determine that they do not apply to a particular model. Depending upon a manufacturer's approach for conducting field testing, additional data may be required. Manufacturers are encouraged to communicate with the Department prior to the commencement of field tests which may be used to support a petition for waiver. Section 6.3 provides an example of for waiver when it is believed with an adaptive water fill control system. Other features, such as the use of various spin speed selections, could be the subject of field tests.

6.2 Nonconventional Wash System Energy Consumption Test. The field test may consist of a minimum of 10 of the nonconventional clothes washers ("test clothes washers") and 10 clothes washers already being distributed in commerce ("base clothes washers"). The tests should include a minimum of 50 energy test cycles per clothes washer. The test clothes washers and base clothes washers should be identical in construction except for the controls or systems being tested. Equal numbers of both the test clothes washer and the base clothes washer should be tested simultaneously in comparable settings to minimize seasonal or consumer laundering conditions or variations. The clothes washers should be monitored in such a way as to accurately record the average total energy and water consumption per cycle, including water heating energy when electrically heated water is used, and the energy required to remove the remaining moisture of the test load. The field test results should be used to determine the best method to correlate the rating of the test clothes washer to the rating of the base clothes washer.

6.3 Adaptive water fill control system field test. Section 3.2.3.1 defines the test method for measuring energy consumption for clothes washers which incorporate control systems having both adaptive and alternate cycle selections. Energy consumption calculated by the method defined in section 3.2.3.1 assumes the adaptive cycle will be used 50 percent of the time. This section can be used to develop field test data in support of a petition for waiver when it is believed that the adaptive cycle will be used more than 50 percent of the time. The field test sample size should be a minimum of 10 test clothes washers. The test clothes washers should be totally representative of the design, construction, and control system that will be placed in commerce. The duration of field testing in the user's house should be a minimum of 50 energy test cycles, for each unit. No special instructions as to cycle selection or product usage should be given to the field test participants, other than inclusion of the product literature pack which would be shipped with all units, and instructions regarding filling out data collection forms, use of data collection equipment, or basic procedural methods. Prior to the test clothes washers being installed in the field test locations, baseline data should be developed for all field test units by conducting laboratory tests as defined by section 1 through section 5 of these test procedures to determine the energy consumption, water consumption, and remaining moisture content values. The following data should be measured and recorded for each wash load during the test period: wash cycle selected, the mode of the clothes washer (adaptive or manual), clothes load dry weight (measured after the clothes washer and clothes dryer cycles are completed) in pounds, and type of articles in the clothes load (e.g., cottons, linens, permanent press). The wash loads used in calculating the in-home percentage split between adaptive and manual cycle usage should be only those wash loads which conform to the definition of the energy test cycle.

Calculate:

\[ T = \frac{\text{The total number of energy test cycles run during the field test}}{\text{The total number of adaptive control energy test cycles}} \times 100 \]  

\[ T_m = \frac{\text{The total number of manual control energy test cycles}}{\text{The percentage weighting factors:}} \]

\[ P_a = \frac{T_a}{T} \times 100 \]  

\[ P_m = \frac{T_m}{T} \times 100 \]

Energy consumption (HE, ME, and DE) and water consumption (QW) values calculated in section 4 for the manual and adaptive modes, should be combined using Pₐ and Pₘ as the weighting factors.

APPENDIX J2 TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF AUTOMATIC AND SEMI-AUTOMATIC CLOTHES WASHERS

Manufacturers may use Appendix J2 to certify compliance with existing DOE energy conservation standards until the compliance date of any amended standards that address standby and off mode power consumption for residential clothes washers. After this date, all residential clothes washers shall be tested using the provisions of Appendix J2.

1. DEFINITIONS AND SYMBOLS

1.1 Active mode means a mode in which the clothes washer is connected to a mains
power source, has been activated, and is performing one or more of the main functions of washing, soaking, tumbling, agitating, rinsing, and/or removing water from the clothing, or is involved in functions necessary for these main functions, such as admitting water into the washer or pumping water out of the washer. Active mode also includes delay start and cycle finished modes.

1.2 Active washing mode means a mode in which the clothes washer is performing any of the operations included in a complete cycle intended for washing a clothing load, including the main functions of washing, soaking, tumbling, agitating, rinsing, and/or removing water from the clothing.

1.3 Adaptive control system means a clothes washer control system, other than an adaptive water fill control system, which is capable of automatically adjusting washer operation or washing conditions based on characteristics of the clothes load placed in the clothes container, without allowing or requiring consumer intervention or actions. The automatic adjustments may, for example, include automatic selection, modification, or control of any of the following: Water, water temperature, agitation or tumble cycle time, number of rinse cycles, and spin speed. The characteristics of the clothes load, which could trigger such adjustments, could, for example, consist of or be indicated by the presence of either soil, soap, suds, or any other additive laundering substitute or complementary product.

NOTE: Appendix J2 does not provide a means for determining the energy consumption of a clothes washer with an adaptive control system. A waiver must be obtained pursuant to 10 CFR 430.27 to establish an acceptable test procedure for each such clothes washer.

1.4 Adaptive water fill control system means a clothes washer water fill control system which is capable of automatically adjusting the water fill level based on the size or weight of the clothes load placed in the clothes container, without allowing or requiring consumer intervention or actions.

1.5 Bone-dry means a condition of a load of test cloth which has been dried in a dryer at maximum temperature for a minimum of 10 minutes, removed and weighed before cool down, and then dried again for 10 minute periods until the final weight change of the load is 1 percent or less.

1.6 Clothes container means the compartment within the clothes washer that holds the clothes during the operation of the machine.

1.7 Cold rinse means the coldest rinse temperature available on the machine.

1.8 Combined low-power mode means the aggregate of available modes other than active washing mode, including inactive mode, off mode, delay start mode, and cycle finished mode.

1.9 Compact means a clothes washer which has a clothes container capacity of less than 1.6 ft³ (45 L).

1.10 Cycle finished mode means an active mode which provides continuous status display, intermittent tumbling, or air circulation following operation in active washing mode.

1.11 Deep rinse cycle means a rinse cycle in which the clothes container is filled with water to a selected level and the clothes load is rinsed by agitating it or tumbling it through the water.

1.12 Delay start mode means an active mode in which activation of active washing mode is facilitated by a timer.

1.13 Energy test cycle for a basic model means:

(A) The cycle selection recommended by the manufacturer for washing cotton or linen clothes, and includes all wash/rinse temperature selections for each of the temperature use factors (TUFs) offered in that cycle, and

(B) If the cycle selection described in Part (A) does not include all wash/rinse temperature selections for each of the TUFs available on the clothes washer, the energy test cycle shall include, in addition to Part (A), the alternate cycle selection(s) offering these remaining wash/rinse temperature selection(s), tested only at the wash/rinse temperature selection(s) for each TUF not available on the cycle selection described in Part (A).

Where multiple alternate cycle selections offer a wash/rinse temperature selection for which a TUF has been developed, and that is not available on the cycle selection recommended by the manufacturer for washing cotton or linen clothes described in Part (A), the alternate cycle selection certified by the manufacturer to have the highest energy consumption for that TUF, as measured according to section 2.13, shall be included in the energy test cycle, so that each TUF that is available on the clothes washer has been tested once.

(C) All cycle selections included under Part (A) and all cycle selections included under Part (B) shall be tested using each appropriate load size as defined in section 2.8 and Table 5.1 of this appendix.

(D) For any cycle selection tested under (A) or (B), the manufacturer default settings shall be used, except for the temperature selection, if necessary. This includes wash conditions such as agitation-tumble operation, soil level, spin speed(s), wash times, rinse times, and all other wash parameters or optional features applicable to that cycle, including water heating time for water heating clothes washers.
(E) Each wash cycle included as part of the energy test cycle shall include the entire active washing mode and exclude any delay start or cycle finished modes.

(F) The energy test cycle shall not include any cycle, if available, that is dedicated for cleaning, deodorizing, or sanitizing the clothes washer, and is separate from clothes washing cycles.


1.15 Inactive mode means a standby mode that facilitates the activation of active mode by remote switch (including remote control), internal sensor, or timer, or that provides continuous status display.

1.16 Integrated modified energy factor means the quotient of the cubic foot (or liter) capacity of the clothes container divided by the total clothes washer energy consumption per cycle, with such energy consumption expressed as the sum of:

(a) The machine electrical energy consumption;
(b) The hot water energy consumption;
(c) The energy required for removal of the remaining moisture in the wash load; and
(d) The combined low-power mode energy consumption.

1.17 Integrated water factor means the quotient of the total weighted per-cycle water consumption for all wash cycles in gallons divided by the cubic foot (or liter) capacity of the clothes washer.

1.18 Load usage factor means the percentage of the total number of wash loads that a user would wash a particular size (weight) load.

1.19 Lot means a quantity of cloth that has been manufactured with the same batches of cotton and polyester during one continuous process.

1.20 Manual control system means a clothes washer control system which requires that the consumer make the choices that determine washer operation or washing conditions, such as, for example, wash/rinse temperature selections and wash time, before starting the cycle.

1.21 Manual water fill control system means a clothes washer water fill control system which requires the consumer to determine or select the water fill level.

1.22 Modified energy factor means the quotient of the cubic foot (or liter) capacity of the clothes container divided by the total clothes washer energy consumption per cycle, with such energy consumption expressed as the sum of the machine electrical energy consumption, the hot water energy consumption, and the energy required for removal of the remaining moisture in the wash load.

1.23 Non-water-heating clothes washer means a clothes washer which does not have an internal water heating device to generate hot water.

1.24 Off mode means a mode in which the clothes washer is connected to a mains power source and is not providing any active or standby mode function, and where the mode may persist for an indefinite time. An indicator that only shows the user that the product is in the off position is included within the classification of an off mode.

1.25 Roll means a subset of a lot.

1.26 Spray rinse cycle means a rinse cycle in which water is sprayed onto the clothes for a period of time without maintaining any specific water level in the clothes container.

1.27 Standard means a clothes washer which has a clothes container capacity of 1.6 ft³ (45 L) or greater.

1.28 Standby mode means any mode in which the clothes washer is connected to a mains power source and offers one or more of the following user oriented or protective functions that may persist for an indefinite time:

(a) To facilitate the activation of other modes (including activation or deactivation of active mode) by remote switch (including remote control), internal sensor, or timer;
(b) Continuous functions, including information or status displays (including clocks) or sensor-based functions.

A timer is a continuous clock function (which may or may not be associated with a display) that provides regular scheduled tasks (e.g., switching) and that operates on a continuous basis.

1.29 Symbol usage. The following identity relationships are provided to help clarify the symbology used throughout this procedure.

C—Capacity
C (with subscripts)—Cold Water Consumption
D—Energy Consumption for Removal of Moisture from Test Load
E—Electrical Energy Consumption
F—Load Usage Factor
H—Hot Water Consumption
HE—Hot Water Energy Consumption
ME—Machine Electrical Energy Consumption
P—Power
Q—Water Consumption
RMC—Remaining Moisture Content
S—Annual Hours
TUF—Temperature-Weighted Hot Water Consumption
W—Mass of Water
WC—Weight of Test Load After Extraction
WI—Initial Weight of Dry Test Load

Subscripts:
a or avg—Average Test Load
B—Part B of the Energy Test Cycle
c—Cold Wash (minimum wash temp.)
only one warm wash temperature selection, ° temperature) water temperatures within the mean of the warm selections is less than connecting the warmest and the coldest the point where that temperature is depicted on the temperature/selection line formed by the temperature at any warm wash selection and the difference between the actual water temperature and the warm wash selections for which the warm wash water temperature has a linear relationship as specified above is that the difference immediately before and after the test measurement period, it is acceptable to measure and record the total harmonic content immediately before and after the test measurement period.

2.3 Supply Water

2.3.1 Clothes washers in which electrical energy consumption or water energy consumption are affected by the inlet water temperature. (For example, water heating clothes washers or clothes washers with thermostatically controlled water valves.): The temperature of the hot water supply at the water inlets shall not exceed 135 °F (57.2 °C) and the cold water supply at the water inlets shall not exceed 60 °F (15.6 °C). A water meter shall be installed in both the hot and cold water lines to measure water consumption.
2.3.2 Clothes washers in which electrical energy consumption and water energy consumption are not affected by the inlet water temperature. The temperature of the hot water supply shall be maintained at \(135 \pm 5^\circ F \) (57.2 \(^\circ C \pm 2.8 \(^\circ C\)) and the cold water supply shall be maintained at \(60 \pm 5^\circ F \) (15.6 \(^\circ C \pm 2.8 \(^\circ C\)). A water meter shall be installed in both the hot and cold water lines to measure water consumption.

2.4 Water pressure. The static water pressure at the hot and cold water inlet connection of the clothes washer shall be maintained at 35 pounds per square inch gauge (psig) \(\pm 2.5 \text{ psig} \) (241.3 kPa \(\pm 17.2 \text{ kPa}\)) when the water is flowing. The static water pressure for a single water inlet connection shall be maintained at 35 psig \(\pm 2.5 \text{ psig} \) (241.3 kPa \(\pm 17.2 \text{ kPa}\)) when the water is flowing. A water pressure gauge shall be installed in both the hot and cold water lines to measure water pressure.

2.5 Instrumentation. Perform all test measurements using the following instruments, as appropriate:

- **Weighing scales.**

  - **Weighing scale for test cloth.** The scale shall have a resolution of no larger than 0.2 oz (5.7 g) and a maximum error no greater than 0.3 percent of the measured value.

  - **Weighing scale for clothes container capacity measurement.** The scale should have a resolution no larger than 0.50 lbs (0.23 kg) and a maximum error no greater than 0.5 percent of the measured value.

- **Watt-hour meter.** The watt-hour meter shall have a resolution no larger than 1 Wh (3.6 kJ) and a maximum error no greater than 2 percent of the measured value for any demand greater than 50 Wh (180.0 kJ).

- **Watt meter.** The watt meter used to measure combined low-power mode power consumption shall comply with the requirements specified in Section 4, Paragraph 4.4 of IEC 62301. If the power measuring instrument used for testing is unable to measure and record the crest factor, power factor, or maximum current ratio during the test measurement period, it is acceptable to measure and record the crest factor, power factor, and maximum current ratio immediately before and after the test measurement period.

- **Temperature measuring device.** The device shall have an error no greater than \(\pm 1^\circ F \) (\(\pm 0.6^\circ C\)) over the range being measured.

- **Water meter.** The water meter shall have a resolution no larger than 0.1 gallons (0.41 liters) and a maximum error no greater than 2 percent for the water flow rates being measured.

- **Water pressure gauge.** The water pressure gauge shall have a resolution of 1 pound per square inch gauge (psig) (6.9 kPa) and shall have an error no greater than 5 percent of any measured value.

2.6 Test cloths.

2.6.1 Energy Test Cloth. The energy test cloth shall be made from energy test cloth material, as specified in section 2.6.4 of this Appendix, that is 24 \(\pm \frac{1}{2}\) inches by 36 \(\frac{1}{2}\) inches (61.0 \(\pm 1.3\) cm by 91.4 \(\pm 1.3\) cm) and has been hemmed to 22 \(\pm \frac{1}{2}\) inches by 34 \(\pm \frac{1}{2}\) inches (55.9 \(\pm 1.3\) cm by 86.4 \(\pm 1.3\) cm) before washing. The energy test cloth shall be clean and shall not be used for more than 60 test runs (after preconditioning as specified in 2.6.3 of this appendix). All energy test cloth must be permanently marked identifying the lot number of the material. Mixed lots of material shall not be used for testing a clothes washer.

2.6.2 Energy Stuffer Cloth. The energy stuffer cloth shall be made from energy test cloth material, as specified in section 2.6.4 of this Appendix, and shall consist of pieces of material that are 12 \(\pm \frac{1}{4}\) inches by 12 \(\pm \frac{1}{4}\) inches (30.5 \(\pm 0.6\) cm by 30.5 \(\pm 0.6\) cm) and have been hemmed to 10 \(\pm \frac{1}{4}\) inches by 10 \(\pm \frac{1}{4}\) inches (25.4 \(\pm 0.6\) cm by 25.4 \(\pm 0.6\) cm) before washing. The energy stuffer cloth shall be clean and shall not be used for more than 60 test runs (after preconditioning as specified in section 2.6.3 of this Appendix). All energy stuffer cloth must be permanently marked identifying the lot number of the material. Mixed lots of material shall not be used for testing a clothes washer.

2.6.3 Preconditioning of Test Cloths. The new test cloths, including energy test cloths and energy stuffer cloths, shall be pre-conditioned in a clothes washer in the following manner:

2.6.3.1 Perform 5 complete normal wash-spin cycles, the first two with AHAM Standard detergent Formula 3 and the last three without detergent. Place the test cloth in a clothes washer set at the maximum water level. Wash the load for ten minutes with a minimum fill of 20 gallons of soft water (17 ppm hardness or less) using 27.0 grams + 4.0 grams per pound of cloth load of AHAM Standard detergent Formula 3. The wash temperature is to be controlled to 135 \(^\circ F \pm 5^\circ F \) (57.2 \(^\circ C \pm 2.8 \(^\circ C\)) and the rinse temperature is to be controlled to 60 \(^\circ F \pm 5^\circ F \) (15.6 \(^\circ C \pm 2.8 \(^\circ C\)). Repeat the cycle with detergent and then repeat the cycle three additional times without detergent, bone drying the load between cycles (total of five wash and rinse cycles).

2.6.4 Energy test cloth material. The energy test cloths and energy stuffer cloths shall be made from fabric meeting the following specifications. The material should come from a roll of material with a width of approximately 63 inches and approximately 500 yards per roll. However, other sizes may be used if they fall within the specifications.

2.6.4.1 Nominal fabric type. Pure finished bleached cloth made with a momie or granite weave, which is nominally 50 percent cotton and 50 percent polyester.
2.6.4.2 The fabric weight specification shall be 5.80 ± 0.25 ounces per square yard (190.0 ± 8.4 g/m²).
2.6.4.3 The thread count shall be 65 × 57 per inch (warp × fill), ± 2%.
2.6.4.4 The warp yarn and filling yarn shall each have fiber content of 50 percent ± 4 percent cotton, with the balance being polyester, and be open end spun, 15s ± 2 percent cotton count blended yarn.
2.6.4.5 Water repellent finishes, such as Scotchguard™ or other water repellent finish (made at the mill) to confirm the absence of fluoropolymer stain resistant finishes shall not be applied to the test cloth. The absence of such finishes shall be verified by:

2.6.4.5.1 AATCC Test Method 118–2007, (incorporated by reference; see § 430.3), for each new lot of test cloth (when purchased from the mill) to confirm the absence of Scotchguard™ or other water repellent finish (required scores of “D” across the board).
2.6.4.5.2 AATCC Test Method 79–2010, (incorporated by reference; see § 430.3), for each new lot of test cloth (when purchased from the mill) to confirm the absence of Scotchguard™ or other water repellent finish (time to absorb one drop should be on the order of 1 second).
2.6.4.6 The moisture absorption and retention shall be evaluated for each new lot of test cloth by the Standard Extractor Remaining Moisture Content (RMC) Test specified in section 2.6.5 of this Appendix.

2.6.4.6.1 Repeat the Standard Extractor RMC Test in section 2.6.5 of this Appendix three times.
2.6.4.6.2 An RMC correction curve shall be calculated as specified in section 2.6.6 of this Appendix.

2.6.4.7 The maximum shrinkage after preconditioning shall not be more than 5 percent of the length and width. Measure per AATCC Test Method 135–2010, (incorporated by reference; see § 430.3).

2.6.5 Standard Extractor RMC Test Procedure. The following procedure is used to evaluate the moisture absorption and retention characteristics of a lot of test cloth by measuring the RMC in a standard extractor at a specified set of conditions. Table 2.6.5 of this Appendix is the matrix of test conditions. In the table, “g Force” represents units of gravitational acceleration. When this matrix is repeated 3 times, a total of 60 extractor RMC test runs are required. For the purpose of the extractor RMC test, the test cloths may be used for up to 60 test runs (after preconditioning as specified in section 2.6.3 of this Appendix).

<table>
<thead>
<tr>
<th>“g Force”</th>
<th>Warm soak</th>
<th>Cold soak</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15 min. spin</td>
<td>4 min. spin</td>
</tr>
<tr>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>350</td>
<td></td>
<td></td>
</tr>
<tr>
<td>500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>650</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.6.5.1 The standard extractor RMC tests shall be run in a North Star Engineered Products Inc. (formerly Bock) Model 215 extractor (having a basket diameter of 20 inches, height of 11.5 inches, and volume of 2.09 ft³), with a variable speed drive (North Star Engineered Products, P.O. Box 5127, Toledo, OH 43611) or an equivalent extractor with same basket design (i.e. diameter, height, volume, and hole configuration) and variable speed drive. Table 2.6.5.1 shows the extractor spin speed, in revolutions per minute (RPM), that shall be used to attain each required g-force level.

2.6.5.2 Test Load. Test loads shall be comprised of randomly selected cloth at the beginning, middle and end of a lot. Test cloths shall be preconditioned in accordance with section 2.6.3 of this Appendix. The load size shall be 8.4 lbs. It is acceptable to use two test loads for standard extractor RMC tests, with each load used for half of the total number of required tests.

2.6.5.3 Procedure.
2.6.5.3.1 Using a dryer that complies with the temperature requirements specified in section 2.12 of this Appendix, dry the test cloth until it is “bone-dry” according to the definition in section 1.5 of this Appendix. Record the “bone-dry” weight of the test load (WT).
2.6.5.3.2 Prepare the test load for soak by grouping four test cloths into loose bundles. Bundles are created by hanging four cloths vertically from one corner and loosely wrapping the test cloth onto itself to form the bundle. Bundles should be wrapped loosely to
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ensure consistency of water extraction. Bundles are then placed into the water to soak. Eight to nine bundles will be formed depending on the test load. The ninth bundle may not equal four cloths but can incorporate energy stuffer cloths to help offset the size difference.

2.6.5.3.3 Soak the test load for 20 minutes in 10 gallons of soft (<17 ppm) water. The entire test load shall be submerged. The water temperature shall be 100 °F ± 5 °F (37.8 °C ±2.8 °C) at all times between the start and end of the soak.

2.6.5.3.4 Remove the test load and allow each of the test cloth bundles to drain over the water bath for a maximum of 5 seconds.

2.6.5.3.5 Manually place the test cloth bundles in the basket of the extractor, distributing them evenly by eye. The draining and loading process shall take no longer than 1 minute. Spin the load at a fixed speed corresponding to the intended centripetal acceleration level (measured in units of the acceleration of gravity, g) ±5 g for the intended time period ±5 seconds. The timer shall begin when the extractor meets the required spin speed for each test.

2.6.5.3.6 Record the weight of the test load immediately after the completion of the extractor spin cycle (WC).

2.6.5.3.7 Calculate the remaining moisture content of the test load as (WC–WI)/WI.

2.6.5.3.8 It is not necessary to drain the soak tub if the water bath is corrected for water level and temperature before the next extraction.

2.6.6.1 Average the values of 3 test runs, and fill in Table 2.6.5 of this Appendix. Perform a linear least-squares fit to determine coefficients A and B such that the standard RMC values shown in Table 2.6.6.1 of this appendix (RMC_{standard}) are linearly related to the RMC values measured in section 2.6.5 of this appendix (RMC_{run})

\[ \text{RMC}_{\text{corr}} = A \times \text{RMC} + B \]

where A and B are coefficients of the linear least-squares fit.

### Table 2.6.6.1—Standard RMC Values (RMC Standard)

<table>
<thead>
<tr>
<th>&quot;g Force&quot;</th>
<th>Warm soak 15 min. spin (percent)</th>
<th>4 min. spin (percent)</th>
<th>Cold soak 15 min. spin (percent)</th>
<th>4 min. spin (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>45.9</td>
<td>49.9</td>
<td>49.7</td>
<td>52.8</td>
</tr>
<tr>
<td>200</td>
<td>35.7</td>
<td>40.4</td>
<td>37.9</td>
<td>43.1</td>
</tr>
<tr>
<td>350</td>
<td>29.6</td>
<td>33.1</td>
<td>30.7</td>
<td>35.8</td>
</tr>
<tr>
<td>500</td>
<td>24.2</td>
<td>28.7</td>
<td>25.5</td>
<td>30.0</td>
</tr>
<tr>
<td>650</td>
<td>23.0</td>
<td>26.4</td>
<td>24.1</td>
<td>28.0</td>
</tr>
</tbody>
</table>

2.6.6.2 Perform an analysis of variance with replication test using two factors, spin speed and lot, to check the interaction of speed and lot. Use the values from Table 2.6.5 and Table 2.6.6.1 of this Appendix in the calculation. The "F" value of the F-statistic for interaction between spin speed and lot in the variance analysis shall be greater than or equal to 0.1. If the "F" value is less than 0.1, the test load is unacceptable. "F" is a theoretically based measure of interaction based on an analysis of variance.

2.6.7.1 Using the coefficients A and B calculated in section 2.6.6.1 of this Appendix:

\[ \text{RMC}_{\text{corr}} = A \times \text{RMC} + B \]

2.6.7.2 Apply this RMC correction curve to measured RMC values in sections 3.8.2.6, 3.8.3.2, and 3.8.3.4 of this Appendix.

2.7 Test Load Sizes. Maximum, minimum, and, when required, average test load sizes shall be determined using Table 5.1 of this Appendix and the clothes container capacity as measured in sections 3.1.1 through 3.1.5 of this Appendix. Test loads shall consist of energy test cloths, except that adjustments to the test loads to achieve proper weight can be made by the use of energy stuffer cloths with no more than 5 stuffer cloths per load.
2.8 Use of Test Loads. Table 2.8 of this Appendix defines the test load sizes and corresponding water fill settings which are to be used. Adaptive water fill control systems and manual water fill control systems are defined in section 1 of this Appendix:

<table>
<thead>
<tr>
<th>Test load size</th>
<th>Water fill setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max</td>
<td>As determined by the Clothes Washer.</td>
</tr>
<tr>
<td>Min</td>
<td></td>
</tr>
</tbody>
</table>

2.8.1 The test load sizes to be used to measure HMC are specified in section 3.8.1 of this Appendix.

2.8.2 Test loads for energy and water consumption measurements shall be bone dry prior to the first cycle of the test, and dried to a maximum of 104 percent of bone dry weight for subsequent testing.

2.8.3 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.

2.9 Pre-conditioning of Clothes Washer.

2.9.1 Non-water-heating clothes washer. If the clothes washer has not been filled with water in the preceding 96 hours, pre-condition it by running it through a cold rinse cycle and then draining it to ensure that the hose, pump, and sump are filled with water.

2.9.2 Water-heating clothes washer. If the clothes washer has not been filled with water in the preceding 96 hours, or if it has not been in the test room at the specified ambient conditions for 8 hours, pre-condition it by running it through a cold rinse cycle and then draining it to ensure that the hose, pump, and sump are filled with water.

2.10 Wash time setting. If one wash time is prescribed in the energy test cycle, that shall be the wash time setting; otherwise, the wash time setting shall be the higher of either the minimum or 70 percent of the maximum wash time available in the energy test cycle, regardless of the labeling of suggested dial locations. If the clothes washer is equipped with an electromechanical dial controlling wash time, reset the dial to the minimum wash time and then turn it in the direction of increasing wash time to reach the appropriate setting. If the appropriate setting is passed, return the dial to the minimum wash time and then turn in the direction of increasing wash time until the setting is reached.

2.11 Test room temperature. For all clothes washers, maintain the test room ambient air temperature at 75 ± 5 °F (23.9 ± 2.8 °C) for active mode testing and combined low-power mode testing. Do not use the test room ambient air temperature conditions specified in section 4, Paragraph 4.2 of IEC 62301 for combined low-power mode testing.

2.12 Bone dryer temperature. The dryer used for bone drying must heat the test cloth and energy stuffer clothes above 210 °F (99 °C).

2.13 Energy consumption for the purpose of certifying the cycle selection(s) to be included in Part (B) of the energy test cycle definition. Where multiple alternate cycle selections offer a wash/rinse temperature selection for which a TUF has been developed, and that is not available on the cycle selection recommended by the manufacturer for washing cotton or linen clothes described in Part (A) of the energy test cycle definition, the alternate cycle selection with the highest energy consumption for that TUF, as measured according to this section, shall be included in the energy test cycle.

2.13.1 For the TUF being considered under this section, establish the testing conditions set forth in section 2 of this test procedure. Select the applicable cycle selection and temperature selection. Use the manufacturer default settings for agitation/tumble operation, soil level, spin speed(s), wash times, rinse times, and all other wash parameters or optional features applicable to that cycle selection, including water heating time for water heating clothes washers.

2.13.2 Use the clothes washer’s maximum test load size, determined from Table 5.1, for testing under this section.

2.13.3 For clothes washers with a manual water fill control system, user-adjustable adaptive water fill control system, or adaptive water fill control system with alternate manual water fill control system, use the water fill selector setting resulting in the maximum water level available for each cycle selection for testing under this section.

2.13.4 Each wash cycle tested under this section shall include the entire active washing mode and exclude any delay start or cycle finished modes.

2.13.5 Measure each cycle selection’s electrical energy consumption \( E_B \) and hot water consumption \( H_B \). Calculate the total energy consumption for each cycle selection \( E_{Tm} \), as follows:

\[
E_{Tm} = E_B + (H_B \times T \times K)
\]

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Where:

- $E_n$ is the electrical energy consumption, expressed in kilowatt-hours per cycle.
- $H_n$ is the hot water consumption, expressed in gallons per cycle.
- $T = $ temperature rise = 75°F (41.7°C)
- $K = $ Water specific heat in kilowatt-hours per gallon per degree F = 0.00024 kWh/gal-°F (0.00114 kWh/L-°C)

3. Test Measurements

3.1 Clothes container capacity. Measure the entire volume which a clothes load could occupy within the clothes container during active mode washer operation according to the following procedures:

3.1.1 Place the clothes washer in such a position that the uppermost edge of the clothes container opening is leveled horizontally, so that the container will hold the maximum amount of water. For front-loading clothes washers, the shipping bolts and door seal shall remain in place during the capacity measurement.

3.1.2 Line the inside of the clothes container with 2 mil (0.051 mm) plastic sheet. All clothes washer components which occupy space within the clothes container and which are recommended for use with the energy test cycle shall be in place and shall be lined with 2 mil (0.051 mm) plastic sheet to prevent water from entering any void space.

3.1.3 Record the total weight of the machine before adding water.

3.1.4 Fill the clothes container manually with either 60°F ± 5°F (15.6°C ± 2.8°C) or 100°F ± 10°F (37.8°C ± 5.5°C) water, with the door open. For a top-loading, vertical-axis clothes washer, fill the clothes container to the uppermost edge of the rotating portion, including any balance ring. For a front-loading, horizontal-axis clothes washer, fill the clothes container to the uppermost edge that is in contact with the door seal. For all clothes washers, any volume which cannot be occupied by the clothing load during operation must be excluded from the measurement. Measure and record the weight of water, W, in pounds.

3.1.5 The clothes container capacity is calculated as follows:

$$C = \frac{W}{d}$$

Where:

- $C$ = Capacity in cubic feet (liters)
- $W$ = Mass of water in pounds (kilograms)
- $d$ = Density of water (62.0 lbs/ft³ for 100°F (993 kg/m³ for 37.8°C) or 62.3 lbs/ft³ for 60°F (998 kg/m³ for 15.6°C))

3.2 Procedure for measuring water and energy consumption values on all automatic and semi-automatic washers. All energy consumption tests shall be performed under the energy test cycle(s), unless otherwise specified. Table 3.2 of this Appendix defines the sections below which govern tests of particular clothes washers, based on the number of wash/rinse temperature selections available on the model, and also, in some instances, method of water heating. The procedures prescribed are applicable regardless of a clothes washer’s washing capacity, loading port location, primary axis of rotation of the clothes container, and type of control system.

3.2.1 Inlet water temperature and the wash/rinse temperature settings.

3.2.1.1 For automatic clothes washers, set the wash/rinse temperature selection control to obtain the wash water temperature selection desired (extra hot, hot, warm, or cold) and cold rinse, and open both the hot and cold water faucets.

3.2.1.2 For semi-automatic washers:

1. For hot water temperature, open the hot water faucet completely and close the cold water faucet;
2. For warm inlet water temperature, open both hot and cold water faucets completely;
3. For cold water temperature, close the hot water faucet and open the cold water faucet completely.

3.2.1.3 Determination of warm wash water temperature(s) to decide whether a clothes washer has uniformly distributed warm wash temperature selections. The wash water temperature, $T_w$, of each warm water wash selection shall be calculated or measured.

1. For non-water heating clothes washers, calculate $T_w$ as follows:

$$T_w (\text{°F}) = \frac{(H_w \times 155 \text{ °F}) + (C_w \times 60 \text{ °F})}{(H_w + C_w)}$$

2. For water-heating clothes washers, measure and record the temperature of each warm wash/Water/temperature settings available on the model, and also, in some instances, method of water heating. The procedures prescribed are applicable regardless of a clothes washer’s washing capacity, loading port location, primary axis of rotation of the clothes container, and type of control system.

3.2.2 Total water consumption during the energy test cycle shall be measured, including hot and cold water consumption during wash, deep rinse, and spray rinse.

3.2.3 Clothes washers with adaptive water fill/manual water fill control systems.

3.2.3.1 Clothes washers with adaptive water fill control system and alternate manual water fill control systems. If a clothes washer with an adaptive water fill control system allows consumer selection of manual controls as an alternative, then both manual and adaptive modes shall be tested and, for each mode, the energy consumption ($H_n$, $ME_n$, and $D_n$), and water consumption ($Q_w$), values shall be calculated as set forth in section 4 of this Appendix. Then the average of the two values (one from each mode, adaptive and manual)
for each variable shall be used in section 4 of this Appendix for the clothes washer.

3.2.3.2 Clothes washers with adaptive water fill control system.

3.2.3.2.1 Not user adjustable. The maximum, minimum, and average water levels as defined in the following sections shall be interpreted to mean that amount of water fill which is selected by the control system when the respective test loads are used, as defined in Table 2.8 of this Appendix. The load usage factors which shall be used when calculating energy consumption values are defined in Table 4.1.3 of this Appendix.

3.2.3.2.2 User adjustable. Four tests shall be conducted on clothes washers with user adjustable adaptive water fill controls which affect the relative wash water levels. The first test shall be conducted with the maximum test load and with the adaptive water fill control system set in the setting that will give the most energy intensive result. The second test shall be conducted with the minimum test load and with the adaptive water fill control system set in the setting that will give the least energy intensive result. The third test shall be conducted with the average test load and with the adaptive water fill control system set in the setting that will give the most energy intensive result for the given test load. The fourth test shall be conducted with the average test load and with the adaptive water fill control system set in the setting that will give the least energy intensive result for the given test load. The energy and water consumption for the average test load and water level shall be the average of the third and fourth tests.

3.2.3.3 Clothes washers with manual water fill control system. In accordance with Table 2.8 of this Appendix, the water fill selector shall be set to the maximum water level available on the clothes washer for the maximum test load size and set to the minimum water level for the minimum test load size. The usage factors which shall be used when calculating energy consumption values are defined in Table 4.1.3 of this Appendix.

### TABLE 3.2—TEST SECTION REFERENCE

<table>
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<tr>
<th>Max. wash temp. available</th>
<th>≤135 °F (57.2 °C)</th>
<th>&gt;135 °F (57.2 °C)**</th>
<th>Test sections required to be followed</th>
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<td>Number of wash temp. selections</td>
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<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Test sections required to be followed</td>
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<tr>
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</table>

*Only applicable to machines with warm rinse.

** Only applicable to water heating clothes washers on which the maximum wash temperature available exceeds 135 °F (57.2 °C).

3.3 “Extra Hot Wash” (Max Wash Temp >135 °F (57.2 °C)) for water heating clothes washers only. Water and electrical energy consumption shall be measured for each water fill level and/or test load size as specified in sections 3.3.1 through 3.3.3 of this Appendix for the hottest wash setting available.

3.3.1 Maximum test load and water fill. Hot water consumption (Hm₃₃), cold water consumption (Ch₃₃), and electrical energy consumption (Em₃₃) shall be measured for an extra hot wash/cold rinse energy test cycle, with the controls set for the maximum water fill level. The maximum test load size is to be used and shall be determined per Table 5.1 of this Appendix.

3.3.2 Minimum test load and water fill. Hot water consumption (Hm₃₄), cold water consumption (Ch₃₄), and electrical energy consumption (Em₃₄) shall be measured for an extra hot wash/cold rinse energy test cycle, with the controls set for the minimum water fill level. The minimum test load size is to be used and shall be determined per Table 5.1 of this Appendix.

3.3.3 Average test load and water fill. For clothes washers with an adaptive water fill control system, measure the values for hot water consumption (Hm₃₅), cold water consumption (Ch₃₅), and electrical energy consumption (Em₃₅) for an extra hot wash/cold rinse energy test cycle, with an average test load size as determined per Table 5.1 of this Appendix.

3.4 “Hot Wash” (Max Wash Temp ≤135 °F (57.2 °C)). Water and electrical energy consumption shall be measured for each water fill level and/or test load size as specified in sections 3.4.1 through 3.4.3 of this Appendix for a 135 °F (57.2 °C) wash, if available, or for the hottest selection less than 135 °F (57.2 °C).

3.4.1 Maximum test load and water fill. Hot water consumption (Hh₃₅), cold water consumption (Ch₃₅), and electrical energy consumption (Eh₃₅) shall be measured for a hot wash/cold rinse energy test cycle, with the controls set for the maximum water fill level. The maximum test load size is to be used and shall be determined per Table 5.1 of this Appendix.
3.4.2 Minimum test load and water fill. Hot water consumption (H_w), cold water consumption (C_w), and electrical energy consumption (E_w) shall be measured for a hot wash/cold rinse energy test cycle, with the controls set for the minimum water fill level. The minimum test load size is to be used and shall be determined per Table 5.1 of this Appendix.

3.4.3 Average test load and water fill. For clothes washers with an adaptive water fill control system, measure the values for hot water consumption (H_w), cold water consumption (C_w), and electrical energy consumption (E_w) for a hot wash/cold rinse energy test cycle, with an average test load size as determined per Table 5.1 of this Appendix.

This Appendix.

3.5 “Warm Wash.” Water and electrical energy consumption shall be determined for each water fill level and/or test load size as specified in sections 3.5.1 through 3.5.2.3 of this Appendix for the applicable warm water wash temperature(s) with a cold rinse.

3.5.1 Clothes washers with uniformly distributed warm wash temperature selections. The reportable values to be used for the warm water wash setting shall be the arithmetic average of the measurements for the hot and cold wash settings. This is a calculation only; no testing is required.

3.5.2 Clothes washers that lack uniformly distributed warm wash temperature selections. For a clothes washer with fewer than four discrete warm wash selections, test all warm wash temperature selections. For a clothes washer that offers four or more warm wash selections, test at all discrete selections, or test at 25 percent, 50 percent, and 75 percent positions of the temperature selection device between the hottest hot (≤135 °F (57.2 °C)) wash and the coldest cold wash. If a selection is not available at the 25, 50 or 75 percent position, in place of each such unavailable selection use the next warmer setting. Each reportable value to be used for the warm water wash setting shall be the arithmetic average of all tests conducted pursuant to this section.

3.5.2.1 Maximum test load and water fill. Hot water consumption (H_w), cold water consumption (C_w), and electrical energy consumption (E_w) shall be measured with the controls set for the maximum water fill level. The maximum test load size is to be used and shall be determined per Table 5.1 of this Appendix.

3.5.2.2 Minimum test load and water fill. Hot water consumption (H_w), cold water consumption (C_w), and electrical energy consumption (E_w) shall be measured with the controls set for the minimum water fill level. The minimum test load size is to be used and shall be determined per Table 5.1 of this Appendix.

3.5.2.3 Average test load and water fill. For clothes washers with an adaptive water fill control system, measure the values for hot water consumption (H_w), cold water consumption (C_w), and electrical energy consumption (E_w) with an average test load size as determined per Table 5.1 of this Appendix.

3.6 “Cold Wash” (Minimum Wash Temperature Selection). Water and electrical energy consumption shall be measured for each water fill level and/or test load size as specified in sections 3.6.1 through 3.6.3 of this Appendix for the coldest wash temperature selection available. For a clothes washer that offers two or more wash temperature settings labeled as cold, such as “Cold” and “Tap Cold,” the setting with the minimum wash temperature shall be considered the cold wash. If any of the other cold wash temperature settings add hot water to raise the wash temperature above the cold water supply temperature, as defined in section 2.3 of this Appendix, those setting(s) shall be considered warm wash setting(s), as defined in section 1.34 of this Appendix. If none of the cold wash temperature settings add hot water for any of the water fill levels or test load sizes required for the energy test cycle, the wash temperature setting labeled as “Cold” shall be considered the cold wash, and the other wash temperature setting(s) labeled as cold shall not be required for testing.

3.6.1 Maximum test load and water fill. Hot water consumption (H_c), cold water consumption (C_c), and electrical energy consumption (E_c) shall be measured for a cold wash/cold rinse energy test cycle, with the controls set for the maximum water fill level. The maximum test load size is to be used and shall be determined per Table 5.1 of this Appendix.

3.6.2 Minimum test load and water fill. Hot water consumption (H_c), cold water consumption (C_c), and electrical energy consumption (E_c) shall be measured for a cold wash/cold rinse energy test cycle, with the controls set for the minimum water fill level. The minimum test load size is to be used and shall be determined per Table 5.1 of this Appendix.

3.6.3 Average test load and water fill. For clothes washers with an adaptive water fill control system, measure the values for hot water consumption (H_c), cold water consumption (C_c), and electrical energy consumption (E_c) for a cold wash/cold rinse energy test cycle, with an average test load size as determined per Table 5.1 of this Appendix.

3.7 “Warm Wash/Warm Rinse.” Water and electrical energy consumption shall be determined for each water fill level and/or test load size as specified in sections 3.7.2.1 through 3.7.2.3 of this Appendix for the applicable warm wash temperature selection as...
described in section 3.7.1 or 3.7.2 of this Appendix and the hottest available rinse temperature selection.

3.7.1 Clothes washers with uniformly distributed warm wash temperature selection(s). Test the warm wash/warm rinse cycle at the wash temperature selection with the temperature selection device at the 50 percent position between the hottest hot (≤135 °F (57.2 °C)) wash and the coldest cold wash.

3.7.2 Clothes washers that lack uniformly distributed warm wash temperature selections. For a clothes washer that offers four or more warm wash selections, test all warm wash temperature selections for which a warm rinse is available. For a clothes washer with fewer than four discrete warm wash selections, test all at discrete selections for which a warm rinse is available, or test at 25 percent, 50 percent, and 75 percent positions of the temperature selection device between the hottest hot (≤135 °F (57.2 °C)) wash and the coldest cold wash. If a selection is not available at the 25, 50, or 75 percent position, in place of each such unavailable selection use the next warmer setting. Each reportable value to be used for the warm wash/warm rinse setting shall be the arithmetic average of all tests conducted pursuant to this section.

3.7.2.1 Maximum test load and water fill. Hot water consumption (HWW), cold water consumption (CWW), and electrical energy consumption (EWW) shall be measured with the controls set for the maximum water fill level. The maximum test load size is to be used and shall be determined per Table 5.1 of this Appendix.

3.7.2.2 Minimum test load and water fill. Hot water consumption (HWW), cold water consumption (CWW), and electrical energy consumption (EWW) shall be measured with the controls set for the minimum water fill level. The minimum test load size is to be used and shall be determined per Table 5.1 of this Appendix.

3.7.2.3 Average test load and water fill. For clothes washers with an adaptive water fill control system, measure the values for hot water consumption (HWW), cold water consumption (CWW), and electrical energy consumption (EWW) with an average test load size as determined per Table 5.1 of this Appendix.

3.8 Remaining Moisture Content:

3.8.1 The wash temperature will be the same as the rinse temperature for all testing. Use the maximum test load as defined in Table 5.1 of this Appendix for testing.

3.8.2 For clothes washers with cold rinse only:

3.8.2.1 Record the actual “bone dry” weight of the test load (W1), then place the test load in the clothes washer.

3.8.2.2 Set water level selector to maximum fill.

3.8.2.3 Run the energy test cycle.

3.8.2.4 Record the weight of the test load immediately after completion of the energy test cycle (WC).

3.8.2.5 Calculate the remaining moisture content of the maximum test load, RMC, defined as:

\[ RMC = \frac{(WC - W1)}{W1} \times 100\% \]

3.8.2.6 Apply the RMC correction curve described in section 2.6.7 of this Appendix to calculate the corrected remaining moisture content, RMCcorr, expressed as a percentage, which shall be the final RMC used in section 4.3 of this Appendix:

\[ RMCcorr = (A \times RMC + B) \times 100\% \]

Where:

A and B are the coefficients of the RMC correction curve as defined in section 2.6.1 of this Appendix.

3.8.3 For clothes washers with cold and warm rinse options:

3.8.3.1 Complete sections 3.8.2.1 through 3.8.2.4 of this Appendix for cold rinse.

3.8.3.2 Calculate the remaining moisture content of the maximum test load for cold rinse, RMCcold, defined as:

\[ RMCcold = As defined in section 3.8.3.3 \]

3.8.3.3 Apply the RMC correction curve described in section 2.6.7 of this Appendix to calculate the corrected remaining moisture content for cold rinse, RMCcorr cold, expressed as a percentage, as follows:

\[ RMCcorr cold = (A \times RMCcold + B) \times 100\% \]

Where:

A and B are the coefficients of the RMC correction curve as defined in section 2.6.1 of this Appendix.

3.8.3.4 For clothes washers with cold and warm rinse cycles, RMCcorr warm, defined as:

\[ RMCcorr warm = (WC - W1) \times 100\% \]

3.8.3.5 Apply the RMC correction curve described in section 2.6.7 of this Appendix to calculate the corrected remaining moisture content for warm rinse, RMCcorr warm, expressed as a percentage, as follows:

\[ RMCcorr warm = (A \times RMCwarm + B) \times 100\% \]

Where:

A and B are the coefficients of the RMC correction curve as defined in section 2.6.1 of this Appendix.

RMCcorr warm = As defined in section 3.8.3.3 of this Appendix.

3.8.3.6 Apply the RMC correction curve described in section 2.6.7 of this Appendix to calculate the corrected remaining moisture content for cold rinse, RMCcorr cold, expressed as a percentage, as follows:

\[ RMCcorr cold = (A \times RMCcold + B) \times 100\% \]

Where:

A and B are the coefficients of the RMC correction curve as defined in section 2.6.1 of this Appendix.
shall be the final RMC used in section 4.3 of this Appendix:

\[
RMC_{\text{corr}} = RMC_{\text{COLD,corr}} \times (1 - TUF_{ww}) + RMC_{\text{WARM,corr}} \times TUF_{ww}
\]

Where:

- \(RMC_{\text{COLD,corr}}\) is as defined in section 3.8.3.2 of this Appendix.
- \(RMC_{\text{WARM,corr}}\) is as defined in section 3.8.3.4 of this Appendix.
- \(TUF_{\text{ww}}\) is the temperature use factor for warm rinse as defined in Table 4.1.1 of this Appendix.

3.9.2 Combined low-power mode power. Connect the clothes washer to a watt meter as specified in section 2.8 of this Appendix. Establish the testing conditions set forth in sections 3.8.2 or 3.8.3 of this Appendix, as applicable.

The calculated RMC_{\text{corr,max}} and RMC_{\text{corr,min}} extraction at the maximum and minimum settings, respectively, shall be combined as follows and the final corrected RMC to be used in section 4.3 of this Appendix shall be:

\[
RMC_{\text{corr}} = 0.75 \times RMC_{\text{corr,max}} + 0.25 \times RMC_{\text{corr,min}}
\]

Where:

- \(RMC_{\text{corr,max}}\) is the corrected remaining moisture content using the maximum spin setting, calculated according to section 3.8.2 or 3.8.3 of this Appendix, as applicable.
- \(RMC_{\text{corr,min}}\) is the corrected remaining moisture content using the minimum spin setting, calculated according to section 3.8.2 or 3.8.3 of this Appendix, as applicable.

4. Calculation of derived results from test measurements

4.1 Hot water and machine electrical energy consumption of clothes washers.

4.1.1 Per-cycle temperature-weighted hot water consumption for maximum, average, and minimum water fill levels using each appropriate load size as defined in section 2.8 and Table 5.1 of this Appendix. Calculate for the cycle under test the per-cycle temperature-weighted hot water consumption for the maximum water fill level, \(V_{hx}\), the average water fill level, \(V_x\), and the minimum water fill level, \(V_m\), expressed in gallons per cycle (or liters per cycle) and defined as:

(a) \(V_{hx} = [H_{x} \times TUF_{a}] + [H_{w} \times TUF_{a}] + [H_{ww} \times TUF_{a}] + [H_{h} \times TUF_{a}]\)

(b) \(V_x = [H_{x} \times TUF_{a}] + [H_{w} \times TUF_{a}] + [H_{ww} \times TUF_{a}] + [H_{h} \times TUF_{a}]\)

(c) \(V_m = [H_{x} \times TUF_{a}] + [H_{w} \times TUF_{a}] + [H_{ww} \times TUF_{a}] + [H_{h} \times TUF_{a}]\)

Where:

- \(H_{x}\), \(H_{w}\), and \(H_{ww}\), are reported hot water consumption values, in gallons per-cycle (or liters per cycle), at maximum, average, and minimum water fill, respectively, for the extra hot wash cycle with the appropriate test loads as defined in section 2.8 of this Appendix.
- \(H_{h}\), \(H_{x}\), and \(H_{m}\), are reported hot water consumption values, in gallons per-cycle (or liters per cycle), at maximum, average, and minimum water fill, respectively, for the hot wash cycle with the appropriate test loads as defined in section 2.8 of this Appendix.
- \(H_{ww}\), \(H_{w}\), and \(H_{ww}\), are reported hot water consumption values, in gallons per-cycle (or liters per cycle), at maximum, average, and minimum water fill, respectively, for the warm wash cycle with the appropriate test loads as defined in section 2.8 of this Appendix.
4.1.2 Total per-cycle hot water energy consumption for all maximum, average, and minimum water fill levels tested. Calculate the total per-cycle hot water energy consumption for the maximum water fill level, \( HE_{\text{max}} \), the minimum water fill level, \( HE_{\text{min}} \), and the average water fill level, \( HE_{\text{avg}} \), expressed in kilowatt-hours per cycle and defined as:

(a) \( HE_{\text{max}} = (TV_h \times T \times K)_n \) Total energy when a maximum load is tested. 
(b) \( HE_{\text{avg}} = (TV_h \times T \times K)_c \) Total energy when an average load is tested. 
(c) \( HE_{\text{min}} = (TV_h \times T \times K)_m \) Total energy when a minimum load is tested.

Where:

\( V_h, V_a, \) and \( V_m \) are as defined in section 4.1.1 of this Appendix.

\( T = \) Temperature rise = 75 °F (41.7 °C).

\( K = \) Water specific heat in kilowatt-hours per gallon per degree F = 0.00206 kWh/gal-°F (0.00114 kWh/L-°C).

4.1.3 Total weighted per-cycle hot water energy consumption. Calculate the total weighted per-cycle hot water energy consumption, \( HE_T \), expressed in kilowatt-hours per cycle and defined as:

\( HE_T = (HE_{\text{max}} \times F_{\text{max}}) + (HE_{\text{avg}} \times F_{\text{avg}}) + (HE_{\text{min}} \times F_{\text{min}}) \)

Where:

\( HE_{\text{max}}, HE_{\text{avg}}, \) and \( HE_{\text{min}} \) are as defined in section 4.1.2 of this Appendix.

\( F_{\text{max}}, F_{\text{avg}}, \) and \( F_{\text{min}} \) are the load usage factors for the maximum, average, and minimum test loads based on the size and type of the control system on the washer being tested. The values are as shown in Table 4.1.3 of this Appendix.

4.1.4 Total per-cycle hot water energy consumption using gas-heated or oil-heated water. Calculate for the energy test cycle the per-cycle hot water consumption, \( HE_T \), using gas-heated or oil-heated water, expressed in Btu per cycle (or megajoules per cycle) and defined as:

\( HE_T = HE_T \times 3412 \text{ Btu/kWh or } HE_T = HE_T \times 3.6 \text{ MJ/kWh} \)

Where:

\( e = \) Nominal gas or oil water heater efficiency = 0.75.

\( HE_T = \) As defined in section 4.1.3 of this Appendix.

4.1.5 Per-cycle machine electrical energy consumption for all maximum, average, and minimum test load sizes. Calculate the total per-cycle machine electrical energy consumption for the maximum water fill level, \( ME_{\text{max}} \), the average water fill level, \( ME_{\text{avg}} \), and the minimum water fill level, \( ME_{\text{min}} \), expressed in kilowatt-hours per cycle and defined as:

(a) \( ME_{\text{max}} = [Em_n \times TUF_n] + [Eh_n \times TUF_h] + [Eww_n \times TUF_{\text{ww}}] + [Ec_n \times TUF_c] \)

(b) \( ME_{\text{avg}} = [Em_a \times TUF_n] + [Eh_a \times TUF_h] + [Eww_a \times TUF_{\text{ww}}] + [Ec_a \times TUF_c] \)

(c) \( ME_{\text{min}} = [Em_m \times TUF_n] + [Eh_m \times TUF_h] + [Eww_m \times TUF_{\text{ww}}] + [Ec_m \times TUF_c] \)

Where:

\( Em_n, Em_a, \) and \( Em_m, \) are reported electrical energy consumption values, in kilowatt-hours per cycle, at maximum, average, and minimum test loads, respectively, for the extra hot wash cycle.

\( Eh_n, Eh_a, \) and \( Eh_m, \) are reported electrical energy consumption values, in kilowatt-hours per cycle, at maximum, average, and minimum test loads, respectively, for the hot wash cycle.

\( Eww_n, Eww_a, \) and \( Eww_m, \) are reported electrical energy consumption values, in kilowatt-hours per cycle, at maximum, average, and minimum test loads, respectively, for the warm wash cycle.
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Ewwₐ, Ewwₑ, and Ewwₑ are reported electrical energy consumption values, in kilowatt-hours per cycle, at maximum, average, and minimum test loads, respectively, for the warm wash/warm rinse cycle. Ecwₑ, Ecₑ, and Ecₑ are reported electrical energy consumption values, in kilowatt-hours per cycle, at maximum, average, and minimum test loads, respectively, for the cold wash cycle.

TUFₑ, TUFₑ, TUFₑ, TUFₑ, and TUFₑ are as defined in Table 4.1.1 of this Appendix.

4.1.6 Total weighted per-cycle machine electrical energy consumption. Calculate the total weighted per-cycle machine electrical energy consumption, MEₑ, expressed in kilowatt-hours per cycle and defined as:

\[
\text{MEₑ} = [\text{MEₑₐₙₐₓ} \times Fₐₙₐₓ] + [\text{MEₑₑ₂₉} \times Fₑ₂₉] + [\text{MEₑₑ₃₈} \times Fₑ₃₈]
\]

Where:

- MEₑₐₙₐₓ, MEₑₑ₂₉, and MEₑₑ₃₈ are as defined in section 4.1.5 of this Appendix.
- Fₐₙₐₓ, Fₑ₂₉, and Fₑ₃₈ are as defined in Table 4.1.3 of this Appendix.

4.1.7 Total per-cycle energy consumption. Calculate the total per-cycle energy consumption, Eₑₑ, using electrically heated water, expressed in kilowatt-hours per cycle and defined as:

\[
\text{Eₑₑ} = \text{HEₑₑ} + \text{MEₑₑ}
\]

Where:

- MEₑₑ = As defined in section 4.1.6 of this Appendix.
- HEₑₑ = As defined in section 4.1.3 of this Appendix.

4.2 Water consumption of clothes washers.

4.2.1 Per-cycle water consumption for extra hot wash. Calculate the maximum, average, and minimum total water consumption, expressed in gallons per cycle (or liters per cycle), for the extra hot wash cycle and defined as:

\[
\begin{align*}
\text{Qₑₑₑₐₙₐₓ} &= [\text{Hₑₑₑₐₙₐₓ} \times \text{Cₑₑₑₐₙₐₓ}] \\
\text{Qₑₑₑₑ₂₉} &= [\text{Hₑₑₑₑ₂₉} \times \text{Cₑₑₑₑ₂₉}] \\
\text{Qₑₑₑₑ₃₈} &= [\text{Hₑₑₑₑ₃₈} \times \text{Cₑₑₑₑ₃₈}]
\end{align*}
\]

Where:

- Hₑₑₑₐₙₐₓ, Cₑₑₑₐₙₐₓ, Hₑₑₑₑ₂₉, Cₑₑₑₑ₂₉, Hₑₑₑₑ₃₈, and Cₑₑₑₑ₃₈ are defined in section 3.3 of this Appendix.

4.2.2 Per-cycle water consumption for hot wash. Calculate the maximum, average, and minimum total water consumption, expressed in gallons per cycle (or liters per cycle), for the hot wash cycle and defined as:

\[
\begin{align*}
\text{Qₑₑₑₐₙₐₓ} &= [\text{Hₑₑₑₐₙₐₓ} \times \text{Cₑₑₑₐₙₐₓ}] \\
\text{Qₑₑₑₑ₂₉} &= [\text{Hₑₑₑₑ₂₉} \times \text{Cₑₑₑₑ₂₉}] \\
\text{Qₑₑₑₑ₃₈} &= [\text{Hₑₑₑₑ₃₈} \times \text{Cₑₑₑₑ₃₈}]
\end{align*}
\]

Where:

- Hₑₑₑₐₙₐₓ, Cₑₑₑₐₙₐₓ, Hₑₑₑₑ₂₉, Cₑₑₑₑ₂₉, Hₑₑₑₑ₃₈, and Cₑₑₑₑ₃₈ are defined in section 3.4 of this Appendix.

4.2.3 Per-cycle water consumption for warm wash with cold rinse. Calculate the maximum, average, and minimum total water consumption, expressed in gallons per cycle (or liters per cycle), for the warm wash/cold rinse cycle and defined as:

\[
\begin{align*}
\text{Qₑₑₑₐₙₐₓ} &= [\text{Hₑₑₑₐₙₐₓ} \times \text{Cₑₑₑₐₙₐₓ}] \\
\text{Qₑₑₑₑ₂₉} &= [\text{Hₑₑₑₑ₂₉} \times \text{Cₑₑₑₑ₂₉}] \\
\text{Qₑₑₑₑ₃₈} &= [\text{Hₑₑₑₑ₃₈} \times \text{Cₑₑₑₑ₃₈}]
\end{align*}
\]

Where:

- Hₑₑₑₐₙₐₓ, Cₑₑₑₐₙₐₓ, Hₑₑₑₑ₂₉, Cₑₑₑₑ₂₉, Hₑₑₑₑ₃₈, and Cₑₑₑₑ₃₈ are defined in section 3.5 of this Appendix.
the total weighted per-cycle water consumption for the warm wash/cold rinse cycle, $Q_{wr}$, expressed in gallons per cycle (or liters per cycle) and defined as:

$$Q_{wr} = [Q_{max} \times F_{max}] + [Q_{avg} \times F_{avg}] + [Q_{min} \times F_{min}]$$

Where:

- $Q_{max}$, $Q_{avg}$, $Q_{min}$ are defined in section 4.2.3 of this Appendix.
- $F_{max}$, $F_{avg}$, $F_{min}$ are defined in Table 4.1.3 of this Appendix.

4.2.9 Total weighted per-cycle water consumption for warm wash with warm rinse. Calculate the total weighted per-cycle water consumption for the warm wash/warm rinse cycle, $Q_{ww}$, expressed in gallons per cycle (or liters per cycle) and defined as:

$$Q_{ww} = [Q_{ww,max} \times F_{max}] + [Q_{ww.avg} \times F_{avg}] + [Q_{ww.min} \times F_{min}]$$

Where:

- $Q_{ww,max}$, $Q_{ww.avg}$, $Q_{ww.min}$ are defined in section 4.2.4 of this Appendix.
- $F_{max}$, $F_{avg}$, $F_{min}$ are defined in Table 4.1.3 of this Appendix.

4.2.10 Total weighted per-cycle water consumption for cold wash. Calculate the total weighted per-cycle water consumption for the cold wash cycle, $Q_{c}$, expressed in gallons per cycle (or liters per cycle) and defined as:

$$Q_{c} = [Q_{c,max} \times F_{max}] + [Q_{c.avg} \times F_{avg}] + [Q_{c.min} \times F_{min}]$$

Where:

- $Q_{c,max}$, $Q_{c.avg}$, $Q_{c.min}$ are defined in section 4.2.5 of this Appendix.
- $F_{max}$, $F_{avg}$, $F_{min}$ are defined in Table 4.1.3 of this Appendix.

4.2.11 Total weighted per-cycle water consumption for all wash cycles. Calculate the total weighted per-cycle water consumption for all wash cycles, $Q_{T}$, expressed in gallons per cycle (or liters per cycle) and defined as:

$$Q_{T} = [Q_{max} \times TUF_{max}] + [Q_{avg} \times TUF_{avg}] + [Q_{min} \times TUF_{min}]$$

Where:

- $Q_{max}$, $Q_{avg}$, $Q_{min}$ are defined in sections 4.2.6 through 4.2.10 of this Appendix.
- $TUF_{max}$, $TUF_{avg}$, $TUF_{min}$ are defined in Table 4.1.1 of this Appendix.

4.2.12 Water factor. Calculate the water factor, $WF$, expressed in gallons per cycle per cubic foot (or liters per cycle per liter), as:

$$WF = Q_{c}/C$$

Where:

- $Q_{c}$ is defined in section 4.2.10 of this Appendix.
- $C$ is defined in section 3.1.5 of this Appendix.

4.2.13 Integrated water factor. Calculate the integrated water factor, $IWF$, expressed in gallons per cycle per cubic foot (or liter per cycle per liter), as:

$$IWF = Q_{c}/C$$

Where:

- $Q_{c}$ is defined in section 4.2.10 of this Appendix.
- $C$ is defined in section 3.1.5 of this Appendix.

4.3 Per-cycle energy consumption for removal of moisture from test load. Calculate the per-cycle energy required to remove the remaining moisture of the test load, $D_{e}$, expressed in kilowatt-hours per cycle and defined as:

$$D_{e} = [(F_{max} \times \text{Maximum test load weight}) + (F_{avg} \times \text{Average test load weight}) + (F_{min} \times \text{Minimum test load weight})] 	imes (RMC_{corr} - 4\%) \times (\text{DEF}) \times (\text{DUF})$$

Where:

- $F_{max}$, $F_{avg}$, and $F_{min}$ are as defined in Table 4.1.5 of this Appendix.
- Maximum, average, and minimum test load weights are as defined in Table 5.1 of this Appendix.
- $RMC_{corr}$ is as defined in section 3.8.2.3, 3.8.3.5, or 3.8.4 of this Appendix.
- $\text{DEF}$ is Nominal energy required for a clothes dryer to remove moisture from clothes = 0.5 kWh/lb (1.1 kWh/kg).
- $\text{DUF}$ is Dryer usage factor, percentage of washer loads dried in a clothes dryer = 0.91.

4.4 Per-cycle combined low-power mode energy consumption. Calculate the per-cycle combined low-power mode energy consumption, $E_{TLP}$, expressed in kilowatt-hours per cycle and defined as:

$$E_{TLP} = [(P_{w} \times S_{oi}) + (P_{ia} \times S_{oi})] \times K_{o} \times 295$$

Where:

- $P_{w}$ = Washer inactive mode power, in watts, as defined in section 3.9 of this Appendix for clothes washers capable of operating in inactive mode; otherwise, $P_{w} = 0$.
- $P_{ia}$ = Washer off mode power, in watts, as defined in section 3.9.1 of this Appendix for clothes washers capable of operating in off mode; otherwise, $P_{ia} = 0$.
- $S_{oi}$ = Annual hours in inactive mode as defined as $S_{oi}$ if no off mode is possible, $[S_{oi}/2]$ if both inactive mode and off mode are possible, and 0 if no inactive mode is possible.
- $S_{ia}$ = Annual hours in off mode as defined as $S_{ia}$ if no inactive mode is possible, $[S_{ia}/2]$ if both inactive mode and off mode are possible, and 0 if no off mode is possible.
- $S_{ol}$ = Combined annual hours for off and inactive mode = $S_{ia} + S_{oi}$.
- $K_{o}$ = Conversion factor of watt-hours to kilowatt-hours = 0.001.
- 295 = Representative average number of clothes washer cycles in a year.

4.5 Modified energy factor. Calculate the modified energy factor, $MEF$, expressed in cubic feet per kilowatt-hour per cycle (or liters per kilowatt-hour per cycle) and defined as:

$$MEF = \frac{Q_{c}}{C}$$

Where:

- $Q_{c}$ is defined in section 4.2.10 of this Appendix.
- $C$ is defined in section 3.1.5 of this Appendix.
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### TABLE 5.1—TEST LOAD SIZES

<table>
<thead>
<tr>
<th>Container volume</th>
<th>Minimum load</th>
<th>Maximum load</th>
<th>Average load</th>
</tr>
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<td>kg</td>
<td>lb</td>
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<td>3.00</td>
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<td>1.40</td>
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<td>1.36</td>
<td>0.80</td>
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<td>1.36</td>
<td>0.60</td>
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<td>0.40</td>
</tr>
<tr>
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</tr>
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<td>1.36</td>
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</tr>
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</table>
6. WAIVERS AND FIELD TESTING

6.1 Waivers and Field Testing for Nonconventional Clothes Washers. Manufacturers of nonconventional clothes washers, such as clothes washers with adaptive control systems, must submit a petition for waiver pursuant to 10 CFR 430.27 to establish an acceptable test procedure for that clothes washer if the washer cannot be tested pursuant to the DOE test procedure or the DOE test procedure yields results that are so unrepresentative of the clothes washer’s true energy consumption characteristics as to provide materially inaccurate comparative data. In such cases, field testing may be appropriate for establishing an acceptable test procedure. The following are guidelines for field testing which may be used by manufacturers in support of petitions for waiver. These guidelines are not mandatory and the Department may determine that they do not apply to a particular model. Depending upon a manufacturer’s approach for conducting field testing, additional data may be required. Manufacturers are encouraged to communicate with the Department prior to the commencement of field tests, which may be used to support a petition for waiver. Section 6.3 of this Appendix provides an example of field testing for a clothes washer with an adaptive water fill control system. Other features, such as the use of various spin speed selections, controls or systems being tested.

6.2 Nonconventional Wash System Energy Consumption Test. The field test may consist of a minimum of 10 of the nonconventional clothes washers (“test clothes washers”) and 10 clothes washers already being distributed in commerce (“base clothes washers”). The tests should include a minimum of 50 energy test cycles per clothes washer. The test clothes washers and base clothes washers should be identical in construction except for the controls or systems being tested. Equal numbers of both the test clothes washer and the base clothes washer should be tested simultaneously in comparable settings to minimize seasonal or consumer laundering conditions or variations. The clothes washers should be monitored in such a way as to accurately record the average total energy and water consumption per cycle, including water heating energy when electrically heated water is used, and the energy required to remove the remaining moisture of the test load. Standby and off mode energy consumption should be measured according to section 4.4 of this test procedure. The field test results should be used to determine the best method to correlate the rating of the test clothes washer to the rating of the base clothes washer.

6.3 Adaptive Water Fill Control System Field Test. (1) Section 3.2.3.1 of this Appendix defines the test method for measuring energy consumption for clothes washers which incorporate both adaptive and alternate manual water fill control systems. Energy consumption calculated by the method defined in section 3.2.3.1 of this Appendix assumes that the adaptive cycle will be used more than 50 percent of the time. This section can be used to develop field test data in support of a petition for waiver when it is believed that the adaptive cycle will be used more than 50 percent of the time. The field test sample size should be a minimum of 10 test clothes washers. The test clothes washers should be representative of the design, construction, and control system that will be placed in commerce. The duration of field testing in the user’s home should be a minimum of 50 energy test cycles, for each unit. No special instructions as to cycle selection or product usage should be given to the field test participants, other than inclusion of the product literature pack which would be shipped with all units, and instructions regarding filling out data collection forms, use of data collection equipment, or basic procedural methods. Prior to the test clothes washers being installed in the field test locations, baseline data should be developed for all field test units by conducting laboratory tests as defined by section 1 through section 5 of this Appendix to determine the energy consumption, water consumption, and remaining moisture content values. The following data should be measured and recorded for each wash load during the test period: Wash cycle selected, the mode of the clothes washer (adaptive or manual), clothes load dry weight (measured after the clothes washer and clothes dryer cycles are completed) in pounds, and type of articles in the clothes load (e.g., cottons, linens, permanent press). The wash loads used in calculating the in-home percentage split between adaptive and manual cycle usage.
should be only those wash loads which conform to the definition of the energy test cycle.

Calculate:

\[ T = \text{The total number of energy test cycles run during the field test.} \]

\[ T_a = \text{The total number of adaptive control energy test cycles.} \]

\[ T_m = \text{The total number of manual control energy test cycles.} \]

The percentage weighting factors:

\[ P_a = \left( \frac{T_a}{T} \right) \times 100\% \text{ (the percentage weighting for adaptive control selection)} \]

\[ P_m = \left( \frac{T_m}{T} \right) \times 100\% \text{ (the percentage weighting for manual control selection)} \]

(2) Energy consumption (\( HE_T \), \( ME_T \), and \( DE_T \)) and water consumption (\( QT \)), values calculated in section 4 of this Appendix for the manual and adaptive modes, should be combined using \( P_a \) and \( P_m \) as the weighting factors.

[77 FR 13939, Mar. 7, 2012]

APPENDIXES K–L TO SUBPART B OF PART 430 [RESERVED]

APPENDIX M TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF CENTRAL AIR CONDITIONERS AND HEAT PUMPS

NOTE: The procedures and calculations that refer to off mode energy consumption (i.e., sections 3.13 and 4.2.8 of this appendix M) need not be performed to determine compliance with energy conservation standards for central air conditioners and heat pumps at this time. However, any representation related to standby mode and off mode energy consumption of these products made after corresponding revisions to the central air conditioners and heat pumps test procedure must be based upon results generated under this test procedure, consistent with the requirements of 42 U.S.C. 6293(o)(2). For residential central air conditioners and heat pumps manufactured on or after January 1, 2015, compliance with the applicable provisions of this test procedure is required in order to determine compliance with energy conservation standards.

1. DEFINITIONS

2. TESTING CONDITIONS

2.1 Test room requirements.

2.2 Test unit installation requirements.

2.2.1 Defrost control settings.

2.2.2 Special requirements for units having a multiple-speed outdoor fan.

2.2.3 Special requirements for multi-split air conditioners and heat pumps, and systems composed of multiple mini-split units (outdoor units located side-by-side) that would normally operate using two or more indoor thermostats.

2.2.4 Wet-bulb temperature requirements for the air entering the indoor and outdoor coils.

2.2.4.1 Cooling mode tests.

2.2.4.2 Heating mode tests.

2.2.5 Additional refrigerant charging requirements.

2.3 Indoor air volume rates.

2.3.1 Cooling tests.

2.3.2 Heating tests.

2.4 Indoor coil inlet and outlet duct connections.

2.4.1 Outlet plenum for the indoor unit.

2.4.2 Inlet plenum for the indoor unit.

2.5 Indoor coil air property measurements and air damper box applications.

2.5.1 Test set-up on the inlet side of the indoor coil:

2.5.1.1 If the section 2.4.2 inlet plenum is installed.

2.5.1.2 If the section 2.4.2 inlet plenum is not installed.

2.5.2 Test set-up on the inlet side of the indoor unit:

2.5.3 Indoor coil static pressure difference measurement.

2.5.3.1 Outlet air damper box placement and requirements.

2.5.3.2 Procedures to minimize temperature maldistribution.

2.5.4 Test set-up on the outlet side of the indoor coil.

2.5.5 Dry bulb temperature measurement.

2.5.6 Water vapor content measurement.

2.5.7 Air damper box performance requirements.

2.5.8 Airflow measuring apparatus.

2.5.9 Electrical voltage supply.

2.5.10 Electrical power and energy measurements.

2.5.11 Measurement of test room ambient conditions.

2.5.12 Measurement of indoor fan speed.

2.5.13 Measurement of barometric pressure.

3. TESTING PROCEDURES

3.1 General Requirements.

3.1.1 Primary and secondary test methods.

3.1.2 Manufacturer-provided equipment overrides.

3.1.3 Airflow through the outdoor coil.

3.1.4 Airflow through the indoor coil.

3.1.5 Cooling Certified Air Volume Rate Method.

3.1.6 Refrigerant Enthalpy Method.

3.1.7 Measurement of test room ambient conditions.

3.1.8 Measurement of indoor fan speed.

3.1.9 Measurement of barometric pressure.