



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

Draft 2 Test Method for Determining Residential Dishwasher Cleaning Performance Rev. Oct-2012

1 OVERVIEW

The following test method shall be used for determining compliance with the cleaning performance requirements included in the ENERGY STAR Eligibility Criteria for Residential Dishwashers. Cleaning performance of soil-sensing dishwashers shall be determined during the same cycles as the energy and water consumption tests for ENERGY STAR qualification, while that of non-soil sensing dishwashers shall be evaluated immediately following the energy and water consumption tests.

Note: This document contains the proposed ENERGY STAR test method for evaluating the cleaning performance of residential dishwashers. U.S. Department of Energy (DOE) and U.S. Environmental Protection Agency (EPA) intend to require the use of this test method for dishwashers seeking ENERGY STAR qualification under the Version 6.0 specification. DOE considered all of the feedback received in response to the Draft 1 Test Method for Determining Residential Dishwasher Cleaning Performance (Draft 1 Test Method) that was published in February 2012 and the ENERGY STAR Residential Dishwasher Cleaning Performance Stakeholder Webinar (Draft 1 Webinar) held on February 27, 2012 in its development of the Draft 2 Test Method. DOE and EPA thank all stakeholders who participated and provided feedback during the webinar and through written comments. DOE invites stakeholders to comment on the proposed test method (Draft 2 Test Method) for evaluating residential dishwasher cleaning performance outlined below.

2 APPLICABILITY

The following test method shall be used to determine the cleaning performance of all residential dishwasher products for the ENERGY STAR program.

3 DEFINITIONS

Unless otherwise specified, all terms used in this document are consistent with the definitions in the ENERGY STAR Eligibility Criteria for Residential Dishwashers, and those in the Federal test procedure for residential dishwashers that will be codified in the Code of Federal Regulations (CFR) at 10 CFR Part 430, Subpart B, Appendix C1.

Note: The current Federal test procedure for residential dishwashers is codified in the CFR at 10 CFR Part 430, Subpart B, Appendix C, and the Draft 1 Test Method proposed to reference provisions from it to harmonize the energy and water use measurement with cleaning performance. On September 14, 2012, DOE issued a final rule establishing an amended dishwasher test procedure (10 CFR Part 430, Subpart B, Appendix C1) that will be required to be used to demonstrate compliance with new Federal energy and water consumption standards as of May 30, 2013. 10 CFR Part 430, Subpart B, Appendix C1 may also optionally be used prior to this date in place of 10 CFR Part 430, Subpart B, Appendix C. The final rule,

33 which details the provisions of 10 CFR Part 430, Subpart B, Appendix C1, may be found on DOE's
34 website at: http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/aham-1_tp_final_rule.pdf¹.

35 Where this proposed Draft 2 Test Method references the Federal test procedure, it refers to the
36 provisions in 10 CFR Part 430, Subpart B, Appendix C1 because this is the Federal test procedure that
37 will be required for measuring dishwasher energy and water consumption when Version 6.0 of the
38 ENERGY STAR Specification for Residential Dishwashers will take effect.

39

40 A) Acronyms and Units:

41 1) AHAM: Association of Home Appliance Manufacturers

42 2) ANSI: American National Standards Institute

43 3) CFR: Code of Federal Regulations

44 4) DOE: U.S. Department of Energy

45 5) EPA: U.S. Environmental Protection Agency

46 6) IEC: International Electrotechnical Commission

47 7) K: Kelvin

48 8) ppm: Parts per million

49 9) UUT: Unit under test

50 **4 TEST SETUP**

51 A) Test Setup and Instrumentation: Test setup and instrumentation for all portions of this method shall
52 be in accordance with those specified in 10 CFR Part 430, Subpart B, Appendix C1.

53 B) Cleaning Performance Rating Conditions: The lighting setup in the evaluation room shall be
54 according to the requirements specified in section 6.7.1 of International Electrotechnical Commission
55 (IEC) standard 60436, "Electric dishwashers for household use – Methods for measuring the
56 performance" Edition 3.1, 2009-11 (IEC standard 60436 Ed. 3.1, 2009-11).

57 C) Water Hardness: The supply water hardness shall be as specified in the American National
58 Standards Institute (ANSI) and Association of Home Appliance Manufacturers (AHAM) standard,
59 ANSI/AHAM DW-1-2010, "Household Electric Dishwashers" (ANSI/AHAM standard DW-1-2010).

¹ Note: This link will expire once the final rule is published in the Federal Register.

60 **Note:** As requested by stakeholders, DOE has referenced the relevant sections of the IEC standard
61 60436 Ed. 3.1, 2009-11 and ANSI/AHAM standard DW-1-2010 to specify the cleaning performance rating
62 conditions and water hardness requirements.

63 DOE is specifying the water hardness requirement even though it is not specified in 10 CFR Part 430,
64 Subpart B, Appendix C1 because water hardness may impact the cleaning performance of a dishwasher.
65 The water hardness requirement is not precluded by 10 CFR Part 430, Subpart B, Appendix C1, and
66 DOE does not expect the water hardness specification to affect the energy and water consumption
67 results.

68 **5 TEST PROCEDURES FOR ALL PRODUCTS**

69 **5.1 Test Cycles**

70 A) Preconditioning Cycle: Precondition the unit under test (UUT) as specified in 10 CFR Part 430,
71 Subpart B, Appendix C1. The quantity of detergent required for operating the UUT shall be
72 determined as specified in 10 CFR Part 430, Subpart B, Appendix C1. For soil-sensing dishwashers,
73 input power to the UUT shall be supplied continuously, throughout all preconditioning and test cycles,
74 as required by 10 CFR Part 430, Subpart B, Appendix C1, to ensure that the turbidity sensor, which
75 detects the presence of soil particles in water and infers the soil level of the load to initiate the
76 appropriate cycle, does not change its calibration between tests.

77 B) Soil-sensing Dishwashers: For dishwashers with a soil-sensing normal cycle, as defined in 10 CFR
78 Part 430, Subpart B, Appendix C1, testing shall be conducted according to 10 CFR Part 430, Subpart
79 B, Appendix C1. Cleaning performance shall be evaluated during the same cycles that measure
80 energy and water consumption using the test loads described in 10 CFR Part 430, Subpart B,
81 Appendix C1. The tests shall be conducted starting with the sensor heavy response test load,
82 followed by the sensor medium response test load, then the sensor light test load, with no cleaning of
83 the UUT between test cycles. For dishwashers with soil-sensing capability, but a non-soil sensing
84 normal cycle, as defined in 10 CFR Part 430, Subpart B, Appendix C1, cleaning performance shall be
85 evaluated following the non-soil sensing dishwasher provisions in section 5.1.C.

86 C) Non-soil Sensing Dishwashers: Testing shall be conducted according to 10 CFR Part 430, Subpart B,
87 Appendix C1; however, cleaning performance shall be evaluated on the normal cycle using the
88 sensor heavy, medium, and light response test loads described for soil-sensing dishwashers in 10
89 CFR Part 430, Subpart B, Appendix C1 immediately after performing the energy and water
90 consumption tests. The tests shall be conducted starting with the sensor heavy response test load,
91 followed by the sensor medium response test load, then the sensor light test load. No other cycles
92 shall be operated and the UUT shall not be cleaned in between any of the test cycles.

93 D) Manufacturers' use and care guide instructions shall be followed for loading the UUT. Additionally,
94 each item of the test load shall alternate the clean and soiled items while following the manufacturer
95 instructions. Clean items should be loaded in the UUT first followed by the soiled items. For each soil
96 load, the alternating of clean and soiled items for standard dishwashers is explained below:

97 1) Sensor Heavy Response Test Load: Alternate clean and soiled items, with similar items loaded in
98 the racks consecutively without any empty rack spaces in between. Empty rack spaces between
99 items are acceptable only if the manufacturer's use and care guide for the UUT instructs the user
100 to have empty spaces while loading. Figure 1 in Appendix A provides a schematic of the Sensor
101 Heavy loading pattern for an example dishwasher.

102 2) Sensor Medium Response Test Load: Load items such that the soiled item is repeated after
103 every two clean items, with similar items loaded in the racks consecutively without any empty
104 rack spaces in between. Empty rack spaces between items are acceptable only if the
105 manufacturer's use and care guide for the UUT instructs the user to have empty spaces while
106 loading. Figure 2 in Appendix A shows a schematic of the Sensor Medium loading pattern for an
107 example dishwasher.

108 3) Sensor Light Response Test Load: Load the soiled item towards the middle of the load (for
109 example, when all dinner plates are loaded into the dishwasher, the soiled dinner plate should be
110 either the fourth or fifth dinner plate), with similar items loaded in the racks consecutively without
111 any empty rack spaces in between. Empty rack spaces between items are acceptable only if the
112 manufacturer's use and care guide for the UUT instructs the user to have empty spaces while
113 loading. Figure 3 in Appendix A shows a schematic of the Sensor Light loading pattern for an
114 example dishwasher.

115 For each soil load, the alternating of clean and soiled items for compact dishwashers is explained
116 below:

117 1) Sensor Heavy Response Test Load: Alternate clean and soiled items, with similar items loaded in
118 the racks consecutively without any empty rack spaces in between. Empty rack spaces between
119 items are acceptable only if the manufacturer's use and care guide for the UUT instructs the user
120 to have empty spaces while loading.

121 2) Sensor Medium Response Test Load and Sensor Light Response Test Load: Load the soiled
122 item towards the middle of the load (for example, when all dinner plates are loaded into the
123 dishwasher, the soiled dinner plate should be either the second or third dinner plate), with similar
124 items loaded in the racks consecutively without any empty rack spaces in between. Empty rack
125 spaces between items are acceptable only if the manufacturer's use and care guide for the UUT
126 instructs the user to have empty spaces while loading.

127 E) Rinse aid shall not be used in the UUT.

128 **Note:** The preconditioning cycle requirement has been changed to reference the Federal test procedure
129 in 10 CFR Part 430, Subpart B, Appendix C1, which is the same requirement for two preconditioning
130 cycles that were specified in the Draft 1 Test Method. DOE agrees with stakeholder comments that the
131 number of preconditioning cycles required cannot differ from the Federal test procedure. DOE has also
132 updated the detergent dosing calculation to reference the procedure in 10 CFR Part 430, Subpart B,
133 Appendix C1. Finally, as discussed during the Draft 1 Webinar, DOE has observed during internal testing
134 that it is necessary to ensure that the power supply to a soil-sensing dishwasher is not turned off once
135 testing begins, that is, from the beginning of preconditioning. A continuous power supply ensures that the
136 turbidity sensor does not reset itself over the course of testing and thereby increase variability in the
137 energy and water consumption measurements of the UUT. This requirement is also included in 10 CFR
138 Part 430, Subpart B, Appendix C1.

139 For both soil-sensing and non-soil sensing dishwashers, DOE is specifying that cleaning performance
140 shall be determined on the same cycle settings as the energy and water consumption tests. The Federal
141 test procedure in 10 CFR Part 430, Subpart B, Appendix C1 does not always require soil-sensing units to
142 be tested on a soil-sensing cycle. Instead, it specifies that the cycle recommended by manufacturers for
143 normal, typical use shall be used. The cleaning performance shall be determined on these same cycles
144 that are recommended by manufacturers for normal, typical use for both soil-sensing and non-soil
145 sensing dishwashers.

146 Further, for non-soil sensing dishwashers, DOE specified in the Draft 1 Test Method that the three soiled
147 test loads should be performed immediately after the energy and water consumption tests. Stakeholders
148 commented that because non-soil sensing dishwashers go through a prescribed wash profile, regardless
149 of the soil load, it would make sense to run only one soiled test load rather than the three different loads
150 specified in the test method. However, internal tests performed by DOE have shown that while changing
151 the soil load does not affect the energy and water consumption results, it may affect the cleaning
152 performance. Therefore, DOE considers it important to test non-soil sensing dishwashers at the three
153 different soil levels to ensure that the UUT meets the qualification criteria at each soil load.

154 Stakeholders commented that manufacturer's instructions should control the loading pattern in the UUT.
155 DOE agrees and has stated explicitly that manufacturers' user and care guide instructions should be
156 followed to load the UUT. Additionally, while following the manufacturers' instructions, the clean and
157 soiled test load items shall be alternated.

158 DOE invites stakeholder comments on the updated pre-conditioning cycle, test cycle, and loading pattern
159 requirements of residential dishwashers.

160 5.2 Scoring

161 A) Each item in the test load shall be assessed for cleaning performance and the score noted
162 individually after the completion of each test cycle according to the instructions in section 6.7.1 of IEC
163 standard 60436 Ed. 3.1, 2009-11. Table 2 in section 6.7.1 of IEC standard 60436 Ed. 3.1, 2009-11 for
164 evaluating the cleaning index should not be used in this test method.

165 **Note:** In response to the Draft 1 Test Method, stakeholders commented that eliminating scoring of
166 flatware items could potentially lead to circumvention of the test method. Further, DOE's internal testing
167 indicated that while the spread of the results between UUTs decreases if flatware scores are included in
168 the per-cycle cleaning performance score, the repeatability of most UUTs increases. Therefore, in this
169 draft of the test method, DOE has not excluded any items of the test load from scoring.

170 Stakeholders also commented that DOE should use the AHAM standard DW-1-2009² scoring procedure
171 to score the test load. Recent testing at two different test laboratories indicated that the scoring procedure
172 specified in IEC standard 60436 Ed. 3.1, 2009-11 is more repeatable than the scoring procedure in
173 ANSI/AHAM standard DW-1-2010, which was consistent with DOE's initial results. Therefore, DOE
174 continues to propose the IEC standard 60436 Ed. 3.1, 2009-11 scoring methodology for the cleaning
175 performance test method.

176 DOE invites stakeholder comment on the proposed scoring method.

177 5.3 Cleaning Performance Score

178 A) For each test cycle, calculate the per-cycle cleaning performance score of the UUT (CPS_i) according
179 to Equation 1 below.

180 Equation 1: Calculation of Per-Cycle Cleaning Performance Score

$$CPS_i = 100 - \frac{(12.5 \times N_{4,i} + 25 \times N_{3,i} + 50 \times N_{2,i} + 75 \times N_{1,i} + 100 \times N_{0,i})}{N}$$

181 *Where:*

- 182 • N is the total number of items in the test load
- 183 • $N_{0,i}$ is the total number of items in the test load with a score of 0
- 184 • $N_{1,i}$ is the total number of items in the test load with a score of 1
- 185 • $N_{2,i}$ is the total number of items in the test load with a score of 2
- 186 • $N_{3,i}$ is the total number of items in the test load with a score of 3
- 187 • $N_{4,i}$ is the total number of items in the test load with a score of 4
- 188 • i is the test cycle type (heavy, h ; medium, m ; or light, l)

189 **Note:** While DOE proposed a performance metric that combined the individual per-cycle cleaning metrics
190 in the Draft 1 Test Method, it is not doing so in this draft of the test method. Instead, DOE is proposing to
191 calculate the individual cleaning performance score at each soil load that should meet minimum criteria to
192 be set by EPA in the future for ENERGY STAR qualification.

193 Stakeholders commented, and DOE agrees, that if a weighted performance metric is used to qualify
194 dishwashers for the ENERGY STAR program, it is possible that a unit may have good performance at the
195 sensor heavy response load but poor performance at the sensor low response and still qualify. Further, a
196 weighted performance metric could lead to circumvention of the test method. Therefore, DOE is
197 proposing that the per-cycle cleaning performance score be calculated at each soil load.

² AHAM standard DW-1-2009 is the same standard as ANSI/AHAM standard DW-1-2010. AHAM DW-1-2009 was accepted for ANSI designation in 2010, after which the title of the standard was updated to ANSI/AHAM DW-1-2010.

198 DOE notes that it has updated the name of the calculated metric from the per-cycle cleaning metric, as
199 proposed in the Draft 1 Test Method, to the per-cycle cleaning performance score. DOE invites
200 stakeholder comments on the proposed calculation of the per-cycle cleaning performance score at each
201 soil load of the UUT.

202 DOE is proposing a sampling plan for qualifying the cleaning performance of dishwashers using this test
203 method. The sampling plan and any rounding requirements will ultimately be included in the Product
204 Specification for Residential Dishwashers Version 6.0.

205 Internal testing at three different laboratories indicates soil-sensing dishwashers may trigger variable
206 cycle responses for a given soil load, and that conducting the test at least three times allows the test
207 results to reflect the different cycle responses that may be triggered. When such variation occurs, the
208 cleaning performance of the UUT is impacted such that it may affect qualification of the dishwasher.
209 Therefore, DOE is proposing that the test shall be performed at least three times for soil-sensing
210 dishwashers to capture such variation in the cycle responses for a given soil load. Testing shows that
211 non-soil sensing units do not significantly alter their energy and water consumption from cycle-to-cycle,
212 and therefore multiple tests would not be necessary.

213 DOE considered two options for conducting the three tests on soil-sensing dishwashers for the sampling
214 plan: (1) performing the test three times on one UUT only; or (2) performing the test one time on three
215 different UUTs. DOE's sampling requirements in 10 CFR 429.19 require that the energy and water
216 consumption test procedure in 10 CFR Part 430, Subpart B, Appendix C1 be performed on at least two
217 UUTs for certification. Conducting the cleaning performance test once each on three UUTs requires that
218 the test procedure be conducted a total of three times, at least two of which would also be used for
219 energy and water consumption certification. Repeating the test method three times on one unit would
220 require conducting the test procedure four times in total (three tests on one unit for ENERGY STAR
221 cleaning performance qualification and energy and water consumption certification, and one test on a
222 second unit to meet the minimum energy and water consumption certification sampling requirement).
223 DOE expects four tests on two units to be a greater burden than three tests on three units. Therefore,
224 DOE is proposing the second option to limit the test burden for stakeholders. Additionally, the three tests
225 on separate units may be conducted concurrently, if feasible, limiting the total testing duration.

226 DOE is proposing that the per-cycle cleaning performance score shall be determined for each test cycle
227 on each of the three UUTs for soil-sensing dishwashers, and the lowest value out of the three UUTs at
228 each soil load shall be rounded and used for ENERGY STAR qualification. DOE considered proposing
229 the average cleaning performance score for a given soil load across the three UUTs for qualification, but
230 is proposing the lowest cleaning performance score for the following reasons:

231 (1) For soil-sensing UUTs that triggered multiple cycle responses, DOE observed that the most common
232 cycle response typically used the least water and energy and thus produced the lowest cleaning
233 performance score. These UUTs may occasionally trigger a cycle that consumes more energy and
234 water compared to the other test cycles at a given soil level, likely resulting in improved cleaning
235 performance and a higher cleaning performance score. In this scenario, the UUT may meet an
236 ENERGY STAR cleaning performance specification if the high-consumption cleaning performance
237 score is high enough to raise the average beyond the minimum cleaning performance specification.
238 However, the lower energy and water use cycles may better reflect the typical cleaning performance
239 of the UUT, and therefore would be more appropriate in qualifying the model.

240 (2) Using the lowest per-cycle cleaning performance score at each soil load allows for more repeatable
241 verification testing, in which DOE would test one unit only, rather than the three required in this test
242 method for qualification. If the lowest value is used for qualification, it is likely that the unit selected by
243 DOE for testing performs at least as well as the lowest performing unit and would therefore be
244 expected to meet the requirements of verification testing. Additionally, as described above, the
245 inconsistent cycle responses at a given soil level could lead to large variations in the average
246 cleaning performance score depending on the cycle response triggered in each of the three units,
247 while the lowest per-cycle cleaning performance score at each soil load would be expected to remain
248 relatively constant.

249 While DOE is proposing that the lowest score from testing at least three UUTs be used for qualification of
250 soil-sensing dishwashers, it is proposing that the per-cycle cleaning performance score from testing at
251 least one UUT be used to qualify non-soil sensing dishwashers because test results show that non-soil

252 sensing dishwashers have consistent cycle responses from test-to-test, and multiple cycles are therefore
253 not necessary to capture variable cycle responses. Additionally, allowing qualification on one test unit
254 limits test burden and is consistent with the current ENERGY STAR sampling plan for energy and water
255 consumption.

256 Manufacturers may choose to test more than one unit to qualify a non-soil sensing basic model for
257 cleaning performance. This is also consistent with the current ENERGY STAR sampling plan for energy
258 and water consumption, which allows manufacturers to select units per the sampling requirements
259 defined in 10 CFR 429.19, which references 10 CFR 429.11. However, DOE is proposing for non-soil
260 sensing dishwashers that the average per-cycle cleaning performance score at each soil load be used for
261 qualification rather than the lowest.

262 Averaging the cleaning performance scores of a UUT from multiple tests generally increases
263 reproducibility and produces results that are most representative of the UUT's performance by eliminating
264 minor test-to-test variability. This approach works well for non-soil sensing units because they have
265 consistent cycle responses from test to test; therefore, the average score is proposed to be used to
266 qualify non-soil sensing units. Soil-sensing dishwashers, however, may occasionally have a different
267 cycle response than the typical response when testing a given soil load. Because the presence of multiple
268 responses could lead to poor reproducibility if the cleaning performance scores from the three tests were
269 averaged, and because the lowest cleaning performance score is representative of the most commonly
270 observed dishwasher operation, DOE is proposing qualifying soil-sensing units with the lowest cleaning
271 performance score to ensure that qualification is made at the most representative performance of the
272 UUT.

273 DOE invites stakeholders to comment on the proposed sampling plan and reporting requirements for
274 qualifying the cleaning performance of dishwashers. In particular, DOE requests comment on using the
275 lowest per-cycle cleaning performance score at each soil load for qualification of soil-sensing
276 dishwashers and the average score for non-soil sensing dishwashers when more than one unit is used for
277 qualification.

278 **6 REFERENCES**

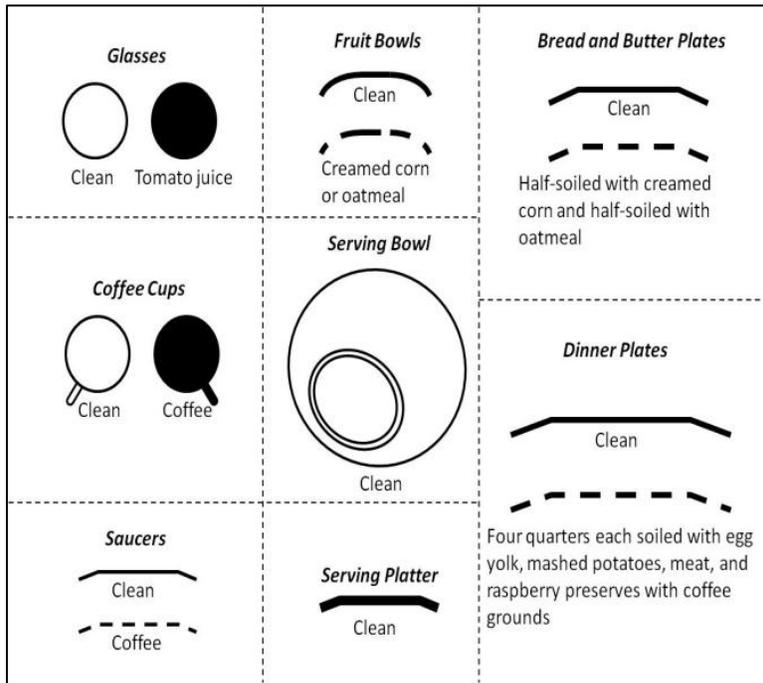
- 279 A) ANSI/AHAM DW-1-2010. Household Electric Dishwashers.
- 280 B) 10 CFR Part 430, Subpart B, Appendix C1. Uniform Test Method for Measuring the Energy
281 Consumption of Dishwashers.³
- 282 C) IEC 60436 Edition 3.1 2009-11. Electric Dishwashers for Household Use – Methods for Measuring
283 the Performance.

³ The test procedure has not been codified in the Code of Federal Regulations yet, but it will be codified after the final rule is published in the Federal Register.

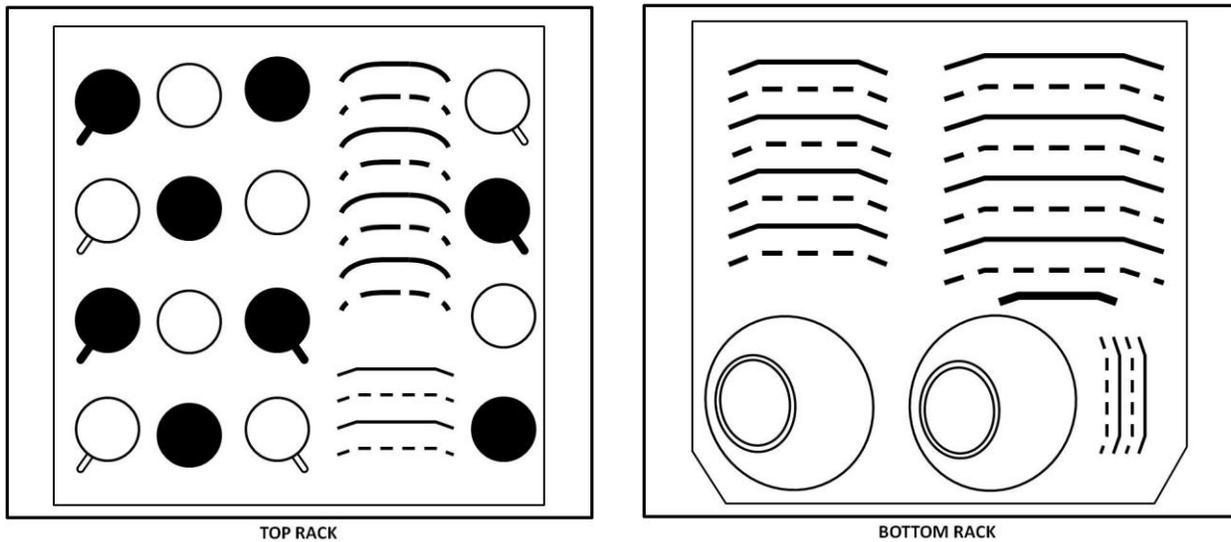
284 **7 APPENDIX A: SCHEMATIC OF LOADING PATTERN**

285 The figures below show schematics for the loading pattern of an example standard dishwasher for the
286 sensor heavy response, sensor medium response, and sensor light response soil loads. These
287 schematics should be used for reference only. Manufacturer use and care guides should be followed for
288 loading the UUT, but clean and soiled items should be alternated in the load as shown in the schematics
289 below.

290 **Note:** Stakeholders commented that DOE should differentiate between the serving platter and dinner
291 plates clearly in the schematics. DOE has updated the schematic to explicitly differentiate between the
292 serving platter and dinner plates.

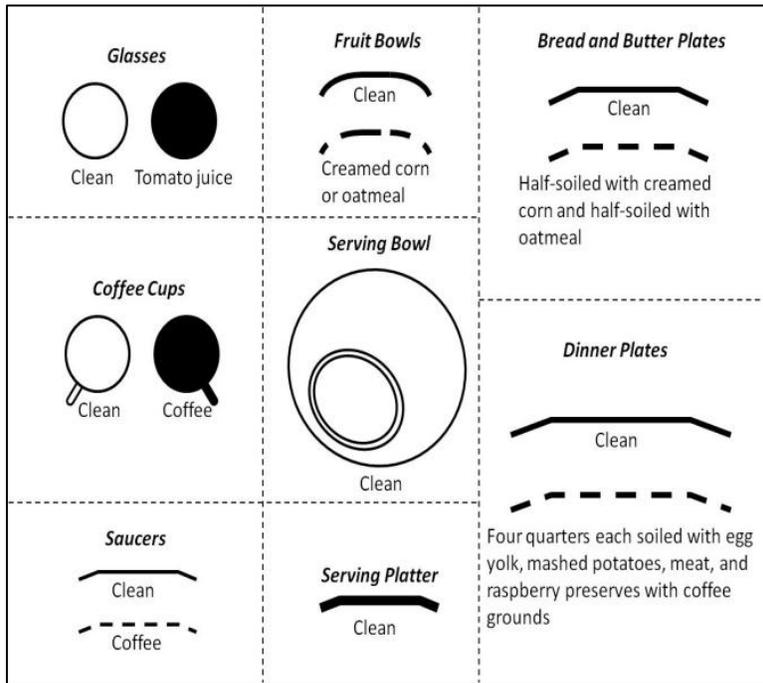


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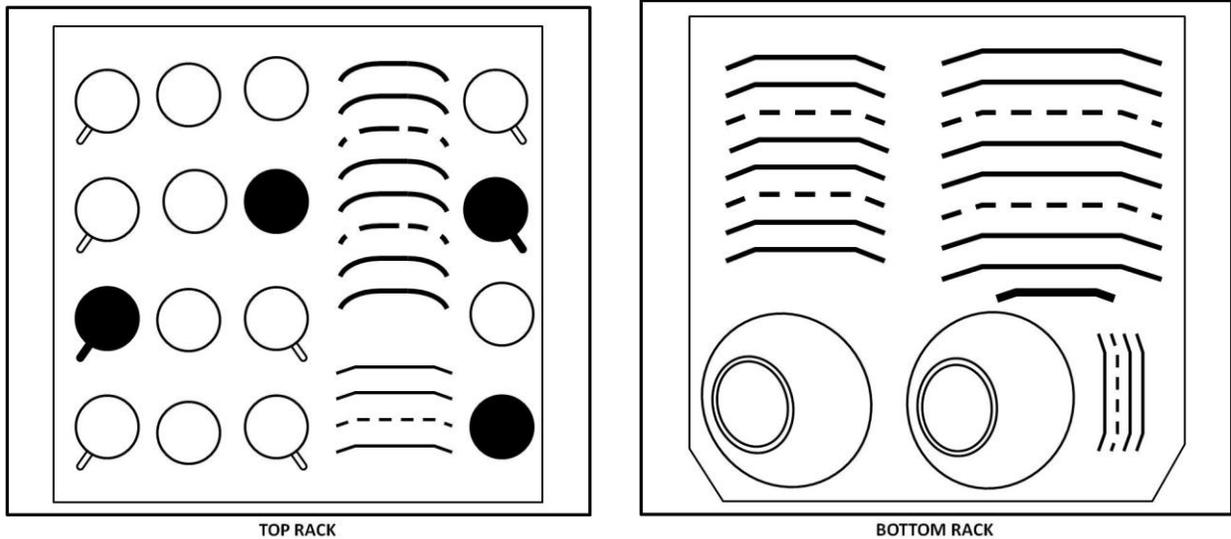


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Figure 1: Loading pattern for the sensor heavy response soil load.

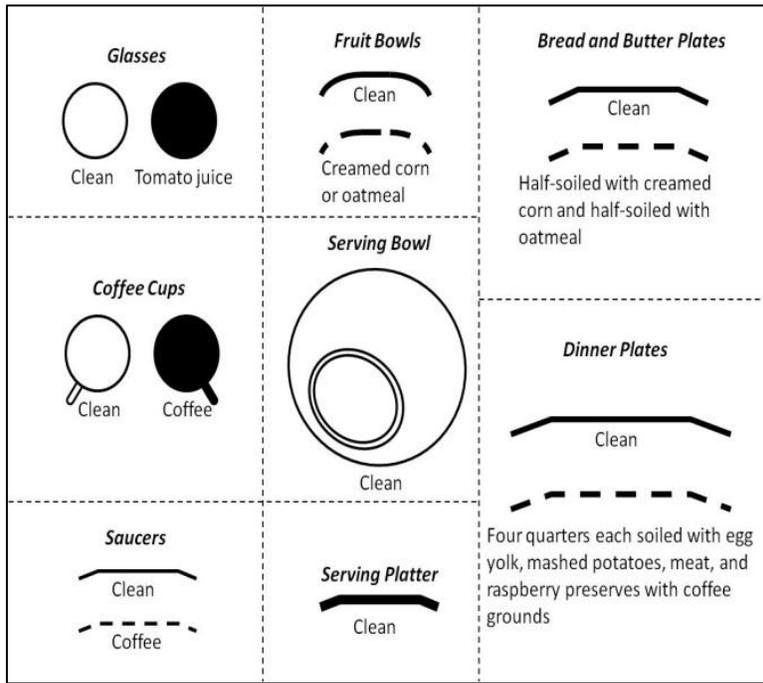


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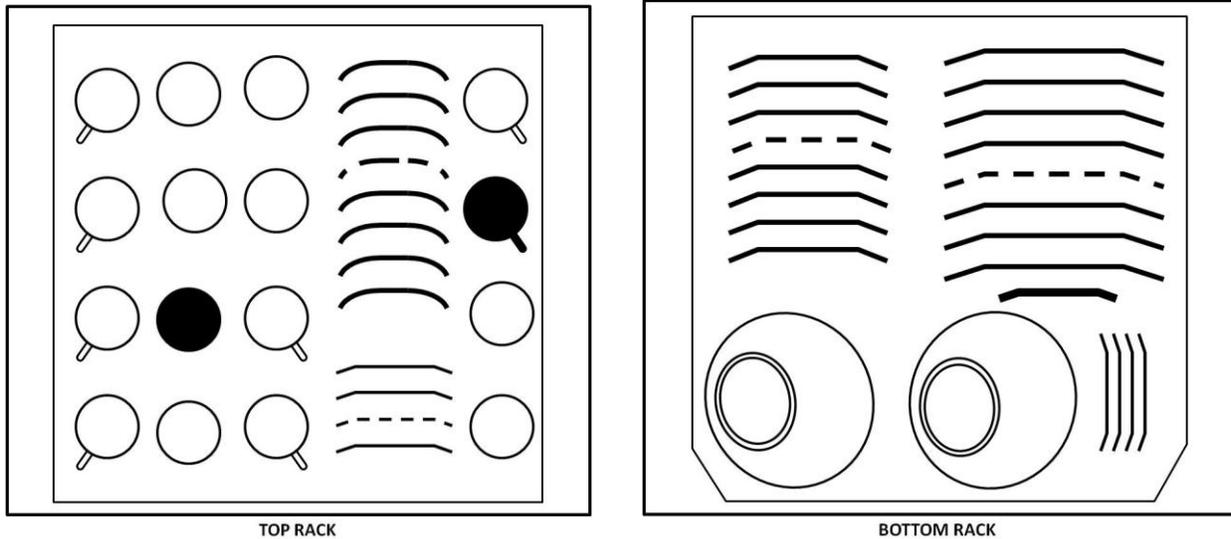


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Figure 2: Loading pattern for the sensor medium response soil load.



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Figure 3: Loading pattern for the sensor light response soil load.