



# ENERGY STAR® Program Requirements Product Specification for Residential Clothes Washers

## Draft 1 Test Method for Determining Residential Clothes Washer Cleaning Performance October 2016

### 1. OVERVIEW

The following test method shall be used for determining the cleaning performance of residential clothes washers that meet the ENERGY STAR Eligibility Criteria for Clothes Washers. Cleaning performance shall be determined on the same test units immediately following the energy and water consumption tests for ENERGY STAR qualification. Cleaning performance is measured under test conditions that are consistent with the test conditions used to determine the energy and water performance.

**Note:** DOE recognizes that it is desirable to measure clothes washer cleaning performance under the same test conditions as specified in the DOE clothes washer test procedure (10 CFR 430, Subpart B, Appendix J2, referred to here as "Appendix J2") to minimize test burden and ensure that performance metrics are relevant to certified energy and water use.

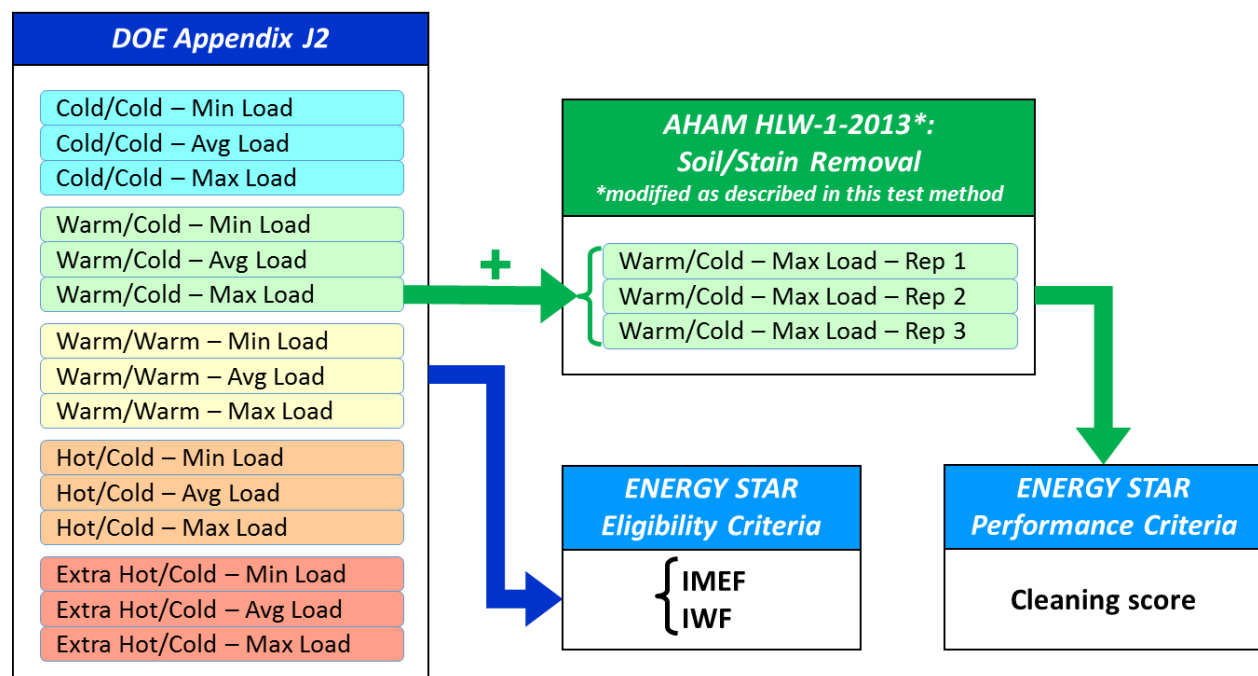
Appendix J2 does not contain a procedure for measuring cleaning performance; therefore, this proposed ENERGY STAR test method incorporates modified procedures from the Association of Home Appliance Manufacturers (AHAM) test method HLW-1-2013, "Performance Evaluation Procedures for Household Clothes Washers" (referred to here as "AHAM HLW-1-2013"). Specifically, the proposed test method incorporates the Soil/Stain Removal Test from AHAM HLW-1-2013, performed using DOE test cloth rather than the 100% cotton load specified in AHAM HLW-1-2013, and with detergent as specified in AHAM HLW-1-2013.

#### *Structure of the Proposed Test Method*

Cleaning performance would be measured using the hottest Warm Wash/Cold Rinse temperature selection and maximum load size test cycle defined in Section 3.5.1 of Appendix J2 (hereafter referred to as the "Warm/Cold Max Load cycle"). As proposed, cleaning performance would be measured separately from energy and water consumption, immediately after performing all test cycles required for Appendix J2. DOE recognizes that measuring cleaning performance concurrently with energy and water consumption would provide the strongest linkage between cleaning performance results and certified energy and water use. However, the energy and water use of residential clothes washers must be certified using the existing version of Appendix J2, which does not incorporate any aspects of cleaning performance. DOE invites comment on an alternative proposal presented below that would provide a more direct link between energy, water, and cleaning performance.

Justification for proposing the use of the Warm/Cold Max Load cycle to measure cleaning performance is provided later in this document.

Figure 1 below illustrates the structure of the proposed test method in terms of the test cycles that would be performed for each purpose. The diagram shows how the resulting cleaning performance score relates to the existing Integrated Modified Energy Factor (IMEF) and Integrated Water Factor (IWF).



**Figure 1. Structure of Proposed Test Method**

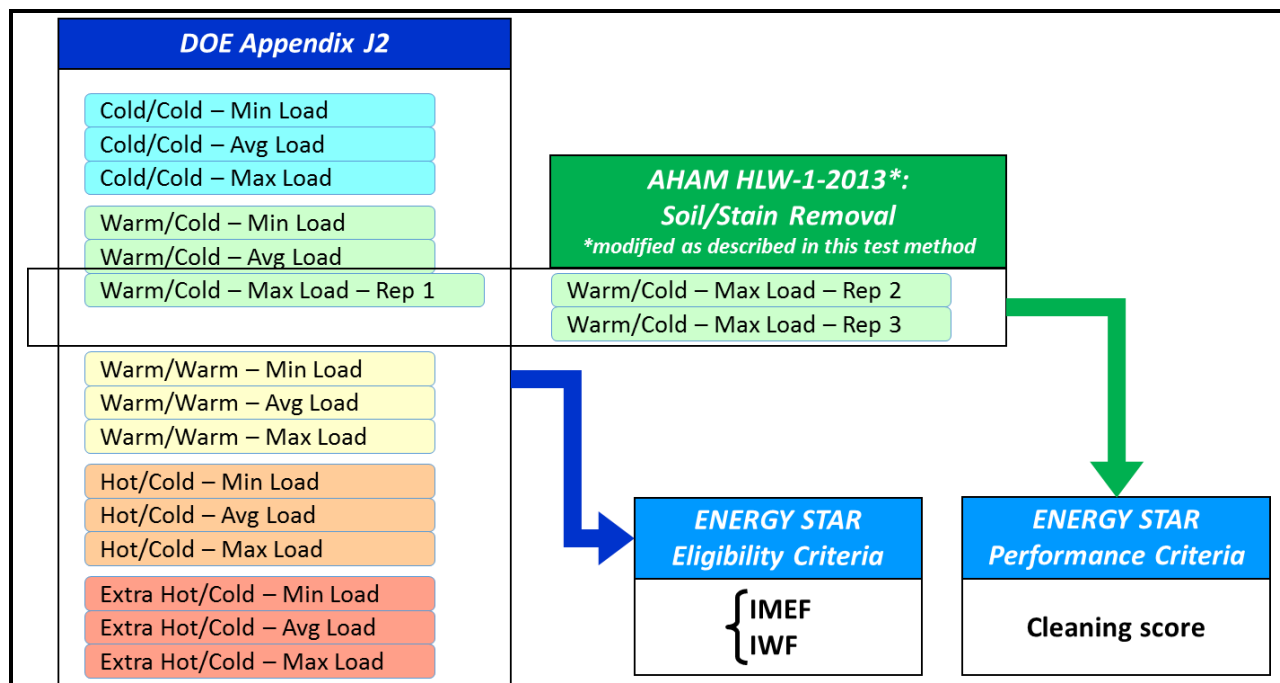
AHAM HLW-1-2013 requires performing three replications of any given load condition; therefore, three replications of the Warm/Cold Max Load cycle would be performed.

As proposed, this test method would require three additional wash cycle runs beyond those required for measuring energy and water use in accordance with Appendix J2.

**Note:**

*Structure of Alternative Test Method*

DOE invites comment on an alternative structure for the cleaning performance test method, which would further integrate energy and water use with cleaning performance. In this alternative method, energy and water consumption would be measured concurrently with cleaning performance on the first replication of the Warm/Cold Max Load cycle. Figure 2 below illustrates the structure of this alternative test method in terms of the test cycles that would be performed for each purpose.



**Figure 2. Structure of Alternative Test Method**

For this alternative method, cold water, hot water, and electrical energy use would be measured during the first cleaning performance replication and the values would be used to represent the Warm/Cold Max Load cycle in Section 3.5.1 of Appendix J2 and subsequent calculations. This alternative test method would require two additional wash cycle runs beyond those required for measuring energy and water use in accordance with Appendix J2.

DOE recognizes that the presence of detergent and the added weight of the test strips in the Warm/Cold Max Load cycle may impact the energy and water consumption results for that cycle, and subsequently the overall calculations of IMEF and IWF. However, DOE believes that any such impact on the results of the Warm/Cold Max Load cycle would be minor, and the subsequent impact on the overall IMEF and IWF calculations would be insignificant.

DOE invites input on how the presence of detergent and test strips in the Warm/Cold Max Load cycle might impact the energy and water results of that cycle and the overall IMEF and IWF calculations.

DOE invites comment on the suitability of using the water and electrical energy consumption measurements obtained during the first replication of the cleaning performance test to represent the hottest Warm/Cold Max Load cycle in Section 3.5.1 of Appendix J2.

**Note:** DOE also invites comment on whether the Rinsing Effectiveness Test, as identified in AHAM HLW-1-2013, should be included in this test method to evaluate rinsing performance.

## 2. APPLICABILITY

The proposed test method shall be used to determine the cleaning performance of residential clothes washers within the ENERGY STAR program.

## 3. DEFINITIONS

Unless otherwise specified, all terms used in this document are consistent with the definitions in:

- (1) ENERGY STAR Program Requirements, Product Specification for Clothes Washers, Eligibility Criteria Version 8.0
- (2) U.S. Department of Energy (DOE) test procedure at 10 CFR 430, Subpart B, Appendix J2, "Uniform Test Method for Measuring the Energy Consumption of Automatic and Semi-Automatic Clothes Washers." ("Appendix J2")
- (3) Association of Home Appliance Manufacturers (AHAM) HLW-1-2013, "Performance Evaluation Procedures for Household Clothes Washers." ("AHAM HLW-1-2013")

**Note:** This ENERGY STAR test method incorporates definitions from the multiple sources listed above. DOE has evaluated the definitions contained within the referenced publications and did not find any contradictions between the sources.

A) Acronyms and Units:

- 1) AHAM: Association of Home Appliance Manufacturers
- 2) CFR: Code of Federal Regulations
- 3) DOE: U.S. Department of Energy
- 4) IMEF: Integrated Modified Energy Factor
- 5) IWF: Integrated Water Factor
- 6) UUT: Unit under test

B) Definitions:

- 1) Performance Test Load: The maximum load size of energy test cloth as defined in Table 5.1 of Appendix J2, based on the UUT's capacity as measured in Section 3.1 of Appendix J2, plus the required amount of soil/stain removal test strips, as determined in Section 4.D of this test method.
- 2) Total Cleaning Score: A measure of soil/stain removal that represents an average of individual cleaning scores from soil/stain removal test strip swatches of different stain types. An individual cleaning score represents the ratio of the cleaning performance of the UUT to a calibrated reference level. A higher Total Cleaning Score represents better soil/stain removal (i.e., better cleaning performance).

## 4. TEST SETUP

Testing conditions, instrumentation, and materials for all portions of this method shall follow Section 2 of Appendix J2, with the following additions.

A) Test Conditions

- 1) Maintain the supply water hardness as specified in Section 4.5.3 of AHAM HLW-1-2013.

**Note:** AHAM HLW-1-2013 specifies a water hardness limit of 50 parts per million (ppm) or less. Appendix J2 does not provide water hardness specifications for the wash cycles performed as part of the energy test cycle; however, Section 2.7.3 of Appendix J2 specifies a water hardness limit of 17 ppm or less for pre-conditioning DOE energy test cloth.

B) Instrumentation and Equipment

- 1) The scale used for weighing test cloth must have a resolution of no larger than 0.2 oz. (5.7 g) and a maximum error no greater than 0.1 percent of the measured value.

**Note:** Appendix J2 requires the test load weighing equipment to provide accuracy to within  $\pm 0.3\%$ ; whereas AHAM HLW-1-2013 requires a greater level of accuracy, to within  $\pm 0.1\%$ . DOE believes that specifying a greater accuracy for the load-weighing equipment may produce more accurate and

repeatable results for cleaning performance testing, and invites stakeholder comment on the benefits and test burden of requiring such equipment.

- 2) The scale used for weighing detergent must be in accordance with the specifications in Section 6.2.d of AHAM HLW-1-2013.
- 3) The Tristimulus Colorimeter/Spectrocolorimeter used to measure post-wash reflectance must be in accordance with the specifications in Annex A, Section A.10 of AHAM HLW-1-2013.
- 4) The sewing machine or stapling equipment for attaching soil/stain removal test strips to load items must be in accordance with the specifications in Section 6.2.c of AHAM HLW-1-2013.

C) Test Materials: Detergent

- 1) Detergent formulation, concentration and storage specifications must be in accordance with Section 4.7 of AHAM HLW-1-2013.
- 2) When loading the detergent into the clothes washer, follow Section 6.6.4.1 of AHAM HLW-1-2013 for a clothes washer with a detergent dispenser or Section 6.6.4.2 of AHAM HLW-1-2013 for a clothes washer without a detergent dispenser.

D) Test Materials: Soil/Stain Removal Test Strips

- 1) Soil/stain removal test strips (hereafter referred to as "test strips") must be in accordance with Annex A, Sections A.6 and A.7 of AHAM HLW-1-2013.
- 2) Mark each test strip with a unique identifying reference in accordance with Section 6.5.6 of AHAM HLW-1-2013.
- 3) Table 1 of this test method indicates the quantity of test strips to use based on the capacity of the UUT, as measured in Section 3.1 of Appendix J2, and the associated maximum load size.

**Table 1: Number of test strips based on clothes washer capacity**

| Container volume |      | Maximum load | Number of test strips |
|------------------|------|--------------|-----------------------|
| cu. ft.          |      | lb.          |                       |
| ≥                | <    |              |                       |
| 0                | 0.80 | 3.00         | 2                     |
| 0.80             | 0.90 | 3.50         |                       |
| 0.90             | 1.00 | 3.90         |                       |
| 1.00             | 1.10 | 4.30         |                       |
| 1.10             | 1.20 | 4.70         |                       |
| 1.20             | 1.30 | 5.10         | 3                     |
| 1.30             | 1.40 | 5.50         |                       |
| 1.40             | 1.50 | 5.90         |                       |
| 1.50             | 1.60 | 6.40         |                       |
| 1.60             | 1.70 | 6.80         |                       |
| 1.70             | 1.80 | 7.20         | 4                     |
| 1.80             | 1.90 | 7.60         |                       |
| 1.90             | 2.00 | 8.00         |                       |
| 2.00             | 2.10 | 8.40         |                       |
| 2.10             | 2.20 | 8.80         |                       |
| 2.20             | 2.30 | 9.20         | 5                     |
| 2.30             | 2.40 | 9.60         |                       |
| 2.40             | 2.50 | 10.00        |                       |
| 2.50             | 2.60 | 10.50        |                       |
| 2.60             | 2.70 | 10.90        |                       |
| 2.70             | 2.80 | 11.30        | 6                     |
| 2.80             | 2.90 | 11.70        |                       |
| 2.90             | 3.00 | 12.10        |                       |
| 3.00             | 3.10 | 12.50        |                       |

|      |      |       |    |
|------|------|-------|----|
| 3.10 | 3.20 | 12.90 |    |
| 3.20 | 3.30 | 13.30 |    |
| 3.30 | 3.40 | 13.70 |    |
| 3.40 | 3.50 | 14.10 | 7  |
| 3.50 | 3.60 | 14.60 |    |
| 3.60 | 3.70 | 15.00 |    |
| 3.70 | 3.80 | 15.40 |    |
| 3.80 | 3.90 | 15.80 | 8  |
| 3.90 | 4.00 | 16.20 |    |
| 4.00 | 4.10 | 16.60 |    |
| 4.10 | 4.20 | 17.00 |    |
| 4.20 | 4.30 | 17.40 |    |
| 4.30 | 4.40 | 17.80 | 9  |
| 4.40 | 4.50 | 18.20 |    |
| 4.50 | 4.60 | 18.70 |    |
| 4.60 | 4.70 | 19.10 |    |
| 4.70 | 4.80 | 19.50 |    |
| 4.80 | 4.90 | 19.90 | 10 |
| 4.90 | 5.00 | 20.30 |    |
| 5.00 | 5.10 | 20.70 |    |
| 5.10 | 5.20 | 21.10 |    |
| 5.20 | 5.30 | 21.50 |    |
| 5.30 | 5.40 | 21.90 | 11 |
| 5.40 | 5.50 | 22.30 |    |
| 5.50 | 5.60 | 22.80 |    |
| 5.60 | 5.70 | 23.20 |    |
| 5.70 | 5.80 | 23.60 |    |
| 5.80 | 5.90 | 24.00 | 12 |
| 5.90 | 6.00 | 24.40 |    |

**Note:** The number of test strips is based on the maximum load size in Table 5.1 of Appendix J2 and is consistent with the number of test strips per pound of load provided in Table 2 of AHAM HLW-1-2013. DOE linearly extrapolated Table 2 of AHAM HLW-1-2013 beyond 20lb. loads to include quantities for all capacities currently included in Table 5.1 of Appendix J2. See Section 5 of this test method for a discussion on use of the maximum load size.

#### E) Loading the Performance Test Load

- 1) Attach each test strip to an energy test cloth from the maximum test load, as defined in Table 5.1 of Appendix J2, in accordance with Section 6.5.7 of AHAM HLW-1-2013, substituting "energy test cloth" for "towel."
- 2) Fold the energy test cloths with attached test strips in accordance with Figure 1 of AHAM HLW-1-2013, substituting "energy test cloth" for "towel."
- 3) Load the test cloths as follows:
  - a) Top-loading clothes washer: Load 7 test cloths without test strips followed by 1 test cloth with an attached test strip, ensuring an even distribution of test cloths without test strips, and that test cloths with attached test strips are not placed on top of each other. Repeat this sequence until the final test cloth with an attached test strip is loaded; the last sequence may include fewer than 7 test cloths without test strips. Load any remaining test cloths without test strips, including any energy stuffer cloths, on top.
  - i) To load test cloths without test strips, follow the instructions provided in Section 2.9.2.1 of Appendix J2.

- 158 ii) To load test cloths with attached test strips, follow the instructions provided in  
159 Sections 5.3.2.2 and 5.3.2.2.2 of AHAM HLW-1-2013. Test cloths with attached test  
160 strips must be placed in one of the 4 quadrants around the vertical axis, shown in  
161 Figure 11 of AHAM HLW-1-2013. Place the first test cloth with an attached test strip  
162 in the left quadrant; the second test cloth with an attached test strip in the back  
163 quadrant; and so forth, placing each subsequent test cloth with an attached test strip  
164 in the next quadrant in the clockwise direction.
- 165 b) Front-loading clothes washer: Load 14 test cloths without test strips followed by 2 test  
166 cloths with attached test strips, ensuring an even distribution of test cloths without test  
167 strips. Repeat this sequence until the final test cloths with attached test strips are loaded;  
168 the last sequence may include fewer than 14 test cloths without test strips, or only one  
169 test cloth with an attached test strip. Load any remaining test cloths without test strips,  
170 including any energy stuffer cloths, on top.
- 171 i) To load test cloths without test strips, use alternating orientations according to the  
172 “towels” illustration in Figure 9 of AHAM HLW-1-2013.
- 173 ii) To load test cloths with attached test strips, follow the instructions provided in  
174 Sections 5.3.2.2 and 5.3.2.2.1 of AHAM HLW-1-2013. Test cloths with attached test  
175 strips must be placed into the UUT according to Figure 10 of AHAM HLW-1-2013. If  
176 an odd number of test strips are required, position the last test cloth with an attached  
177 test strip midway between the front and back of the wash drum.

178 **Note:** DOE has included loading instructions for the performance test load because no test strip loading  
179 instructions are available in Appendix J2. Where possible, DOE has referenced loading instructions from  
180 Appendix J2, which are generally applicable to loading DOE test cloth into clothes washers. Test cloths  
181 with attached test strips are to be loaded in accordance with AHAM HLW-1-2013.

182 As noted above, AHAM HLW-1-2013 specifies the use of 1 test strip for every 2 lb. of test load. Based on  
183 the fabric weight specifications for DOE energy test cloth in Section 2.7.4.3 of Appendix J2, 2 lb. of test  
184 load corresponds to approximately 8 energy test cloths. Therefore, each test strip is accompanied by 8  
185 energy test cloths.

186 DOE has proposed loading sequences for test loads that would ensure a) even loading of test cloths  
187 without test strips, b) even distribution of test cloths with attached test strips throughout the test load, and  
188 c) consistent and repeatable loading conditions. DOE is aware that the loading sequence can influence  
189 performance results and requests stakeholder comments on specific experience regarding the impacts of  
190 the loading sequence on the repeatability and reproducibility of cleaning performance results.

## 191 5. TEST METHOD

192 The hottest Warm Wash/Cold Rinse (“Warm/Cold”) temperature selection used for Section 3.5.1 of  
193 Appendix J2 shall be performed 3 times immediately after performing all test cycles required for Appendix  
194 J2, as follows:

- 195 A) Use the performance test load and detergent, as specified in Sections 3.B.1 and 4.C of this test  
196 method.
- 197 B) After completion of each wash cycle separate the test strips from the test cloth and dry them  
198 according to Sections 6.6.6 and 6.6.7 of AHAM HLW-1-2013.
- 199 1) Measure the post-wash reflectance of each soiled swatch on each test strip according to  
200 Section 6.6.8 of AHAM HLW-1-2013.

201 **Note:** DOE proposes testing only the Warm/Cold temperature selection for cleaning performance  
202 because this temperature selection has the highest consumer usage factor according to Table 4.1.1 in  
203 Appendix J2. DOE believes that this will provide an appropriate tradeoff between minimizing test burden  
204 and maintaining test conditions that are most representative of consumer usage.

DOE invites comment on whether the cleaning test results obtained from the Warm/Cold cycle would sufficiently distinguish performance among clothes washer models at different efficiency levels.

DOE also invites comment on whether requiring testing of only the Warm/Cold temperature selection represents an appropriate tradeoff between minimizing test burden while maintaining test conditions representative of consumer usage.

**Note:** DOE proposes testing cleaning performance using the maximum test load size. DOE recognizes that for clothes washers with automatic water fill control systems, the average test load size has the highest consumer usage factor according to Table 4.1.3 in Appendix J2. However, DOE believes that a number of other factors support using the maximum test load size, including the following:

1. For clothes washers with manual water fill control systems, the maximum load size has the highest consumer usage factor. By testing with the maximum load size for all clothes washers, the cleaning performance results will be comparable regardless of which type of water fill control system is used.

2. The maximum load size represents the most challenging cleaning burden that a clothes washer would experience under the test conditions of AHAM HLW-1-2013.

3. The maximum load size is based on the maximum capacity of the clothes container, which is used to calculate IMEF and IWF.

4. The maximum capacity of the clothes container is a key feature of a clothes washer that is advertised to the consumer.

DOE invites comment on the appropriateness of using the maximum load size for measuring cleaning performance.

## 6. CALCULATIONS AND SCORING

Calculation of results shall be as follows:

- A) Total Cleaning Score: Calculate a Total Cleaning Score for the UUT in accordance with Section 6.7 and Figure 14 of AHAM HLW-1-2013, using the post-wash reflectance values obtained in Section 5.B.1 of this test method.

## 7. REFERENCES

- A) AHAM HLW-1-2013. "Performance Evaluation Procedures for Household Clothes Washers"
- B) DOE Appendix J2 to Subpart B of 10 CFR 430, "Uniform Test Method for Measuring the Energy Consumption of Automatic and Semi-Automatic Clothes Washers"