



# ENERGY STAR® Program Requirements Product Specification for Residential Dishwashers

## Draft 1 Test Method for Determining Residential Dishwasher Cleaning Performance Rev. Feb.-2012

### 1 OVERVIEW

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

**Note:** This document contains the proposed ENERGY STAR test method for evaluating the cleaning performance of residential dishwashers. EPA intends to call for the use of this test method for dishwashers seeking ENERGY STAR qualification under the next V6.0 specification. The proposed test method incorporates the feedback received during and after the residential dishwasher cleanability webinar held on September 19, 2011. U.S. Department of Energy (DOE) and U.S. Environmental Protection Agency (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 for evaluating residential dishwasher cleaning performance outlined below. Please send comments via email to [appliances@energystar.gov](mailto:appliances@energystar.gov) no later than March 19, 2012.

Please note that the cleaning performance shall be evaluated with the same cycles utilized for the energy and water use test for soil-sensing dishwashers. For non-soil sensing dishwashers, cleaning performance shall be evaluated subsequent to the energy and water use test as specified in Section 5 below.

### 2 APPLICABILITY

The test method proposed in this document 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 DOE test procedure at 10 CFR 430, Subpart B, Appendix C (Appendix C).

#### A) Acronyms and Units:

- 1) AHAM: Association of Home Appliance Manufacturers
- 2) DOE: U.S. Department of Energy
- 3) EPA: U.S. Environmental Protection Agency
- 4) IEC: International Electrotechnical Commission
- 5) K: Kelvin
- 6) ppm: Parts per million
- 7) UUT: Unit under test

## 4 TEST SETUP

- A) Test Setup and Instrumentation: Test setup and instrumentation for all portions of this method shall be in accordance with those specified in Appendix C.
- B) Cleanability Rating Conditions: The evaluation room shall have diffused light with a color temperature of 3,500 – 4,500 Kelvin (K) and the luminance measured at the plane of evaluation shall be 1,000 – 1,500 lux for scoring each piece of dishware.
- C) Water Hardness: Supply water hardness should be between 0 and 85 parts per million (ppm).

**Note:** The cleanability rating conditions are as specified in IEC Standard 60436. DOE does not expect the proposed setup for the cleanability rating conditions to be a significant burden for stakeholders and request comment on the test burden.

The water hardness requirement specified in 4.C is described in the Association of Home Appliance Manufacturers (AHAM) Standard DW-1-1992, “Household Electric Dishwashers” (AHAM Standard DW-1-1992). DOE understands that the water hardness requirement in the most recent version of the AHAM Standard DW-1-2009 specifies that the water hardness should be between 0 and 85 ppm of CaCO<sub>3</sub>. While water hardness is typically determined with reference to CaCO<sub>3</sub>, DOE requests comment about whether this additional information should be included. Further, Appendix C does not specify a water hardness requirement. While DOE does not expect the water hardness requirement to affect the energy and water consumption results, stakeholders are invited to comment and provide supporting data, if available, about whether specifying the water hardness requirement would impact these results.

Finally, at the webinar held on September 19, stakeholders recommended that a reference dishwasher be used for normalizing the performance of the UUT. DOE considered the use of the reference dishwasher specified in IEC Standard 60436 because it is a custom-made, consistently performing unit. More extensive test data obtained since the webinar indicate that the reference dishwasher does not improve test-to-test repeatability. Additionally, DOE recognizes the following concerns with using a reference dishwasher:

- 1) the significant cost of purchasing the dishwasher for those manufacturers and test labs that do not already have the reference dishwasher;
- 2) the difference in models specified for the reference dishwasher in different editions of IEC Standard 60436, and thus different reference dishwashers among those manufacturers and test labs that already have a reference dishwasher;
- 3) the increase in test burden to soil and score more dishes for each test run; and
- 4) the need for a test setup to accommodate the European supply power required for the reference unit.

Therefore, DOE has not included the use of the reference dishwasher in this draft test method. DOE invites further stakeholder comments on whether or not the reference dishwasher should be included in the draft test method.

## 5 TEST METHOD

### 5.1 Test Cycles

- A) Preconditioning Cycles: Perform two preconditioning cycles on the UUT as specified in section 2.10 of Appendix C for soil-sensing dishwashers. Perform one preconditioning cycle on non-soil sensing dishwashers as specified in section 2.10 of Appendix C. The quantity of detergent required for operating the UUT under Appendix C shall be determined during the last preconditioning cycle.

80 B) Soil-sensing Dishwashers: Testing shall be conducted according to section 4 of Appendix C. Cleaning  
81 performance shall be evaluated during the same cycles as energy and water consumption tests using  
82 the test loads described in sections 2.6.3.1, 2.6.3.2, and 2.6.3.3 of Appendix C. The tests shall be  
83 conducted starting with the sensor heavy response test load, followed by the sensor medium  
84 response test load, then the sensor light test load, with no cleaning of the UUT between test cycles.  
85 Input power to the UUT shall be supplied continuously throughout all test cycles to ensure no turbidity  
86 sensor self-learning changes between tests.

87 C) Non-soil Sensing Dishwashers: Testing shall be conducted according to section 4 of Appendix C;  
88 however, cleaning performance shall be evaluated on the normal cycle using the test loads described  
89 in sections 2.6.3.1, 2.6.3.2, and 2.6.3.3 of Appendix C immediately after performing the energy and  
90 water consumption tests. The tests shall be conducted starting with the sensor heavy response test  
91 load, followed by the sensor medium response test load, then the sensor light test load, with no  
92 cleaning of the unit in between the energy and performance test cycles as well as the three  
93 performance cycles.

94 D) Dishes shall be positioned according to manufacturer instructions as closely as possible. For  
95 standard dishwashers, the following loading pattern shall be used:

96 1) Sensor Heavy Response Test Load: Alternate one clean item with one respective soiled item,  
97 with similar items loaded in the racks consecutively without any empty rack spaces in between.  
98 Figure 1 in Appendix A shows a schematic of the loading pattern for an example dishwasher.

99 2) Sensor Medium Response Test Load: Load items such that the soiled item is repeated after  
100 every two clean items, with similar items loaded in the racks consecutively without any empty  
101 rack spaces in between. Figure 2 in Appendix A shows a schematic of the loading pattern for an  
102 example dishwasher.

103 3) Sensor Light Response Test Load: Load the soiled item towards the middle of the respective load  
104 (for example, when all dinner plates are loaded into the dishwasher, the soiled dinner plate  
105 should be either the fourth or fifth dinner plate), with similar items loaded in the racks  
106 consecutively without any empty rack spaces in between. Figure 3 in Appendix A shows a  
107 schematic of the loading pattern for an example dishwasher.

108 For compact dishwashers, the following loading pattern shall be used:

109 1) Sensor Heavy Response Test Load: Alternate one clean item with one respective soiled item,  
110 with similar items loaded in the racks consecutively without any empty rack spaces in between.

111 2) Sensor Medium Response Test Load and Sensor Light Response Test Load: Load the soiled  
112 item towards the middle of the respective load (for example, when all dinner plates are loaded  
113 into the dishwasher, the soiled dinner plate should be either the second or third dinner plate), with  
114 similar items loaded in the racks consecutively without any empty rack spaces in between.

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

116 **Note:** The above test cycles are intended to harmonize the operating cycles for energy and water  
117 consumption tests and cleaning performance tests, as strongly recommended by the comments received  
118 during and after the stakeholder webinar.

119 DOE is proposing two preconditioning cycles for soil-sensing dishwashers before measuring the energy  
120 and water use, and determining the cleaning performance, so that turbidity sensor thresholds are self-  
121 learned before beginning test measurements. While this may increase burden for test labs, it is important  
122 to allow turbidity sensors to self-learn to ensure that the test to test variability in the energy and water  
123 consumption measurements is as low as possible.

Non-soil sensing dishwashers are tested with no load or with a clean load for energy and water consumption. For testing the cleaning performance of non-soil sensing dishwashers, it is thus recommended that the same cleaning performance tests run for soil-sensing dishwashers be performed after the energy and water consumption tests are completed.

Loading pattern had minimal effect on the cleaning performance of the UUT; however, DOE has specified loading patterns that distribute the soils throughout the dishwasher as evenly as possible to ensure consistency from test lab to test lab. DOE invites comments on the proposed loading patterns and any data that suggests cleaning performance varies with the loading pattern for the type and quantity of soil used in the DOE tests.

DOE is not proposing the use of rinse aid for testing the cleaning performance of dishwashers because rinse aid is not required for the energy and water consumption tests. DOE understands that the lack of rinse aid might increase the time required for scoring each item and might have a very small impact on the performance index, but would like to maintain consistency with the DOE test procedure requirements to allow cleaning performance to be measured concurrently with energy and water consumption.

DOE invites stakeholder comments on the proposed test method for evaluating the cleaning performance of residential dishwashers.

## 5.2 Scoring

- A) Each item in the test load, with the exception of flatware, shall be assessed for cleaning performance and the score noted individually after the completion of each test cycle according to the instructions in section 6.7.1 of IEC Standard 60436. Flatware items, including all forks, knives, spoons, and serving flatware, shall not be scored for cleaning performance. Table 2 in section 6.7.1 of IEC Standard 60436 for evaluating the cleaning index should not be used in this test method.

**Note:** DOE is proposing to use the cleanability evaluation criteria specified in Table 1 of section 6.7.1 of IEC Standard 60436 because initial testing suggests that the IEC scoring method is consistent and repeatable. One significant difference between this proposed test method and the IEC evaluation is the exclusion of grading flatware items. During DOE testing, flatware items were typically completely clean, received scores of 5, and did not contribute significantly to the overall cleaning performance score. DOE determined that the test burden of grading flatware items was not justified by an improvement in the measured cleaning performance, and therefore eliminated that evaluation requirement.

DOE invites stakeholder comment on the proposed scoring method.

## 5.3 Performance Metric

- A) After each test cycle, calculate the per-cycle cleaning metric of the UUT ( $CM_i$ ) according to Equation 1 below.

### Equation 1: Calculation of Per-Cycle Cleaning Metric

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

Where:

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

- B) After completing the heavy, medium, and light test cycles, calculate the performance metric, PM, of the UUT according to Equation 2 below.

#### Equation 2: Calculation of Performance Metric

$$PM = W_h \times CM_h + W_m \times CM_m + W_l \times CM_l$$

Where:

- $W_h$  is the weighting factor applied to the sensor heavy cleaning performance, 0.34
- $W_m$  is the weighting factor applied to the sensor medium cleaning performance, 0.33
- $W_l$  is the weighting factor applied to the sensor light cleaning performance, 0.33

**Note:** DOE is proposing that the cleaning metric per-cycle be calculated by assigning increasing weights to each score from four to zero. This calculation method was developed from AHAM Standard DW-1-2009 and was found to produce consistent, repeatable results during internal testing. The weighting factors in Equation 1 are the same as provided in AHAM Standard DW-1-2009, although the scores to which each factor is applied are adjusted according to the range from the IEC scoring method. Further, the performance metric is calculated in Equation 2 as a single weighted average of the per-cycle cleaning metrics. The weighting factors applied to the cleaning metrics were determined empirically to provide the most repeatable and representative results for the performance metric, and will also limit the opportunity for circumvention. This method is employed because only one cycle per soil load is required in DOE testing. In the event that a reference dishwasher is included in the final ENERGY STAR test method, the proposed performance metric calculation could be retained by normalizing the UUT per-cycle cleaning metrics to those of the reference dishwasher. DOE invites stakeholder comments on the proposed calculation of the performance metric.

## 6 REFERENCES

- A) AHAM DW-1-1992. Household Electric Dishwashers.
- B) AHAM DW-1-2009. Household Electric Dishwashers.
- C) DOE Appendix C to Subpart B of Part 430. Uniform Test Method for Measuring the Energy Consumption of Dishwashers.
- D) IEC 60436 Edition 3.1 2009-11. Electric Dishwashers for Household Use – Methods for Measuring the Performance.

## 7 APPENDIX A: SCHEMATIC OF LOADING PATTERN

The figures below show schematics for the loading pattern of an example standard dishwasher for the sensor heavy response, sensor medium response, and sensor light response soil loads.

**Note:** The coffee cups and glasses have been numbered in the schematics shown below for reference. Stakeholders are requested to use the numbers to refer to the items for specific comments about the location of the respective items. For all other items stakeholders are requested to develop a well defined numbering system to refer to a particular item.

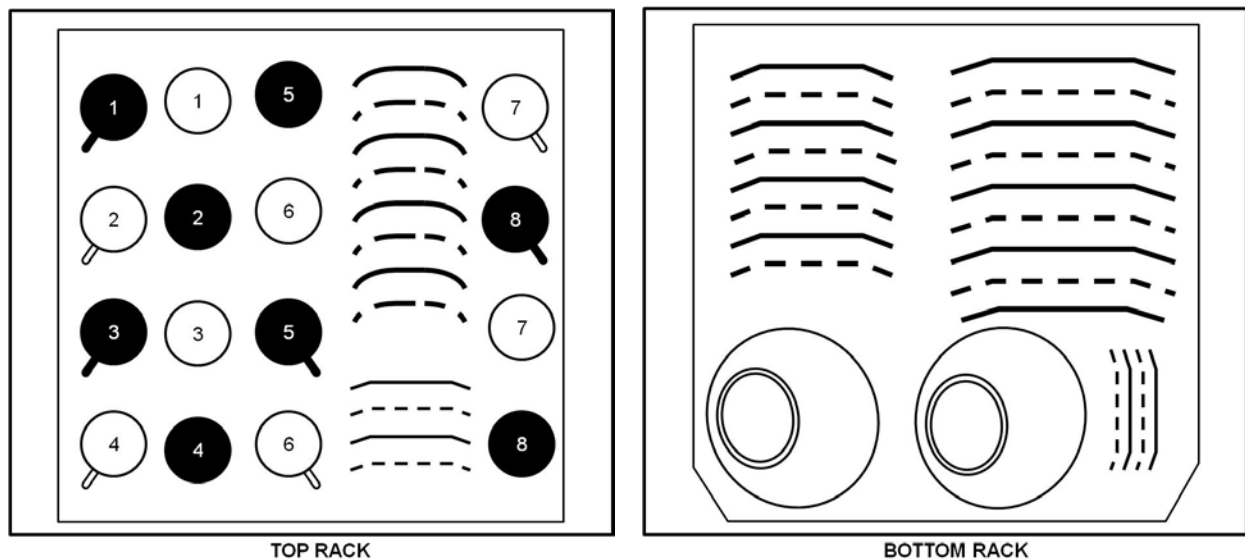
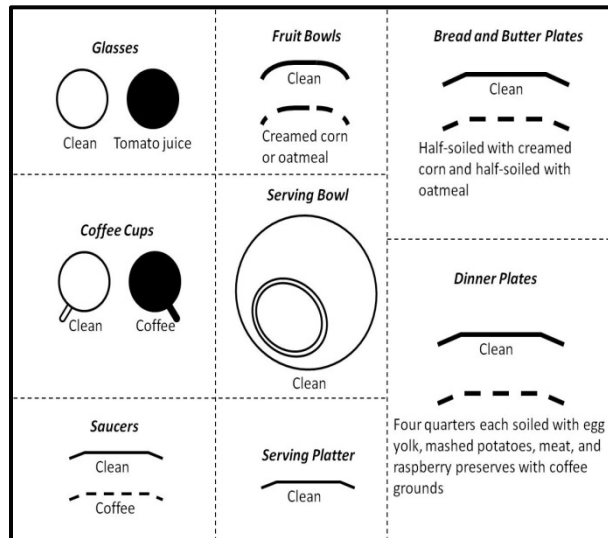


Figure 1: Loading pattern for the sensor heavy response soil load.

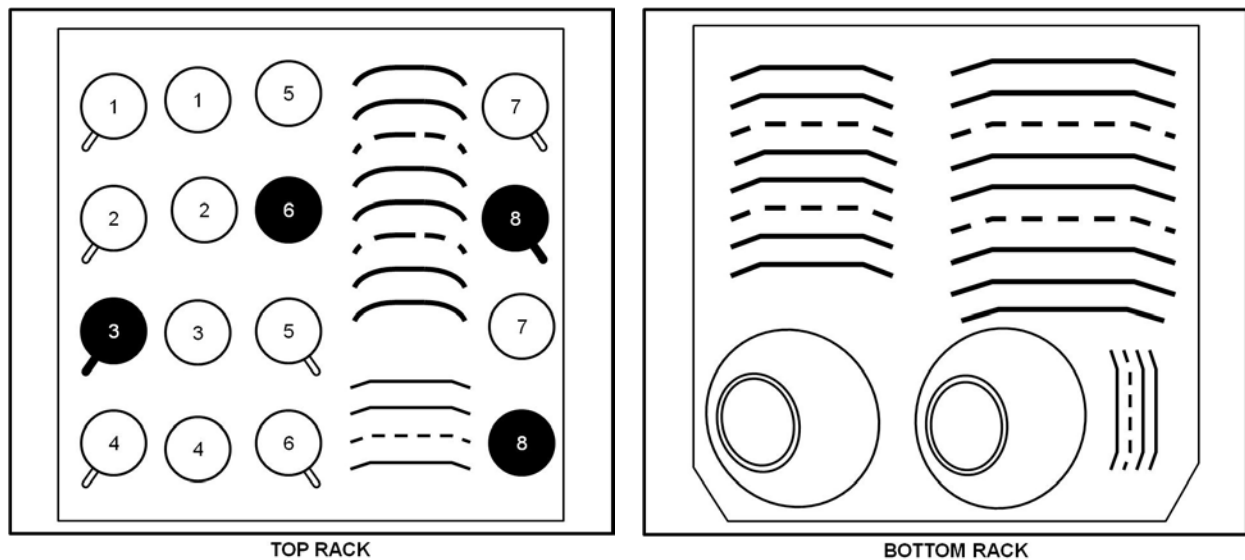
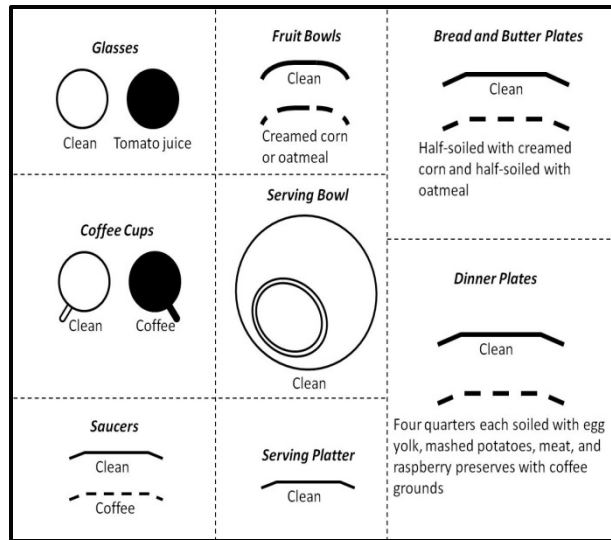
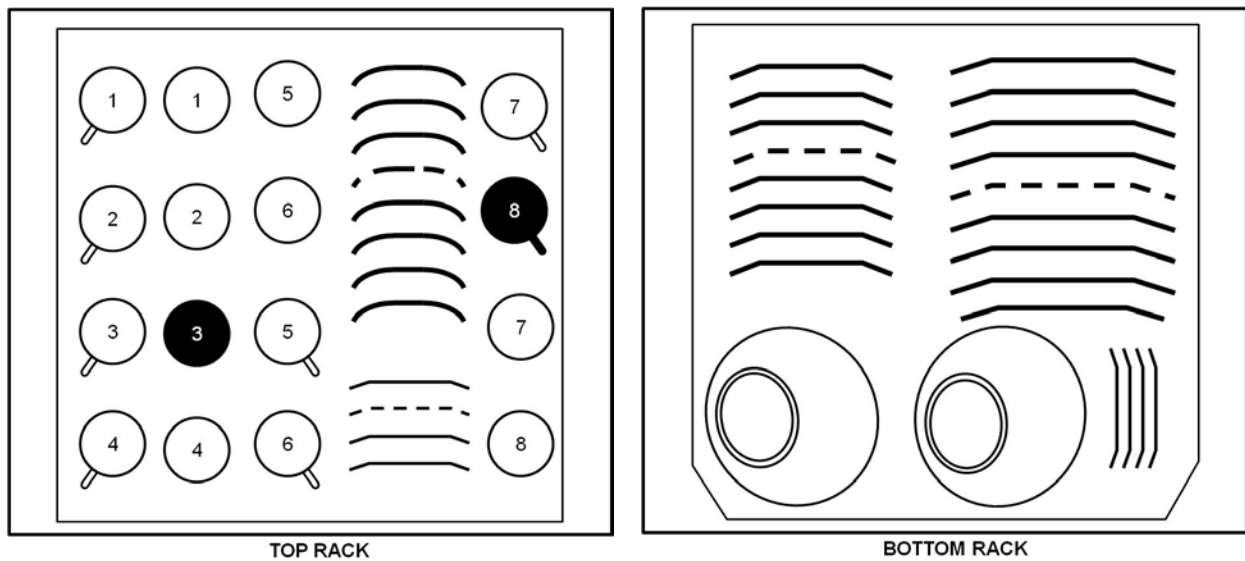
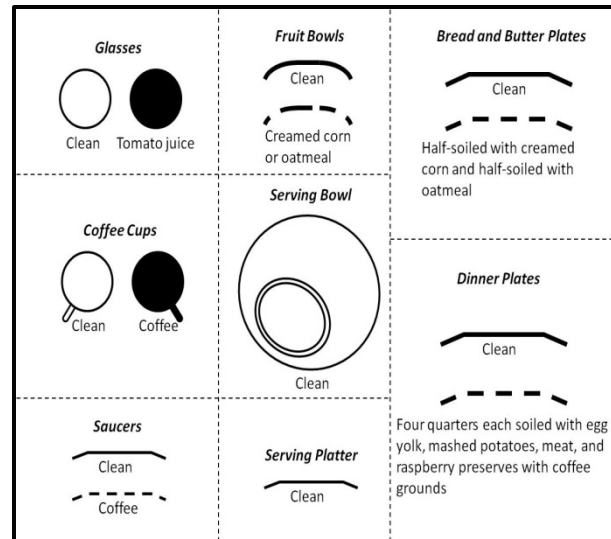


Figure 2: Loading pattern for the sensor medium response soil load.



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