



ENERGY STAR® Program Requirements Product Specification for Residential Dishwashers

Draft Final Test Method for Determining Residential Dishwasher Cleaning Performance Rev. Feb-2013

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. The 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 2 Test Method for Determining Residential Dishwasher Cleaning Performance (Draft 2 Test Method) that was published in October 2012 and the ENERGY STAR Residential Dishwasher Cleaning Performance Draft 2 Test Method Stakeholder Webinar (Draft 2 Test Method Webinar) held on October 17, 2012 in its development of the Draft Final Test Method. DOE and EPA thank all stakeholders who participated and provided feedback during the webinar and through written comments.

DOE expects to publish the Final Test Method in April 2013. While DOE will review all stakeholder comments on the test method outlined below, the Final Test Method will include only editorial revisions. Any substantial revisions will be considered for the next version of the test method.

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 is codified in the Code of Federal Regulations (CFR) at 10 CFR Part 430, Subpart B, Appendix C1.

Note: Stakeholders supported referencing the revised Federal test procedure for Residential Dishwashers, which is codified in the CFR at 10 CFR Part 430, Subpart B, Appendix C1, and which is required to be used to demonstrate compliance with Federal water and energy standards for dishwashers manufactured on or after May 30, 2013. DOE continues to reference this Federal test procedure in the Draft Final Test Method. This section of the Draft Final Test Method has not changed from the Draft 2 Test Method.

A) Acronyms and Units:

- 1) AHAM: Association of Home Appliance Manufacturers

- 36 2) ANSI: American National Standards Institute
- 37 3) CFR: Code of Federal Regulations
- 38 4) DOE: U.S. Department of Energy
- 39 5) EPA: U.S. Environmental Protection Agency
- 40 6) IEC: International Electrotechnical Commission
- 41 7) UUT: Unit under test

42 **4 TEST SETUP**

- 43 A) Test Setup and Instrumentation: Test setup and instrumentation for all portions of this method shall
- 44 be in accordance with those specified in 10 CFR Part 430, Subpart B, Appendix C1.
- 45 B) Cleaning Performance Rating Conditions: The lighting setup in the evaluation room shall be
- 46 according to the requirements specified in section 6.7.1 of International Electrotechnical Commission
- 47 (IEC) standard 60436, "Electric dishwashers for household use – Methods for measuring the
- 48 performance" Edition 3.1, 2009-11 (IEC standard 60436 Ed. 3.1, 2009-11).
- 49 C) Water Hardness: The supply water hardness shall be as specified in section 4.8.3 of American
- 50 National Standards Institute (ANSI) and Association of Home Appliance Manufacturers (AHAM)
- 51 standard, ANSI/AHAM DW-1-2010, "Household Electric Dishwashers" (ANSI/AHAM standard DW-1-
- 52 2010).

53 **Note:** Stakeholders commented that the cleaning performance rating conditions specified in IEC standard
54 60436 Ed. 3.1, 2009-11 are substantively the same as those listed in ANSI/AHAM standard DW-1-2010,
55 so DOE should reference ANSI/AHAM standard DW-1-2010 for consistency with the rest of the test
56 method. However, DOE has maintained the reference to IEC standard 60436 Ed. 3.1, 2009-11 in the
57 Draft Final Test Method to be consistent with the reference to IEC standard 60436 Ed. 3.1, 2009-11 for
58 the grading requirements that are described in section 5.2 of this test method.

59 **5 TEST PROCEDURES FOR ALL PRODUCTS**

60 **5.1 Test Cycles**

- 61 A) Preconditioning Cycle: Precondition the unit under test (UUT) as specified in 10 CFR Part 430,
- 62 Subpart B, Appendix C1. The quantity of detergent required for operating the UUT shall be
- 63 determined as specified in 10 CFR Part 430, Subpart B, Appendix C1.
- 64 1) For soil-sensing dishwashers, input power to the UUT shall be supplied continuously, throughout
- 65 all preconditioning and test cycles, as required by 10 CFR Part 430, Subpart B, Appendix C1, to
- 66 ensure that the turbidity sensor, which detects the presence of soil particles in water and infers
- 67 the soil level of the load to initiate the appropriate cycle, does not change its calibration between
- 68 tests.
- 69 B) Soil-sensing Normal Cycle: For dishwashers with a soil-sensing normal cycle, as defined in 10 CFR
- 70 Part 430, Subpart B, Appendix C1, testing shall be conducted according to 10 CFR Part 430, Subpart
- 71 B, Appendix C1.
- 72 1) Cleaning performance shall be evaluated during the same cycles that measure energy and water
- 73 consumption using the test loads described in 10 CFR Part 430, Subpart B, Appendix C1.
- 74 2) The tests shall be conducted starting with the sensor heavy response test load, followed by the
- 75 sensor medium response test load, then the sensor light test load, with no cleaning of the UUT
- 76 between test cycles.

- 77 C) Non-soil Sensing Normal Cycle: For non-soil sensing dishwashers, and dishwashers with soil-sensing
78 capability, but a non-soil sensing normal cycle as defined in 10 CFR Part 430, Subpart B, Appendix
79 C1, testing shall be conducted according to 10 CFR Part 430, Subpart B, Appendix C1; however,
80 cleaning performance shall be evaluated on the normal cycle using the sensor heavy, medium, and
81 light response test loads described for soil-sensing dishwashers in 10 CFR Part 430, Subpart B,
82 Appendix C1 immediately after performing the energy and water consumption tests.
- 83 1) The tests shall be conducted starting with the sensor heavy response test load, followed by the
84 sensor medium response test load, then the sensor light test load.
- 85 2) No other cycles shall be operated and the UUT shall not be cleaned in between any of the test
86 cycles.
- 87 D) Loading Requirements: Instructions in the manufacturer's use and care guide shall be followed for
88 loading the UUT.
- 89 1) Each item of the test load shall alternate clean and soiled items while following the manufacturer
90 instructions.
- 91 2) **Similar items** (e.g., all bread and butter plates or all fruit bowls) shall be loaded in the racks
92 consecutively without any empty rack spaces in between. Empty rack spaces between **different**
93 **items** (e.g., between the set of bread and butter plates or set of fruit bowls) are acceptable only if
94 one, or both, of the following conditions are met:
- 95 a) The capacity of the UUT is greater than the number of place settings required by the test
96 procedure in 10 CFR Part 430, Subpart B, Appendix C1.
- 97 b) The manufacturer's use and care guide for the UUT instructs the user to leave empty spaces
98 while loading.
- 99 3) Clean items should be loaded in the UUT first, followed by the soiled items.
- 100 4) For each soil load, the alternating of clean and soiled items for **standard dishwashers** is
101 explained below:
- 102 a) Sensor Heavy Response Test Load: Alternate clean and soiled items. Figure 1 in Appendix A
103 provides a schematic of the Sensor Heavy loading pattern for an example dishwasher.
- 104 b) Sensor Medium Response Test Load: Load items such that the soiled item is repeated after
105 every two clean items. Figure 2 in Appendix A shows a schematic of the Sensor Medium
106 loading pattern for an example dishwasher.
- 107 c) Sensor Light Response Test Load: Load the soiled item towards the middle of the load (e.g.,
108 when all dinner plates are loaded into the dishwasher, the soiled dinner plate should be either
109 the fourth or fifth dinner plate). Figure 3 in Appendix A shows a schematic of the Sensor Light
110 loading pattern for an example dishwasher.
- 111 5) For each soil load, the alternating of clean and soiled items for **compact dishwashers** is
112 explained below:
- 113 a) Sensor Heavy Response Test Load: Alternate clean and soiled items.
- 114 b) Sensor Medium Response Test Load and Sensor Light Response Test Load: Load the soiled
115 item towards the middle of the load (e.g., when all dinner plates are loaded into the
116 dishwasher, the soiled dinner plate should be either the second or third dinner plate).
- 117 E) Rinse aid shall not be used in the UUT.

118 **Note:** Stakeholders did not have any comments on DOE’s proposed requirements for the pre-
 119 conditioning cycle and test cycles.

120 For the loading pattern, stakeholders commented that DOE should allow manufacturers to provide
 121 images of the loading pattern for ENERGY STAR qualification via a publicly available webpage. DOE
 122 believes that the information provided in this test method along with the information provided in the
 123 manufacturer’s use and care guide should be sufficient to load the UUT. DOE has included additional
 124 specificity regarding empty rack spaces for the loading requirements in the Draft Final Test Method. DOE
 125 has clarified that there shall be no empty spaces between similar items of a load; there may be empty
 126 spaces between different items of a load only if the manufacturer’s use and care guide requires empty
 127 spaces or if the capacity of the dishwasher (number of place settings) is greater than the capacity
 128 specified in the test procedure in 10 CFR Part 430, Subpart B, Appendix C1.

129 Stakeholders also commented that DOE should reconsider the specification of a powder detergent for the
 130 cleaning performance test method because consumers have transitioned to gel and mono-dose packet
 131 detergents over the past decade. However, DOE continues to reference the detergent requirements listed
 132 in the Federal test procedure at 10 CFR 430, Subpart B, Appendix C1, because cleaning performance is
 133 determined on the same cycles as energy and water consumption for soil-sensing dishwashers.
 134 Therefore, the detergent specified in the Federal test procedure must be used for these cycles. While
 135 cleaning performance is being determined for non-soil sensing dishwashers using a different cycle from
 136 energy and water consumption, DOE is not specifying a different detergent for these units to maintain
 137 consistency with the cleaning performance tests performed on soil-sensing units and with the
 138 requirements in 10 CFR 430, Subpart B, Appendix C1.

139 **5.2 Grading**

- 140 A) After the completion of each test cycle, each item in the test load shall be graded on a scale from 0 to
 141 5 according to the instructions in section 6.7.1 of IEC standard 60436 Ed. 3.1, 2009-11. Table 2 in
 142 section 6.7.1 of IEC standard 60436 Ed. 3.1, 2009-11 for evaluating the cleaning index should not be
 143 used in this test method.

144 **Note:** DOE has revised this Draft Final Test Method to include references to grading and grades, which
 145 replace the references to scoring and scores included in the Draft 2 Test Method. DOE made this revision
 146 to avoid confusion between individual item grades and the calculated cleaning performance score.

147 Stakeholders again commented that DOE should use the ANSI/AHAM standard DW-1-2010 grading
 148 procedure to grade the test load. As discussed during the Draft 2 Test Method Webinar, DOE observed
 149 that the grading procedure specified in IEC standard 60436 Ed. 3.1, 2009-11 is more repeatable for test
 150 loads subject to the Federal test procedure at 10 CFR 430, Subpart B, Appendix C1 than the grading
 151 procedure in ANSI/AHAM standard DW-1-2010. Therefore, DOE continues to propose the IEC standard
 152 60436 Ed. 3.1, 2009-11 grading methodology for the cleaning performance test method.

153 Stakeholders also commented that DOE should reference the note in ANSI/AHAM standard DW-1-2010
 154 section 5.10, which specifies that the same individual should perform grading in a given facility, or that a
 155 method to eliminate the grading bias of multiple technicians should be in place. However, DOE cannot
 156 require a test lab to use only one technician for grading and has not included this note from ANSI/AHAM
 157 standard DW-1-2010. DOE believes the instructions included in this test method, with the references to
 158 industry test procedures, provide a basis for consistent grading.

159 **5.3 Cleaning Performance Score**

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

162 **Equation 1: Calculation of Per-Cycle Cleaning Performance Score**

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

163 *Where:*
 164 • *N is the total number of items in the test load*

- 165 • $N_{0,i}$ is the total number of items in the test load with a grade of 0
- 166 • $N_{1,i}$ is the total number of items in the test load with a grade of 1
- 167 • $N_{2,i}$ is the total number of items in the test load with a grade of 2
- 168 • $N_{3,i}$ is the total number of items in the test load with a grade of 3
- 169 • $N_{4,i}$ is the total number of items in the test load with a grade of 4
- 170 • i is the test cycle type (heavy, h ; medium, m ; or light, l)

171 Note: The total number of items in the test load with a grade of 5 ($N_{5,i}$), is not included in the equation
172 for calculating CPS_i because this grade represents a completely clean item, and the CPS_i calculation
173 deducts points from a perfect score of 100 for items that have some residual soil. While items
174 receiving a grade of 5 are not included in the calculation of CPS_i , these items are accounted for in the
175 total number of items in the test load.

176 **Note:** Stakeholders commented that DOE should clarify that the total number of items in the test load with
177 a grade of 5 ($N_{5,i}$) is intentionally excluded from the equation to calculate CPS_i . Accordingly, DOE has
178 added a note to explain why items with a grade of 5 have been excluded from the equation to calculate
179 CPS_i .

180

181 **Note:** In a notebbox in the Draft 2 Test Method, DOE and EPA discussed the sampling plan and
182 qualification requirements for dishwasher cleaning performance. DOE and EPA received several
183 comments from stakeholders on qualification and verification testing. Based on stakeholders' comments,
184 DOE and EPA have revised the proposed sampling and qualification requirements. These requirements
185 are discussed below, including the requirements for verification testing. The sampling plan, rounding
186 requirements, and criteria for qualification will be included in the Product Specification for Residential
187 Dishwashers Version 6.0.

188 Sampling Plan:

189 In a notebbox in the Draft 2 Test Method, DOE and EPA discussed a sampling plan that included testing a
190 minimum of three units for soil-sensing dishwashers and a minimum of one unit for non-soil sensing
191 dishwashers. In response to this discussion, stakeholders commented that the sampling plan should be
192 the same for both soil-sensing and non-soil sensing dishwashers. Stakeholders further commented that
193 manufacturers should be required to test the same number of units for cleaning performance as they test
194 for energy and water consumption under the Federal sampling plan specified in 10 CFR Parts 429.11 and
195 429.19. Manufacturers commented that they are willing to accept the additional test burden associated
196 with testing non-soil sensing dishwashers.

197 DOE and EPA agree with stakeholder comments and are proposing to revise the sampling plan
198 requirements to be the same as those specified in 10 CFR Parts 429.11 and 429.19. While DOE's
199 internal testing indicated that testing three units generally captured the variability associated with certain
200 soil-sensing dishwashers (as was discussed in the Draft 2 Test Method), the sampling requirements in 10
201 CFR 429.11 and 429.19 allow for additional units to be tested at the manufacturer's discretion above the
202 minimum requirements of two. DOE believes that manufacturers may choose to test additional units to
203 help capture any variability in cycle responses at a given soil load for soil-sensing dishwashers.
204 Therefore, DOE and EPA are proposing that the number of units tested for qualification of cleaning
205 performance be consistent with the sampling plan specified in 10 CFR Parts 429.11 and 429.19.

206 Qualification Requirements:

207 In a notebbox in the Draft 2 Test Method, DOE and EPA discussed that the lowest CPS_i at each soil load
208 should be used to qualify soil-sensing dishwashers, and, if more than one unit is tested, the average CPS_i
209 at each soil load should be used to qualify non-soil sensing dishwashers. In response to this discussion,
210 stakeholders commented that similar requirements to those specified in the CFR for energy and water
211 consumption should be used to determine the CPS_i for qualifying both soil-sensing and non-soil sensing
212 dishwashers. For energy and water consumption, for which consumers would prefer a lower value, the
213 CFR specifies that the higher of the mean or the upper confidence limit (UCL) based on the test sample
214 should be used to qualify the dishwasher. For the cleaning performance score, for which consumers
215 would prefer a higher value, the lower of the mean or lower confidence limit (LCL) based on the test
216 sample would be used. DOE and EPA agree with stakeholder comments and proposes that the CPS_i to

217 qualify both soil-sensing and non-soil sensing dishwashers shall be determined in accordance with the
218 requirements specified in 10 CFR 429.19 (a)(2)(ii).

219 Verification Testing:

220 DOE and EPA did not discuss the verification testing requirements for dishwasher cleaning performance
221 in the Draft 2 Test Method. However, stakeholders requested that DOE and EPA provide the verification
222 testing requirements and included recommendations for verification testing. Stakeholders commented
223 that verification testing for cleaning performance should be consistent with the ENERGY STAR
224 verification testing requirements currently in place for energy and water consumption, where an initial spot
225 check on one unit is used to verify the performance of a given basic model within a certain tolerance of
226 the specification. Stakeholders commented that the 5-percent tolerance for energy and water
227 consumption may not be appropriate for cleaning performance, and noted that Europe allows a 10-
228 percent tolerance for dishwasher cleaning performance. If the initial spot check does not meet the
229 specification within the given tolerance, tests on three additional units would be used to determine
230 compliance.

231 DOE and EPA agree that verification requirements for dishwasher cleaning performance should be
232 consistent with the ENERGY STAR verification requirements that are generally applicable to all products.
233 For DOE-covered products that are qualified based on a sample size of more than one unit, the
234 verification would include a first test on one unit and, if the first unit tests more than 5-percent worse than
235 the specification, testing a second sample of three units.¹ From test results at three laboratories, DOE
236 noted that UUTs with consistent operation from cycle-to-cycle typically generated CPS_i results within a 5-
237 percent range, and that a 10-percent tolerance range would likely be broad enough for poor-performing
238 units to be deemed compliant (depending on the final qualification criteria). Therefore, DOE and EPA
239 propose to adopt the ENERGY STAR verification testing requirements for dishwasher cleaning
240 performance without changing the tolerance requirements.

241 DOE and EPA invite stakeholder comments on the sampling plan, qualification requirements, and
242 verification testing requirements that will be included in the Product Specification for Residential
243 Dishwashers Version 6.0. Stakeholder comments on these topics will be considered and addressed when
244 EPA initiates the Version 6.0 specification development.

245 **6 REFERENCES**

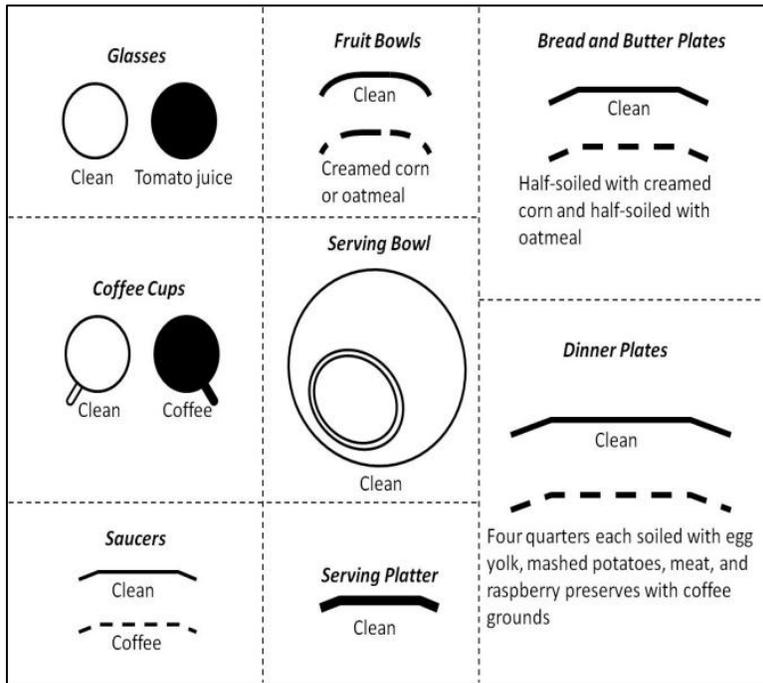
- 246 A) ANSI/AHAM DW-1-2010. Household Electric Dishwashers.
- 247 B) 10 CFR Part 430, Subpart B, Appendix C1. Uniform Test Method for Measuring the Energy
248 Consumption of Dishwashers.
- 249 C) IEC 60436 Edition 3.1 2009-11. Electric Dishwashers for Household Use – Methods for Measuring
250 the Performance.

¹ ENERGY STAR Verification Testing for Certification Bodies – Test Sample Sizes and Determining Testing Failures (Non-Lighting Products). Third Party Certification Implementation. ENERGY STAR® Products. Directive No. 2011-04. May 9, 2011. Available at http://www.energystar.gov/ia/partners/downloads/mou/ES_Product_Certification_Directive_2011_04_Test_Sample_Sizes.pdf?d4b4-4a57.

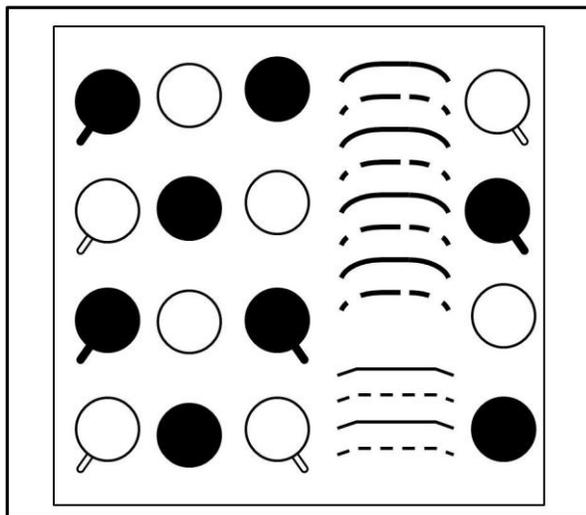
251 **7 APPENDIX A: SCHEMATIC OF LOADING PATTERN**

252 The figures below show schematics for the loading pattern of an example standard dishwasher for the
253 sensor heavy response, sensor medium response, and sensor light response soil loads. These
254 schematics show examples of potential ways to alternate clean and soiled items and should be used for
255 reference only. Manufacturer’s use and care guide should be followed for loading the UUT, but clean and
256 soiled items should be alternated in the load as shown in the examples below.

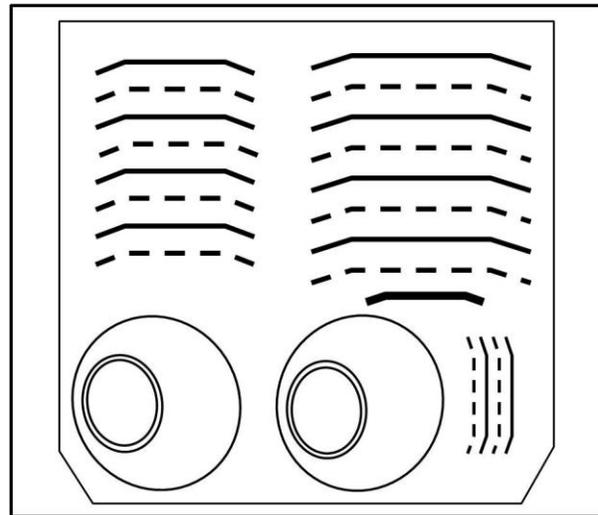
257 **Note:** DOE has included clarification that these schematics show examples of potential ways to alternate
258 clean and soiled items, as suggested by stakeholder comments.



259



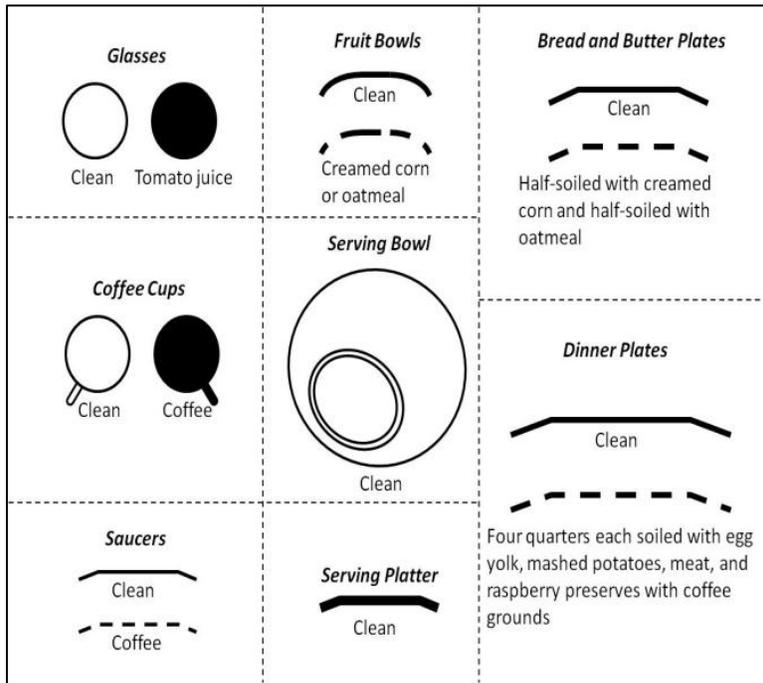
TOP RACK



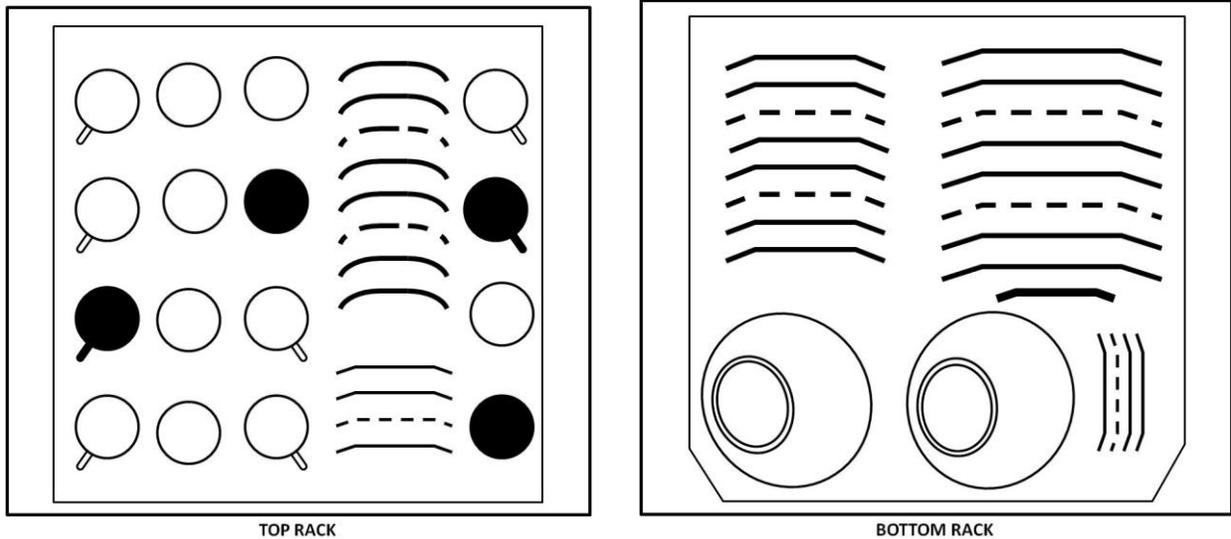
BOTTOM RACK

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

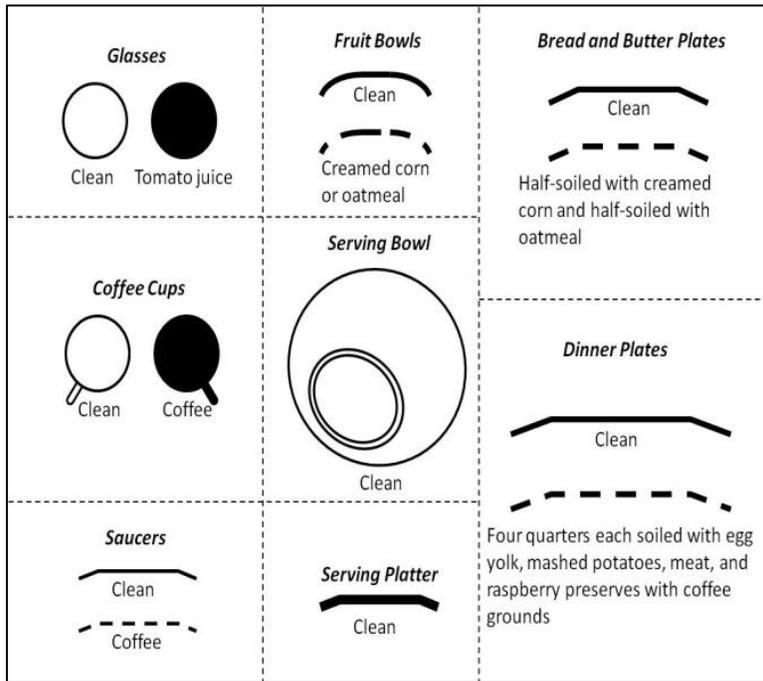


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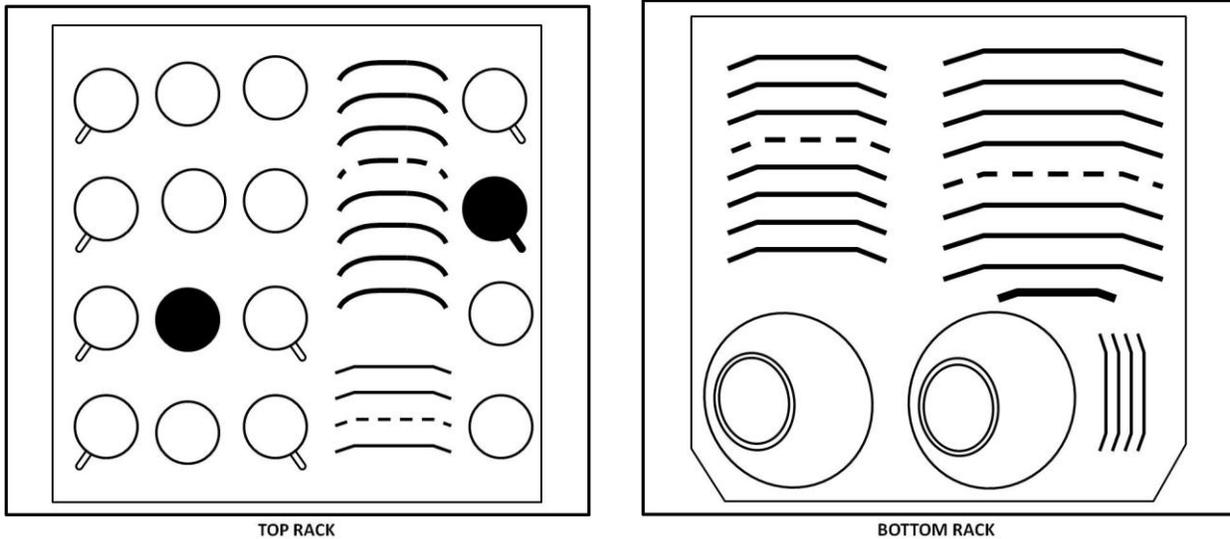


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Figure 2: Loading pattern for the sensor medium response soil load.



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