.*
1199

1200 iii. *For multiple tank machines, with the exterior service door(s) closed, allow the*
1201 *Dishwasher tanks to idle for at least 1 hour for stabilization. Commence*
1202 *monitoring the elapsed time and total energy consumption of the Dishwasher and*
1203 *the temperature of all the tanks when one of the tank heaters “on” cycles again*
1204 *after the 1 hour stabilization period.*
1205

1206 iv. Allow the Dishwasher to idle for 3 hours. *If there have not been ten distinct tank*
1207 *heater cycles for all tank heaters during the 3 hour period, continue to run the*
1208 *test and record data. Stop the test when one of the tank heaters cycles off again*
1209 *after all tank heaters have “on” cycled ten times. Record the final elapsed time*
1210 *and energy consumption of the Dishwasher.*
1211

1212 v. *Record each tank’s minimum tank temperature during the test and confirm that it*
1213 *is at or above the manufacturer’s specified minimum tank temperature(s) minus*
1214 *1 °F, as applicable. If the minimum tank temperature(s) during the idle energy*
1215 *test was below the manufacturer’s specified tank temperature(s) minus 1 °F, the*
1216 *test is invalid and must be repeated. If the tank temperature(s) exceeds 15 °F of*
1217 *the measured minimum tank temperature(s), the test is invalid and must be*
1218 *repeated. Adjust the thermostat per the manufacturer’s instructions if it is user*
1219 *adjustable and repeat the steps in i through iv.*
1220

1221 b) If the Dishwasher has an internal booster heater:
1222

1223 i. Allow the Dishwasher to fill and energize the tank heater(s).
1224

1225 ii. For single tank machines, with the exterior service door(s) closed, allow the
1226 Dishwasher tank to idle for at least 1 hour for stabilization. Commence monitoring
1227 elapsed time, tank temperature, and total energy consumption of the Dishwasher
1228 when the tank heater cycles “on” for the first time after the 1 hour stabilization
1229 period.
1230

1231 iii. For multiple tank machines, with the exterior service door(s) closed, allow the
1232 Dishwasher tanks to idle for at least 1 hour for stabilization. Commence
1233 monitoring the elapsed time and total energy consumption of the Dishwasher and
1234

1235 the temperature of all the tanks when one of the tank heaters “on” cycles again
 1236 after the 1 hour stabilization period.
 1237
 1238 iv. Allow the Dishwasher to idle for 3 hours. If there have not been ten distinct tank
 1239 heater cycles for all tank heaters during the 3 hour period, continue to run the
 1240 test and record data. Stop the test when one of the tank heaters cycles off again
 1241 after all tank heaters have “on” cycled ten times. Record the final elapsed time
 1242 and energy consumption of the Dishwasher.
 1243
 1244 v. The booster idle energy rate shall be reported separately from the total idle
 1245 energy rate.
 1246
 1247 • If possible, sub-monitor the idle energy rate of the booster heater during
 1248 the Dishwasher idle energy test described in steps i through iv above.
 1249
 1250 • If the booster heater idle energy cannot be simultaneously measured
 1251 with the Dishwasher idle energy, the booster heater idle energy may be
 1252 monitored at a different time; however, the test must include the same
 1253 number of booster heater “on” cycles that were in the Dishwasher idle
 1254 energy test. Repeat steps i through iv above, but record the energy
 1255 consumption of the booster heater instead of the total Dishwasher
 1256 energy consumption.
 1257
 1258 • If the booster heater cannot be separately monitored or sub-monitored,
 1259 the booster heater idle energy shall be included as part of the total idle
 1260 energy.
 1261
 1262 vi. Record each tank’s minimum tank temperature during the test(s) and confirm that
 1263 it is at or above the manufacturer’s specified minimum tank temperature(s) minus
 1264 1 °F, as applicable. If the minimum tank temperature(s) during the idle energy
 1265 test is below the manufacturer’s specified tank temperature(s) minus 1 °F, then
 1266 the test is invalid and must be repeated. If the tank temperature(s) exceeds 15 °F
 1267 of the measured minimum tank temperature(s), the test is invalid and must be
 1268 repeated. Adjust the thermostat per the manufacturer’s instructions if it is user
 1269 adjustable and repeat the steps in i through v.
 1270
 1271

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

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

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

1285 DT = Dwell time (i.e. amount of time spent in dwell mode) in seconds as recorded during test
 1286 LT = Load time (30 seconds for under counter Dishwashers, 5 seconds for straight through door-
 1287 type Dishwashers, 7 seconds for corner door-type Dishwashers, 30 seconds for front load/unload
 1288 door-type Dishwashers)

1289
 1290 B) Fresh Water or Pumped Water Sanitizing or Post-Sanitizing Rinse Conveyor Type (excluding
 1291 Flight Type) Machines
 1292

1293 **Equation 2: Racks per Hour for Conveyor Type Machines**

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

1294
 1295 Where:

1296
 1297 Racks per Hour = Number of racks washed per hour, truncated to the next lowest whole number
 1298 RL= Rack length (use 20 inches)
 1299 CS= Manufacturer specified maximum conveyor speed in feet per minute

1300
 1301
 1302 **7.2 Sanitizing and Post-Sanitizing Rinse Water Consumption (Gallons per**
 1303 **Hour, GPH)**

1304 A) Fresh Water or Pumped Water Sanitizing or Post-Sanitizing Rinse Stationary Type Machines

1305
 1306 **Equation 3: Gallons per Hour for Stationary Type Machines**

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

1307
 1308 Where:

1309
 1310 Racks per Hour = Number of racks washed per hour, truncated to the next lowest whole number,
 1311 as calculated in Section 7.1
 1312 NR = Number of racks washed per cycle

1313
 1314 B) Fresh Water or Pumped Water Sanitizing or Post-Sanitizing Rinse Conveyor Type (including
 1315 Flight Type) Machines

1316
 1317 **Equation 4: Gallons per Hour for Conveyor Type Machines**

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

1318
 1319 Where:

1320
 1321 Measured Flow of water for test run n = Flow of water measured by flow meter from one minute
 1322 of sanitizing rinse activation (and post-sanitizing rinse solenoid activation if the water
 1323 consumption including post-sanitizing rinse is being measured).
 1324
 1325

1326 **7.3 Sanitizing and Post-Sanitizing Rinse Water Consumption**

- 1327 A) Fresh Water or Pumped Water Sanitizing or Post-Sanitizing Rinse Stationary Rack Type
1328 Machines

1329 **Equation 5: Gallons per Rack for Stationary Type Machines**

1330

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

1331 Where:

1332 Gallons per Hour= Water use in gallons per hour, as calculated in Section 7.2

1333 Racks per Hour= Number of racks washed per hour, truncated to the next lowest whole number,
1334 as calculated in Section 7.1

- 1335
1336
1337
1338 B) Fresh Water or Pumped Water Sanitizing and Post-Sanitizing Rinse Conveyor Type (excluding
1339 Flight Type) Machines

1340 **Equation 6: Gallons per Rack for Conveyor Type Machines**

1341

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

1342 Where:

1343 Gallons per Hour= Water use in gallons per hour, as calculated in Section 7.2

1344 Racks per Hour= Number of racks washed per hour, truncated to the next lowest whole number,
1345 as calculated in Section 7.1

- 1346
1347
1348
1349 C) Pot, Pan, and Utensil Type Machines

1350 **Equation 7: Gallons per Square Foot for Pot, Pan, and Utensil Type Machines**

1351

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

1352 Where:

1353 Gallons per Rack= Water use in gallons per hour, as calculated in Section 7.3A)

1354 Square foot of rack= Manufacturer specified rack area in ft² for machine tested

1355
1356
1357
1358 **7.4 Gas Energy Consumption**

- 1359 A) The gas energy consumption rate shall be calculated as specified in *ASTM F1920-11; Section*
1360 *11.3* with the following revision.

- 1361 1) Equation (2) shall only be used to calculate V if the gas meter does not already correct
1362 the gas volume based on temperature and pressure using the same standard values for
1363 temperature and pressure that were used to calculate the higher heating value in *ASTM*
1364 *F1920-11; Section 10.1.2.*

1365
1366
1367 **7.5 Steam Coil Energy Consumption**

- 1368 A) Inlet Steam Mass Flow Rate

- 1370
1371
1372
1373
1374
1375
1376
1377
1378
- 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:

1379 **Equation 8: Inlet Steam Mass Flow Rate for Steam Coil Machines**

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

1380
1381 Where:

1382
1383 \dot{M}_{Steam} = Mass flow rate of steam (pounds (lb)/h)
1384 \dot{V}_{Steam} = Measured volumetric flow rate of steam (ft³/h)
1385 ρ_{Steam} = Density of steam (lb/ft³), calculated from steam tables
1386

1387 B) Inlet Steam Total Mass

1388
1389 **Equation 9: Inlet Steam Total Mass for Steam Coil Machines**

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

1390
1391 Where:

1392
1393 M_{Total} = Total steam consumption during time period (lb)
1394 $\dot{M}_{Steam,i}$ = Instantaneous steam mass flow rate for each data point (lb/h)
1395 N = Total number of data points during time period, excluding extra data to account for
1396 t_{delay}
1397 t_i = Time interval of each data point (seconds)
1398

1399 C) Inlet Stream Enthalpy

- 1400
1401
1402
1403
1404
1405
1406
- 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.

1407 D) Outlet Water Enthalpy

- 1408
1409
1410
- 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

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.

1411 temperature value ($T_{Saturated}$). If the exact pressure is not listed in the table, interpolate
1412 between the two closest pressure values to calculate the enthalpy.

1413
1414 2) Calculate the enthalpy of the outlet water for each data point as follows:
1415

1416 **Equation 10: Outlet Water Enthalpy for Steam Coil Machines**

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

1417
1418 Where:

1419
1420 H_{Outlet} = Enthalpy of Dishwasher outlet stream (British thermal units (Btu)/lb)
1421 $H_{Saturated}$ = Saturated liquid enthalpy value listed in steam tables (Btu/lb)
1422 C_p = Heat capacity of water (1 Btu/lb °F)
1423 $T_{Saturated}$ = Saturated liquid temperature value listed in steam tables (°F)
1424 $T_{Measured}$ = Recorded temperature of liquid water outlet stream during test (°F)
1425

1426 E) Instantaneous Energy Consumption

1427
1428 1) Calculate the energy for each data point as follows:

1429
1430 **Equation 11: Instantaneous Energy Consumption for Steam Coil Machines**

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

1431
1432 Where:

1433
1434 E_i = Instantaneous energy consumption for each data point (Btu)
1435 $\dot{M}_{Steam,i}$ = Calculated mass flow rate of steam for each data point (lb/h)
1436 $H_{Inlet,i}$ = Enthalpy of Dishwasher inlet steam for each data point (Btu/lb)
1437 $H_{Outlet,i+t_{delay}}$ = Enthalpy of Dishwasher outlet water for each data point (Btu/lb)
1438 t_{delay} = Measured time between steam entering the flow meter and exiting as water
1439 (seconds)
1440 t_i = Time interval of each data point (seconds)
1441

1442 F) Total Energy Consumption

1443
1444 **Equation 12: Total Energy Consumption for Steam Coil Machines**

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

1445
1446 Where:

1447
1448 E_{Total} = Total energy consumption during test (active or idle) (Btu)
1449 E_i = Instantaneous energy consumption for each data point (Btu)
1450 $E_{Electric}$ = Electric energy consumption during test (Btu)
1451 N = Total number of data points, excluding extra data to account for t_{delay}
1452
1453

1454 **7.6 Booster and Tank Heater Maximum Power**

- 1455 A) The idle energy input rate (i.e. maximum power) shall be calculated as specified in *ASTM F1920-*
1456 *11; Section 11.4* if a direct measurement of power was not taken.
1457
1458 1) The value 60 provided in the equation is a conversion factor from minute to hours.
1459
1460 2) This calculation shall also be used for steam.
1461

1462 **7.7 Idle Energy Rate (Power)**

- 1463 A) The idle energy rate (i.e. power) shall be calculated as specified in *ASTM F1920-11; Section 11.5*
1464 with the following clarification, and additions.
1465
1466 1) The value 60 provided in the equation is a conversion factor from minute to hours.
1467
1468 2) This calculation shall also be used for steam.
1469
1470 3) If the idle energy rate (i.e. power) is reported in Btu/h, convert it to kilowatts (kW) based
1471 on the following equation:
1472
1473

Equation 13: Idle Energy Rate Conversion

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

1474
1475 **7.8 Internal Booster Heater Idle Energy Rate (Power)**

- 1476 A) The booster heater idle energy rate (i.e. power) shall be calculated using the same equation as
1477 specified in *ASTM F1920-11; Section 11.5* for the tank heater idle energy rate with the following
1478 clarification and addition.
1479
1480 1) The value 60 provided in the equation is a conversion factor from minute to hours.
1481
1482 2) This calculation shall also be used for steam.
1483
1484 3) If the internal booster heater idle energy rate (i.e. power) is reported in Btu/h, convert it to
1485 kW based on the following equation:
1486
1487

Equation 14: Internal Booster Heater Idle Energy Rate Conversion

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

1489
1490 **8 REFERENCES**

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