ENERGY STAR® Program Requirements
Product Specification for
Clothes Washer Performance

Preliminary Approach for Determining
Clothes Washer Performance
June-2013

1 OVERVIEW

Note: This document is written and formatted as an ENERGY STAR Test Method; however, the U.S. Department of Energy (DOE) recognizes that this draft is the first opportunity stakeholders will have to formally comment. Therefore, this document does not contain the rigor that would be expected from a test method, and instead outlines a proposed approach. For simplicity, DOE will use the term “test method” throughout this document.

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

Note: This proposed test method will be used to produce cleaning and rinsing scores for use in the ENERGY STAR Clothes Washer Program.

DOE recognizes that it is desirable to measure clothes washer performance under test conditions that are similar to those encountered during the DOE energy efficiency test (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 test conditions include: (a) general criteria, such as water temperature and pressure, electrical supply voltage, and electrical supply frequency, and (b) wash- and rinse-specific parameters such as wash/rinse cycle selections and load size. However, because Appendix J2 has no procedures for measuring cleaning or rinsing performance, this proposed ENERGY STAR test method also utilizes certain procedures from the Association of Home Appliance Manufacturers (AHAM) test method HLW-1-2010, “Performance Evaluation Procedures for Household Clothes Washers” (referred to here as “AHAM HLW-1-2010”). Specifically, the proposed test method incorporates AHAM HLW-1-2010’s Soil/Stain Removal and Rinsing Effectiveness Tests.

The general criteria specified in AHAM HLW-1-2010 are functionally equivalent to those in Appendix J2, but AHAM HLW-1-2010 does not specify the wash and rinse settings to be used for performance testing. As such, the proposed test method specifies using wash and rinse settings consistent with those that would be tested with Appendix J2.

Rinsing Performance

AHAM HLW-1-2010 includes, as Annex E, a Rinsing Effectiveness Test that is intended by AHAM to be used solely for internal engineering development purposes. Furthermore, the introductory note accompanying Annex E states that it shall not be used to prove or disprove rinsing effectiveness claims for marketing and/or other purposes.

DOE understands that the precision and bias of the AHAM Rinsing Effectiveness Test as published in AHAM HLW-1-2010 is still under investigation, and that AHAM is currently developing a revised version of the Rinsing Effectiveness Test. (DOE will consider incorporating a more recent version of the Rinsing Effectiveness Test if one is published.) DOE recognizes these potential limitations, but believes that the methodology in Annex E of AHAM HLW-1-2010 represents the best available means to measure clothes washer rinsing performance at this time.

Therefore, DOE proposes to incorporate provisions of the AHAM Rinsing Effectiveness Test into the ENERGY STAR test method, with minor modifications to ensure testing conditions that correspond, to the extent possible, to those in Appendix J2. DOE invites comment on the appropriateness of adopting a
rinsing performance test method that is based on the AHAM Rinsing Effectiveness Test in AHAM HLW-1-2010.

DOE notes that the rinsing value determined in HLW-1-2010, “Rinse Score,” is a measure of residual detergent present in washed articles after the rinsing cycle is completed. As such, a lower value of Rinse Score represents better clothes washer performance; this contrasts with the HLW-1-2010 Cleaning Score, in which a higher score represents better performance. DOE believes that the terminology “Rinse Score” can thus be confusing, especially for consumers. DOE is therefore proposing a rinsing performance metric with the more precise name of “Residual Detergent Score.” DOE invites comment on this proposal.

Structure of the Proposed Test Method

Figure 1 below illustrates how the test conditions from Appendix J2 and procedures from AHAM HLW-1-2010 are used as inputs to the proposed test method. The diagram also shows how the resulting performance test scores (cleaning, rinsing) relate to the existing Integrated Modified Energy Factor (IMEF) and Integrated Water Factor (IWF).

The proposed test method is to be performed separately from the Appendix J2 energy efficiency tests. Several issues regarding the integration of AHAM HLW-1-2010 and Appendix J2 into the performance test method are discussed in more detail in the accompanying analysis document. DOE seeks stakeholder feedback on these issues, as well as other issues put forward in noteboxes throughout this document.

Figure 1. Test Conditions and Procedures Used as Inputs to the Proposed Test Method

2 APPLICABILITY
The proposed test method shall be used to determine the cleaning and rinsing performance of all 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 6.1;
2. Association of Home Appliance Manufacturers (AHAM) test method HLW-1-2010, Performance Evaluation Procedures for Household Clothes Washers.” (“AHAM HLW-1-2010”); and

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) ANSI: American National Standards Institute
3) CFR: Code of Federal Regulations
4) DOE: U.S. Department of Energy
5) UUT: Unit under test
6) UV: Ultraviolet

B) Definitions:
1) Load Treatment Clothes Washer: A dedicated clothes washer used solely for the purpose of pretreatment and normalization of base loads.
2) Total Cleaning Score: A measure of soil/stain removal that represents an average of individual cleaning scores from 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.
3) Residual Detergent Score: A measure of rinsing performance that represents the amount of residual detergent remaining in the load after a complete wash cycle, per pound of load. Equal to the Rinse Score calculated with equation 8-8 of Annex E of AHAM HLW-1-2010. A lower Residual Detergent Score represents greater detergent removal during rinsing.

4 TEST SETUP

4.1 Laboratory Test Conditions

A) Electrical Supply: Maintain the electrical energy supply as specified in Section 2.2 of Appendix J2.
B) Supply Water Temperatures: Maintain the supply water temperatures as specified in Section 2.3 of Appendix J2.
C) Supply Water Pressure: Maintain the supply water pressure as specified in Section 2.4 of Appendix J2.
D) Supply Water Hardness: Maintain the supply water hardness as specified in Section 4.5.3 of AHAM HLW-1-2010.

Note: HLW-1-2010 specifies a water hardness limit of 50 parts per million (ppm) or less. Appendix J2 provides no water hardness specifications for the energy cycle tests themselves; only procedures for pre-conditioning DOE energy test cloth (Sections 2.6.3.1) and the Standard Extractor Remaining Moisture Content (RMC) correction curve procedure (Sections 2.6.5.3.3 and 2.6.5.4) contain a water hardness specification (17 ppm or less).

Standard Extractor RMC Tests are not performed as part of energy testing for clothes washers under Appendix J2; rather, the test cloth supplier or another qualified test laboratory performs the Standard Extractor RMC Test once for each new lot of test cloth to qualify the lot.

E) Ambient Temperature: Maintain the ambient air temperature as specified in Section 2.11 of Appendix J2.

4.2 Required Instrumentation

A) Weighing Equipment: Weighing equipment shall be in accordance with the specifications in Section 6.2 of AHAM HLW-1-2010.

Note: AHAM HLW-1-2010 requires that base load weighing equipment be accurate to within ± 0.1%, while Appendix J2 requires it to be accurate to within ± 0.3%. AHAM HLW-1-2010 additionally requires a separate weighing scale for detergent. DOE believes specifying a greater accuracy for the load-weighing equipment may produce more accurate and repeatable results for washing and rinsing performance testing, and invites stakeholder comment on the benefits and test burden of requiring such equipment.

B) Tristimulus Spectrocolorimeter: Equipment for measuring light reflectance from test strips shall be in accordance with the specifications in Annex A, Section A.10 of AHAM HLW-1-2010.

C) Water Temperature: Equipment for measuring the water supply temperatures shall be in accordance with the specifications in Section 2.5.4 of Appendix J2.

D) Water Pressure: Equipment for measuring the water supply pressures shall be in accordance with the specifications in Section 2.5.6 of Appendix J2.

E) Water Hardness: Equipment for confirming that the water hardness is within that specified in Section 4.5.3 of AHAM HLW-1-2010.

F) Electrical Supply Voltage: Equipment for confirming that the electrical supply voltage is within that specified in Section 2.2 of Appendix J2.

G) UV Spectrometer (for Rinsing Performance): Equipment for measuring the ultraviolet (UV) absorbance of test strips shall be in accordance with the specifications in AHAM HLW-1-2010, Annex E, Section 2.

4.3 Other Required Test Equipment

A) Load Treatment Clothes Washer: A vertical-axis clothes washer that shall be in accordance with Annex E, Section 5.2.1 of AHAM HLW-1-2010.

B) Fabric Drying Equipment: A clothes dryer capable of bone-drying the base loads, that shall be in accordance with Section 3.2 of AHAM HLW-1-2010.

C) Fastening Equipment: Sewing machine or stapling equipment for attaching test strips to load items. Metallic fasteners of any type are not permitted.

D) Rinsing Performance Test Equipment: Equipment as specified in AHAM HLW-1-2010, Annex E, Section 2.

Note: Section 4.3.D references the list of equipment found in the AHAM Rinsing Effectiveness Test. DOE does not suggest any changes to the equipment listed in Annex E, Section 2, and therefore is wholly incorporating that list.
4.4 Test Materials

A) Base Load Composition: [Option A or Option B]

**Note:** Option A corresponds to the base load materials specified in AHAM HLW-1-2010. These consist of 100% cotton bed sheets, pillow cases, and towels. If AHAM base load materials are specified in this test method, the base load composition would be specified by Section 4.2 of AHAM HLW-1-2010.

Option B corresponds to the load materials specified in Appendix J2. These consist of 50% cotton / 50% polyester fabric test cloths. If DOE energy test cloths are used, the base load composition would be specified by Section 2.6.1 of Appendix J2.

The accompanying discussion document discusses the advantages and disadvantages of each test substrate for measuring soil/stain removal and rinsing performance. DOE invites comments from stakeholders regarding whether this Test Method should require using HLW-1-2010 base load materials or Appendix J2 test cloth for the base load composition. In addition to general comments, DOE specifically requests information and comments regarding the following:

1. The appropriate amount of detergent to use if DOE test cloths are required (note that International Electrotechnical Commission (IEC) 60456 requires different amounts of detergent for 100% cotton and for synthetic blends).
2. Whether and what weighted-average age requirements should be applied to base loads consisting of DOE test cloths.
3. The impact of test substrate choice on performance test results for soil/stain removal and rinsing effectiveness, including effects of fabric type and size and shape of base load articles.
4. Whether the presence of synthetic material in the base load would necessitate differences in test methodology, as is the case in IEC 60456 (e.g., for average base load article age).
5. Energy test cloth supply issues if the test substrate is DOE energy test cloths.
6. Relative differences in testing cost and burden between using AHAM base load material or DOE energy test cloth.
7. Key attributes of folding, loading, and test strip attachment that would govern the development of new folding, loading, and test strip attachment procedures applicable to DOE energy test cloths.
8. Any factors that would preclude eliminating Mechanical Action test swatches from the base load.

Based on its evaluation of stakeholder comments and input, DOE will select Option A or Option B as the base load composition in the Draft 1 Test Method.

B) Stuffer Load Composition: [Option A or Option B]

**Note:** Option A corresponds to the stuffer load materials specified in AHAM HLW-1-2010. These consist of hemmed 100% cotton fabric rectangles. If AHAM base load materials are specified in Section 4.4.A of this test method, the stuffer load composition would be specified by Section 4.3 of AHAM HLW-1-2010.

Option B corresponds to the stuffer load materials specified in Appendix J2. These consist of 50% cotton / 50% polyester fabric test cloths. If DOE energy test cloths are specified in Section 4.4.A of this test method, the stuffer load composition would be specified by Section 2.6.2 of Appendix J2.

Based on its evaluation of stakeholder comments and input, DOE will select Option A or Option B as the stuffer load composition in the Draft 1 Test Method. The proposed option will also be consistent with the selection for the base load composition.

C) Soil/Stain Test Strips: Test strips shall be in accordance with Annex A, Sections A.6 and A.7 of AHAM HLW-1-2010.

D) Detergent: Detergent formulation, concentration, and storage specifications shall be in accordance with Section 4.7 of AHAM HLW-1-2010.
E) **Rinsing Performance Test Materials:** Materials as specified in AHAM HLW-1-2010, Annex E, Section 3.

**Note:** Section 4.4.E references the list of materials found in the AHAM Rinsing Effectiveness Test. DOE does not suggest any changes to the materials listed in Annex E, Section 3, and therefore is wholly incorporating that list.

### 4.5 Pre-test Preparation

A) **Test Machine Capacity Measurement:** Determine the clothes container capacity of the UUT according to Section 3.1 of Appendix J2.

B) **Test Machine Installation:** Install the clothes washer in accordance with manufacturer’s instructions.

C) **Pretreatment of Textile Items for Base Loads:** Before their first use, items to be used for base loads shall be pretreated in accordance with Section 4.4.1 of AHAM HLW-1-2010 in the load treatment clothes washer specified in Section 4.3.A of this test method.

D) **Base Load Size:** The base load size shall be the “average” load size for adaptive-fill clothes washers, and the “maximum” load size for manual-fill clothes washers. “Average” and “maximum” load sizes shall be determined in pounds (lb), based on the measured clothes container capacity of the UUT, according to Table 5.1 of Appendix J2. All base load sizes referred to in this test method are “bone dry” weights.

**Note:** These load sizes represent the load sizes with the highest consumer usage factors in Appendix J2 (Table 4.1.3). According to Appendix J2, for adaptive-fill clothes washers, the average load size is selected for 74% of all wash loads. For manual-fill clothes washers, the maximum load size is selected for 72% of all wash loads.

If AHAM base load materials are used in this test method, the following will be added to Section 4.5.C above: “The load sizes specified by Table 5.1 in Appendix J2 shall be rounded to the nearest pound for the purposes of determining the base load composition according to AHAM HLW-1-2010.”

DOE invites comment on the appropriateness of using the “average” or “maximum” load sizes for measuring cleaning and rinsing performance.

E) **Base Load Preparation: Option A or Option B**

**Note:** **Option A (shown below in paragraph 1):** If the AHAM base load is used, base load determination requirements would be in accordance with Section 6.5 of AHAM HLW-1-2010.

**Option B:** If DOE energy test cloth is used for the base load, new base load determination requirements would be developed for this test method.

1) **Base Load Determination:** Determine the size and composition of the base load as specified in Sections 4.5.D, 4.4.A, and 4.4.B above. Select base load items in accordance with Sections 6.5.2 and 6.5.3 of AHAM HLW-1-2010.

2) **Base Load Normalization:** Normalize the base load in the load treatment clothes washer, specified in Section 4.3.A of this test method, in accordance with Section 4.4.2 of AHAM HLW-1-2010.

**Note:** To remove detergent residue, AHAM HLW-1-2010 specifies that before first use in any series of tests, and subsequently after every three cycles, the base load shall be normalized. Normalization consists of performing two hot/cold (wash/rinse) cycles without detergent and bone-drying the items after each cycle.

Appendix J2 does not contain a normalization procedure because all Appendix J2 test cycles are performed without detergent.

F) **Test Strip Attachment:**
1) **Calibration**: Calibration data for each lot of soil/stain test strips shall be provided by the supplier, as specified in Section 6.4 of AHAM HLW-1-2010.

**Note**: Section 6.7 of AHAM HLW-1-2010 states that the cleaning scoring system allows for the optional use of the laboratory’s own calibration data for the soil/stain strips, using a reference clothes washer and the wash treatments defined in Annex A, Section A.7.1, Treatment a).

DOE invites stakeholder input on the following: (1) whether using the supplier’s calibration data for each lot of soil/stain test strips would be appropriate for this test method, or whether the test method should require that each laboratory measure its own calibration data for each lot of soil/stain strips; (2) whether there is any data that compares supplier calibration with other lab calibrations; and (3) whether allowing in-house calibration might provide opportunities to circumvent the test method.

DOE further invites stakeholder comment on the additional burden and reproducibility associated with the calibration test.

2) **Marking the Test Strips**: Record the manufacturer-supplied calibration data for the soil/stain strips and mark each soil/stain strip with a unique identifying reference in accordance with Sections 6.5.5 and 6.6.6 of AHAM HLW-1-2010.

3) **Fastening the Test Strips**: Fasten the test strips to the base load materials in accordance with Section 6.5.7 of AHAM HLW-1-2010.

G) **Detergent Preparation**: Weigh out the specified quantity of standard test detergent in accordance with Sections 4.7 and 6.5.8 of AHAM HLW-1-2010.

5 **TEST METHOD**

5.1 **Test Cycles**

This test method shall be separately performed on the cold wash/cold rinse and the warm wash/cold rinse cycles of the DOE energy test cycle, as defined in Section 1.13 of Appendix J2.

For a clothes washer offering multiple warm wash cycles, as defined in Section 1.34 of Appendix J2, this test method shall be performed on the warm wash/cold rinse cycle that uses the least amount of hot water during the energy test cycle when tested according to Appendix J2.

**Note**: Appendix J2 requires testing additional temperature combinations, if available on the UUT, beyond the cold wash/cold rinse and warm wash/cold rinse cycles proposed for this test method. DOE believes that including only cold wash/cold rinse and warm wash/cold rinse cycles for performance testing represents an appropriate tradeoff between minimizing test burden and the desire to maintain test conditions that are as representative as possible to those in Appendix J2.

The accompanying analysis document discusses the advantages and disadvantages of including additional available wash/rinse temperature cycles on the UUT in this test method. DOE invites stakeholder comment on whether including only the cold wash/cold rinse and warm wash/cold rinse cycles in this test method represents an appropriate tradeoff between minimizing test burden and maintaining test conditions that are representative of those in Appendix J2.

5.2 **Replications**

Perform three replications of the test required for each wash and rinse temperature combination. Use the same base load for each replication.

**Note**: Section 6.5.1 of AHAM HLW-1-2010 states that a minimum of three replications of any given cycle are to be run using the same load. DOE invites stakeholder comment on whether performing only three replications of each test cycle would provide repeatable and reproducible test results.
5.3 Measuring Washing Performance

A) Perform the Soil/Stain Removal Test procedure in accordance with Section 6.6 of AHAM HLW-1-2010 with the following parameters:

1) Clothes Washer Control Setting:

   a) Test Cycle: Perform the cycles specified in Section 5.1 of this test method. For each cycle selection, the manufacturer default settings shall be used, except for the temperature selection, if necessary. Settings include agitation/tumble level, soil level, spin speed(s), wash times, rinse times, and all other wash parameters or optional features applicable to that cycle.

   b) Water Fill Level: For manual-fill machines, select the maximum water fill setting. For adaptive-fill machines, the fill level shall be determined automatically by the clothes washer.

2) Conditioning Cycle: When conditioning the UUT, perform Section 4.8 of ANSI/AHAM HLW-1-2007 instead of Section 4.8 of AHAM HLW-1-2010.

Note: AHAM HLW-1-2010 defines “Conditioning Cycle” in Section 3.3 as “The cycle used to prepare a washer for test.” Although labeled “Conditioning Cycle,” Section 4.8 of AHAM HLW-1-2010 contains requirements for normalization of the base load rather than conditioning of the UUT.

However, Section 4.8 of ANSI/AHAM HLW-1-2007 does specify conditioning of the UUT as:

“Immediately prior to the start of the first run of a test, the test clothes washer is to be operated through one cycle, using the same control settings as for the actual test but with no clothes load or detergent and using the water specified in 4.5, in order to assure consistent initial conditions. A conditioning cycle shall also be run if significant time has elapsed between runs, e.g. before the first run of the day.”

DOE believes that Section 4.8 in ANSI/AHAM HLW-1-2007 is the appropriate method of performing the UUT conditioning cycle for this test method because it specifies clothes washer conditioning rather than base load normalization.

3) Folding and Loading of Test Load (AHAM HLW-1-2010, Section 6.6.5): Option A or Option B

Note: Option A: If AHAM base load materials are used, test load folding and loading shall be performed in accordance with Section 6.6.5 of AHAM HLW-1-2010.

Option B: If DOE test cloth materials are used, new test load folding and loading requirements would need to be developed because the AHAM HLW-1-2010 folding and loading requirements are not applicable to DOE energy test cloths, and because Appendix J2 does not provide folding and loading procedures that would be adequate for the purpose of conducting cleaning performance and rinsing performance tests; Section 5.1 of AHAM HLW-1-2010 states:

“Experience has shown that the way that a washing machine is loaded can influence the results obtained, especially with respect to washing performance. To achieve reproducible results it is therefore necessary to specify both the loading sequence and the position and placement of all load items in the test washing machine … for all performance tests.”

Included in the AHAM HLW-1-2010 folding and loading procedures are specific instructions for attaching, folding, locating, and orienting soil/stain test strips and the articles to which they are attached. Because the DOE energy test does not use test strips, Appendix J2 has no procedures regarding test strips.

Appendix J2 does not specify the position or placement of energy test cloths into the UUT. Section 2.8.3 of Appendix J2 states:

“Load the energy test cloths by grasping them in the center, shaking them to hang loosely and then put them into the clothes container prior to activating the clothes washer.”

If DOE test cloth materials are used in this test method, DOE would conduct extensive testing to develop folding and loading requirements that would produce repeatable and reproducible test results.
5.4 Measuring Rinsing Performance

A) Perform the Rinsing Effectiveness Test in accordance with Annex E of AHAM HLW-1-2010, using the white (unstained) test swatch of each of the stain strips.

B) Calculate the Residual Detergent Score and Standard Deviation of the Residual Detergent Score for each test cycle, using equations 8-8 and 8-9, respectively, in Section 8.2 of AHAM HLW-1-2010, Annex E.

Note: As noted above, the Residual Detergent Score is calculated using the “Rinse Score” formula in Annex E of AHAM HLW-1-2010. The Standard Deviation of the Residual Detergent Score is calculated using the “Standard Deviation of the Rinse Score” formula in Annex E of AHAM HLW-1-2010. Section 5.2.2 of the AHAM Rinsing Effectiveness Test (Annex E of AHAM HLW-1-2010) states that the stain strips shall be labeled along the edge of the sebum stain, and explicitly states not to add markings to the unstained swatch. In contrast, for measuring cleaning performance, Section 6.5.6 in the Soil/Stain Removal Test of AHAM HLW-1-2010 states that each soil/stain strip shall be marked in a corner of the unstained control swatch, so as not to affect the measurements obtained from the stained swatches.

DOE requests information from stakeholders regarding the methods they have used to perform both the Soil/Stain Removal and Rinsing Effectiveness Tests in a single test cycle, using the same set of soil/stain strips, rather than in two separate test cycles with two different sets of soil/stain strips.

6 SCORING

6.1 Total Cold Wash Cycle Cleaning Score

Calculate a Total Cleaning Score for the cold wash/cold rinse cycle in accordance with Section 5.3.B of this test method.

6.2 Total Warm Wash Cycle Cleaning Score

Calculate a Total Cleaning Score for the warm wash/cold rinse cycle in accordance with Section 5.3.B of this test method.

6.3 Cold Wash Cycle Residual Detergent Score

Calculate a Residual Detergent Score for the cold wash/cold rinse cycle in accordance with Section 5.4 of this test method.

6.4 Warm Wash Cycle Residual Detergent Score

Calculate a Residual Detergent Score for the warm wash/cold rinse cycle in accordance with Section 5.4 of this test method.

Note: DOE invites stakeholder comments on whether the metrics in Section 6.1 through 6.4 are appropriate for determining cleaning and rinsing performance within the ENERGY STAR clothes washer program.

7 REFERENCES

A) AHAM HLW-1-2010. "Performance Evaluation Procedures for Household Clothes Washers"