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Energy Efficiency Test Procedure for Residential Clothes Dryers

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Energy Efficiency Test Procedure for Residential Clothes Dryers

A supplemental test procedure for clothes dryers used to generate utility energy savings estimates

Originally Developed by NEEA, PG&E, and Ecova
Version 1.2 – Updated September 2017 by NEEA

This document describes a clothes dryer laboratory test procedure used to calculate an accurate metric for clothes dryer energy use. The procedure describes the different cycles, settings, clothing types and equipment needed to generate the combined energy metric referred to as the Utility Combined Energy Factor (UCEF). The resulting UCEF is based on the field test validated weighting for the five laboratory tests. The resulting test procedure more fully accounts for real world use conditions by testing dryers in a variety of operational modes with a test load composed of realistic test articles.

The Northwest Energy Efficiency Alliance (NEEA) and Pacific Gas and Electric (PG&E) commissioned Ecova to expand on the U.S. Department of Energy's (DOE) new residential clothes dryer test procedure (Uniform Test Method for Measuring the Energy Consumption of Clothes Dryers - Appendix D2). This expanded procedure includes a wider range of drying modes and settings and a more diverse and challenging test load of mostly 100% cotton garments.

NEEA and PG&E contracted Ecova to develop the Utility Test Procedure because the DOE's Appendix D2 only assesses dryer performance in a single mode with a uniform test load composed of thin, half synthetic test cloths. NEEA collected field data showing that real world dryer operation was significantly different; consumers often dried clothing loads of varying size, cotton content, and clothing dimensionality using multiple dryer modes. The supplemental tests more fully account for real world use conditions by testing dryers in a variety of operational modes with a test load composed of realistic test articles.

Appendix D2 was designed to assess dryer performance during auto-terminating operation with a uniform test load and was added to Subpart B of Code of Federal Regulations Part 430 (Uniform Test Method for Measuring the Energy Consumption of Clothes Dryers) on August 13th, 2013. NEEA and PG&E modeled the Utility Test Procedure after Appendix D2 to ensure consistency of approach as much as possible, making it possible for laboratory technicians already familiar with Appendix D2 to carry out the Utility Test Procedure without the need for new equipment or retraining. This Procedure remains largely unchanged from Appendix D2 in Sections 1 through 2.5 and Sections 3.5 through 4.8. Sections 2.6, 2.7 and 3.4 were modified with additional language for the new test loads, and Sections 3.3 and 4.9 for additional tests runs and post data processing.

Version 1.2 changes

The test procedure:

- Applies to all dryers with drum capacity 4ft³ and larger.
- Adjusts the weighting factors applied to each of the 5 tests, consistent with NEEA field test results.
- Addresses how to adjust results for machines that are unable to hit the target results after increasing dryness setting .
- Extends test clothing life (before replacement) from 25 to 50 cycles and increases range of weight and dimensions by 2%.
- Defines method of loading real clothes as defined in Appendix A.
- Drops the drum capacity measurement (section 4.1) because all machines are already tested to the US DOE D2 test procedure for qualification with ENERGYSTAR.
- Validates cycles that achieve a final remaining moisture content (RMC) between 4% and 8%, if a correction for additional energy consumption is applied (Section 3.4.2.6). This correction provides a conservative performance estimate, by adding the energy consumption needed to hit 2% RMC, so it is better if the machine achieves the target moisture of 4%. It allows more of the test cycles to complete rather than re-running the cycle on more-dry. Running a cycle on more-dry was found to in some cases fundamentally change the machine's operating condition.

Version 1.2 changes considered but rejected

The test procedure does not:

- Add an additional cycle with initial moisture content of 45%, a normal sized load and default settings. *(This didn't appear to be that necessary or valuable.)*
- Change cycle 5 ("Fastest") so that cycle setting was set to the most-dry setting. This is to be consistent with EPA's adopted specification for "ENERGYSTAR Most Efficient" and serves to collect data and more consistently apply the worst case drying condition. *(This would have been preferable if we started all over, but given that we have established adjustment factors using field data, it would not be wise to change the test; in addition, the EPA test uses DOE test cloths, not real clothing.)*
- Increase RMC target to 5% for real clothing. *The reason for this is that many cycles do not adequately reach 4% with the very heavy Lands' End clothing set. Rather than reject this, the test method was adjusted to include an extrapolation calculation that is used to determine what the UCEF would be if the clothing had achieved 4%.*

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1. DEFINITIONS

- 1.1 Active mode: Mode in which the clothes dryer is connected to a main power source, has been activated and is performing the main function of tumbling the clothing with or without heated or unheated forced air circulation to remove moisture from the clothing, remove wrinkles, prevent wrinkling of the clothing, or a combination of these functions.
- 1.2 AHAM: Association of Home Appliance Manufacturers.
- 1.3 AHAM HLD-1: The test standard published by the Association of Home Appliance Manufacturers, titled "Household Tumble Type Clothes Dryers," (2009), AHAM HLD-1-2009 (incorporated by reference; see § 430.3).
- 1.4 Automatic termination control: Dryer control system with a sensor which monitors either the dryer load temperature or its moisture content and with a controller which automatically terminates the drying process. A mark, detent, or other visual indicator which indicates a preferred automatic termination control setting must be present if the dryer is to be classified as having an "automatic termination control." A mark is a visible single control setting on one or more dryer controls.
- 1.5 Automatic termination control dryer: Clothes dryer which can be preset to carry out at least one sequence of operations to be terminated by means of a system assessing, directly or indirectly, the moisture content of the load. An automatic termination control dryer with supplementary timer or one which may also be manually controlled shall be tested as an automatic termination control dryer.
- 1.6 Bone dry: Condition of a load of test clothes which has been dried in a dryer at maximum temperature for a minimum of 10 minutes, removed, weighed before cool down, and then dried again for 10-minute periods until the final weight change of the load is 1.0 percent or less.
- 1.7 Compact/compact size: Clothes dryer with a drum capacity of less than 4.4 cubic feet.
- 1.8 Conventional clothes dryer: Clothes dryer that exhausts the evaporated moisture from the cabinet and generates heat by use of an electrical resistance heating element.
- 1.9 Cool down: Portion of the clothes drying cycle when the added gas or electric heat is terminated and the clothes continue to tumble and dry within the drum.
- 1.10 Cycle: Sequence of operation of a clothes dryer which performs a clothes drying operation and may include variations or combinations of the functions of heating, tumbling, and drying.
- 1.11 Drum capacity: Volume of the drying drum in cubic feet.
- 1.12 "IEC 62301" (Second Edition) means the test standard published by the International Electrotechnical Commission ("IEC") titled "Household electrical appliances—Measurement of standby power," Publication 62301 (Edition 2.0 2011-01) (incorporated by reference; see § 430.3).
- 1.13 Inactive mode: 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.
- 1.14 Moisture content: Ratio of the weight of water contained by the test load to the bone-dry weight of the test load, expressed as a percent.

1.15 Moisture sensing control: System which utilizes a moisture sensing element within the dryer drum that monitors the amount of moisture in the clothes and automatically terminates the dryer cycle.

1.16 Off mode: Mode in which the clothes dryer is connected to a main 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.

1.17 Standard size: Clothes dryer with a drum capacity of **4.0** cubic feet or greater.

1.18 Standby mode: Any product mode where the energy using product is connected to a mains power source and offers one or more of the following user-oriented or protective functions which 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.

(c) To maintain connection to the internet or computer network that enables external interaction with the dryer.

1.19 Temperature sensing control: System which monitors dryer exhaust air temperature and automatically terminates the dryer cycle.

1.20 Timer dryer: Clothes dryer that can be preset to carry out at least one operation to be terminated by a timer, but may also be manually controlled, and does not include any automatic termination function.

1.21 Ventless clothes dryer: Clothes dryer that uses a closed-loop system with an internal condenser to remove the evaporated moisture from the heated air. The moist air is not discharged from the cabinet.

1.22 Normal Program: Product mode in which the clothes dryer operates using a group of automated settings designated as normal. For dryers that do not have a “normal” program, the cycle recommended by the manufacturer for drying cotton or linen clothes shall be considered as “normal”.

1.23 Eco Program: Product mode in which the clothes dryer operates using a group of automated settings to achieve energy savings above normal operation during the course of the dryer cycle. The eco program is a pre-determined setting advertised on the product by the manufacturer in order to save energy for a typical cotton/poly load (*e.g.* not “delicates” or other specialty load types). If more than one eco program exists, the test shall be run at the most efficient eco program available as specified by the manufacturer. If no advertised energy savings program exists, the “eco program” will be defined as the normal cycle setting and the lowest temperature setting available, excluding any no-heat settings.

1.24 Fastest Program: Product mode in which the clothes dryer operates using a group of automated settings to achieve the most rapid rate of drying during the course of the dryer cycle. The fastest

program shall use the “HEAVY DUTY” cycle setting or a mode in which the dryer applies the fastest drying rate possible to an eight and a half pound load composed of real clothing of varying thickness and cotton content (i.e. shortest cycle time). The fastest program may be created manually by selecting a cycle setting that allows the highest temperature and shortest drying time (commonly labeled as heavy-duty), excluding any cycles meant to sanitize clothing. If there are separate energy buttons, the fastest setting should be used, such as “speed.”

2. TESTING CONDITIONS

2.1 Installation.

2.1.1 **All clothes dryers.** For both conventional clothes dryers and ventless clothes dryers, as defined in sections 1.8 and 1.21 of this appendix, install the clothes dryer in accordance with manufacturer's instructions as shipped with the unit. If the manufacturer's instructions do not specify the installation requirements for a certain component, it shall be tested in the as-shipped condition. Where the manufacturer gives the option to use the dryer both with and without a duct, the dryer shall be tested without the exhaust simulator described in section 3.3.5.1 of AHAM HLD-1 (incorporated by reference; see § 430.3). All external joints should be taped to avoid air leakage. Control setting indicator lights showing the cycle progression, temperature or dryness settings, or other cycle functions that cannot be turned off during the test cycle shall not be disconnected during the active mode test cycle. For standby and off mode testing, the clothes dryer shall also be installed in accordance with section 5, paragraph 5.2 of IEC 62301 (Second Edition) (incorporated by reference; see § 430.3), disregarding the provisions regarding batteries and the determination, classification, and testing of relevant modes. For standby and off mode testing, all lighting systems shall remain connected.

2.1.2 **Conventional clothes dryers.** For conventional clothes dryers, as defined in section 1.8 of this appendix, the dryer exhaust shall be restricted by adding the AHAM exhaust simulator described in section 3.3.5.1 of AHAM HLD-1 (incorporated by reference; see § 430.3).

2.1.3 **Ventless clothes dryers.** For ventless clothes dryers, as defined in section 1.21, the dryer shall be tested without the AHAM exhaust simulator. If the manufacturer gives the option to use a ventless clothes dryer, with or without a condensation box, the dryer shall be tested with the condensation box installed.

2.2 Ambient temperature and humidity.

2.2.1 To test the drying function, maintain the room ambient air temperature at 75 ± 3 °F and the room relative humidity at 50 ± 10 percent.

2.2.2 For standby and off mode testing, maintain room ambient air temperature conditions as specified in section 4, paragraph 4.2 of IEC 62301 (Second Edition) (incorporated by reference; see § 430.3).

2.3 Energy supply.

2.3.1 **Electrical supply.** Maintain the electrical supply at the clothes dryer terminal block within 1 percent of 120/240 or 120/208Y or 120 volts as applicable to the particular terminal block wiring system and within 1 percent of the nameplate frequency as specified by the manufacturer. If the dryer has a dual voltage conversion capability, conduct the test at the highest voltage specified by the manufacturer.

2.3.1.1 **Supply voltage waveform.** For the clothes dryer standby mode and off mode testing, maintain the electrical supply voltage waveform indicated in section 4, paragraph 4.3.2 of IEC 62301 (Second Edition) (incorporated by reference; see § 430.3). If the power measuring instrument used for testing is unable to measure and record the total harmonic content during the test measurement period, it is acceptable to measure and record the total harmonic content immediately before and after the test measurement period.

2.3.2 Gas supply.

2.3.2.1 **Natural gas.** Maintain the gas supply to the clothes dryer immediately ahead of all controls at a pressure of 7 to 10 inches of water column. If the clothes dryer is equipped with a gas appliance pressure regulator for which the manufacturer specifies an outlet pressure, the regulator outlet pressure shall be within ± 10 percent of the value recommended by the manufacturer in the installation manual, on the nameplate sticker, or wherever the manufacturer makes such a recommendation for the basic model. The hourly Btu rating of the burner shall be maintained within ± 5 percent of the rating specified by the manufacturer. If the requirement to maintain the hourly Btu rating of the burner within ± 5 percent of the rating specified by the manufacturer cannot be achieved under the allowable range in gas inlet test pressure, the orifice of the gas burner should be modified as necessary to achieve the required Btu rating. The natural gas supplied should have a heating value of approximately 1,025 Btu's per standard cubic foot. The actual heating value, H_n in Btu's per standard cubic foot, for the natural gas to be used in the test shall be obtained either from measurements made by the manufacturer conducting the test using a standard continuous flow calorimeter as described in section 2.4.6 or by the purchase of bottled natural gas whose Btu rating is certified to be at least as accurate a rating as could be obtained from measurements with a standard continuous flow calorimeter as described in section 2.4.6.

2.3.2.2 **Propane gas.** Maintain the gas supply to the clothes dryer immediately ahead of all controls at a pressure of 11 to 13 inches of water column. If the clothes dryer is equipped with a gas appliance pressure regulator for which the manufacturer specifies an outlet pressure, the regulator outlet pressure shall be within ± 10 percent of the value recommended by the manufacturer in the installation manual, on the nameplate sticker, or wherever the manufacturer makes such a recommendation for the basic model. The hourly Btu rating of the burner shall be maintained within ± 5 percent of the rating specified by the manufacturer. If the requirement to maintain the hourly Btu rating of the burner within ± 5 percent of the rating specified by the manufacturer cannot be achieved under the allowable range in gas inlet test pressure, the orifice of the gas burner should be modified as necessary to achieve the required Btu rating. The propane gas supplied should have a heating value of approximately 2,500 Btu's per standard cubic foot. The actual heating value, H_p in Btu's per standard cubic foot, for the propane gas to be used in the test shall be obtained either from measurements made by the manufacturer conducting the test using a standard continuous flow calorimeter as described in section 2.4.6 or by the purchase of bottled gas whose Btu rating is certified to be at least as accurate a rating as could be obtained from measurement with a standard continuous calorimeter as described in section 2.4.6.

2.4 Instrumentation.

Perform all test measurements using the following instruments as appropriate.

2.4.1 **Weighing scale for test cloth.** The scale shall have a range of 0 to a maximum of 30 pounds, with a resolution of at least 0.2 ounces and a maximum error no greater than 0.3 percent of any measured value within the range of 3 to 15 pounds.

2.4.1.2 **Weighing scale for drum capacity measurements.** The scale should have a range of 0 to a at least 600 pounds with resolution of 0.50 pounds and a maximum error no greater than 0.5 percent of the measured value.

2.4.2 **Kilowatt-hour meter.** The kilowatt-hour meter shall have a resolution of 0.001 kilowatt-hours and a maximum error no greater than 0.5 percent of the measured value.

2.4.3 **Gas meter.** The gas meter shall have a resolution of 0.001 cubic feet and a maximum error no greater than 0.5 percent of the measured value.

2.4.4 **Dry and wet bulb psychrometer.** The dry and wet bulb psychrometer shall have an error no greater than ± 1 °F. A relative humidity meter with a maximum error tolerance expressed in °F equivalent to the requirements for the dry and wet bulb psychrometer ,or with a maximum error tolerance of ± 2 percent relative humidity, would be acceptable for measuring the ambient humidity.

2.4.5 **Temperature.** The temperature sensor shall have an error no greater than ± 1 °F.

2.4.6 **Standard Continuous Flow Calorimeter.** The calorimeter shall have an operating range of 750 to 3,500 Btu per cubic foot. The maximum error of the basic calorimeter shall be no greater than 0.2 percent of the actual heating value of the gas used in the test. The indicator readout shall have a maximum error no greater than 0.5 percent of the measured value within the operating range and a resolution of 0.2 percent of the full-scale reading of the indicator instrument.

2.4.7 **Standby mode and off mode watt meter.** The watt meter used to measure standby mode and off mode power consumption shall meet the requirements specified in section 4, paragraph 4.4 of IEC 62301 (Second Edition) (incorporated by reference; see § 430.3). 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 the crest factor, power factor, and maximum current ratio immediately before and after the test measurement period.

2.5 Lint Trap(s).

Clean the lint trap(s) thoroughly before each test run.

2.6 Test Items.

2.6.1 **Energy test cloth for DOE test.** The energy test cloth shall be clean and consist of the following:

- (a) Pure finished bleached cloth, made with a momie or granite weave, which is a blended fabric of 50-percent cotton and 50-percent polyester, weighs within ± 10 percent of 5.75 ounces per square yard after test cloth preconditioning, and has 65 ends on the warp and 57 picks on the fill. The individual warp and fill yarns are a blend of 50-percent cotton and 50-percent polyester fibers.
- (b) Cloth material that is 24 inches by 36 inches and has been hemmed to 22 inches by 34 inches before washing. The maximum shrinkage after five washes shall not be more than 4 percent on the length and width.
- (c) The number of test runs on the same energy test cloth shall not exceed 25 runs.

2.6.2 Energy stuffer cloths for DOE test. The energy stuffer cloths shall be made from energy test cloth material, and shall consist of pieces of material that are 12 inches by 12 inches and have been hemmed to 10 inches by 10 inches before washing. The maximum shrinkage after five washes shall not be more than 4 percent on the length and width. The number of test runs on the same energy stuffer cloth shall not exceed 25 runs after test cloth preconditioning.

2.6.3.1 Supplemental test clothes descriptions The following supplemental test clothing shall be purchased from Lands' End Clothing catalog. Clothing dimension measurements shall be measured as described in section 3.4.9 of this test procedure using a standard scale (in pounds). The test laboratory shall match as close as possible the fiber type, dimensions and weight. Fiber type and weight are the most important selection criteria. Dimensions and model number are provided for aiding in selection of nearest equivalent.

- (a) Article: V-neck T-shirt (Model # 411453-AH2)
 Specifications: Regular fit, Short Sleeve, Relaxed
 Size: Medium
 Color: Black
 Cotton content: 100%
 Approximate Dimensions: 21.5"x 17"
 Bone dry weight after conditioning: 0.318 lbs. ± 0.038 lbs.
- (b) Article: Dress Socks (pair) (Model #: 412010-AH5)
 Size: Medium
 Color: Navy
 Cotton content: 70%
 Dimensions (per sock): 16.5"x 2.5"
 Bone dry weight after conditioning (per pair) 0.116 lbs. ± 0.014 lbs.
- (c) Article: Boxer Shorts (Model #: 385086-AH0)

Size: 42

Color: Pearl gray

Cotton content: 100%

Dimensions: 14.56"x 16.517"

Bone dry weight after conditioning: 0.294 lbs. ± 0.035 lbs.

(d) Article: Corduroy Leggings (Model #: 420127-AH0)

Specifications: Regular Fit 2 Sport

Size: Medium

Color: Deep Black

Cotton content: 73%

Dimensions: 35.5"x 13"

Bone dry weight after conditioning: 0.642 lbs. ± 0.077 lbs.

(e) Article: Bath Towel (Model #: 400365-AHX)

Size: Bath Towel "Suprema Bath Towel"

Color: Orchid Petal

Cotton content: 100%

Dimensions: 51"x 27"

Bone dry weight after conditioning: 1.498 lbs. ± 0.18 lbs.

(f) Article: Blue Jeans (Model #: 307460-AH3)

Specifications: Medium, Uncuffed

Size: 30" x 30" (length x inseam)

Color: Indigo

Cotton content: 100%

Dimensions: 39"x 16"

Bone dry weight after conditioning: 1.422 lbs. ± 0.17 lbs.

2.6.3.2 Test clothing life.

The number of test runs on the same article of clothing shall not exceed 50 runs.

2.6.4 DOE Test Cloth Preconditioning.

All new test cloth load and energy stuffer cloths shall be treated as follows:

- (1) Bone dry the load to a weight change of ± 1 percent, or less, as prescribed in section 1.6 of this appendix.
- (2) Place the test cloth load in a standard clothes washer set at the maximum water fill level. Wash the load for 10 minutes in soft water (17 parts per million hardness or less), using 60.8 grams of AHAM standard test detergent Formula 3. Wash water temperature should be maintained at $140^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ($60^{\circ}\text{C} \pm 2.7^{\circ}\text{C}$). Rinse water temperature is to be controlled at $100^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ($37.7^{\circ}\text{C} \pm 2.7^{\circ}\text{C}$).
- (3) Rinse the load again at the same water temperature.
- (4) Bone dry the load as prescribed in section 1.6 of this appendix and weigh the load.
- (5) Steps (2)-(4) are repeated until there is a weight change of 1 percent or less.
- (6) The final cycle is to be a hot water wash with no detergent, followed by two warm water rinses.
- (7) Bone dry the load once again, as prescribed in section 1.6 of this appendix, and weigh the load before using the load for testing.

2.6.5 Supplemental Test Clothes Preconditioning.

All new test clothing loads shall be treated as follows:

- (1) Bone dry the load to a weight change of ± 1.0 percent, or less, as prescribed in section 1.6 of this appendix.
- (2) Place the test cloth load (not more than 10lbs) in a standard clothes washer set at the maximum water fill level. Wash the load for 10 minutes in soft water (17 parts per million hardness or less), using 60.8 grams of AHAM standard test detergent Formula 3. Wash water temperature should be maintained at $140^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ($60^{\circ}\text{C} \pm 2.7^{\circ}\text{C}$). Rinse water temperature is to be controlled at $100^{\circ}\text{F} \pm 5^{\circ}\text{F}$ ($37.7^{\circ}\text{C} \pm 2.7^{\circ}\text{C}$).
- (3) Rinse the load again at the same water temperature.
- (4) Bone dry the load as prescribed in section 1.6 of this appendix and weigh the load.
- (5) Steps (2)-(4) are repeated until there is a weight change of 0.5 percent or less.
- (6) The final cycle is to be a hot water wash with no detergent, followed by two warm water rinses.
- (7) Bone dry the load once again, as prescribed in section 1.6 of this appendix, and weigh the load before using the load for testing.

2.7 Test Loads.

2.7.1 **DOE Test Cloths - For dryers smaller than 4.0 ft³.** Prepare a bone-dry test load of energy cloths that weighs 3.00 pounds \pm .03 pounds. The test load can be adjusted to achieve proper weight by adding energy stuffer cloths, but no more than **five** stuffer cloths may be added per load. Dampen the load by agitating it in water whose temperature is 60 °F \pm 5 °F and consists of 0 to 17 parts per million hardness for approximately 2 minutes to saturate the fabric. Then, extract water from the wet test load by spinning the load until the moisture content of the load is between 52.5 and 57.5 percent of the bone-dry weight of the test load. Make a final mass adjustment, such that the moisture content is 57.5 percent \pm 0.33 percent by adding uniformly distributed water among all of the test cloths using a spray bottle with a very fine spray.

2.7.2 **DOE Test Cloths - for dryers 4.0 ft³ or larger.** Prepare a bone-dry test load of energy cloths that weighs 8.45 pounds \pm .085 pounds. The test load can be adjusted to achieve proper weight by adding stuffer cloths, but no more than **five** stuffer cloths may be added per load. Dampen the load by agitating it in water whose temperature is 60 °F \pm 5 °F and consists of 0 to 17 parts per million hardness for approximately 2 minutes to saturate the fabric. Then, extract water from the wet test load by spinning the load until the moisture content of the load is between 52.5 and 57.5 percent of the bone-dry weight of the test load. Make a final mass adjustment, such that the moisture content is 57.5 percent \pm 0.33 percent by adding uniformly distributed water among all of the test clothes using a spray bottle with very fine spray.

2.7.3 Supplemental Test Loads.

2.7.3.1 **Small Supplemental Test Load.** Prepare a bone-dry test load of the supplemental test clothes composed of one of each article of supplemental test clothes (a pair of socks constitutes one article), referenced in section 2.6.3 a-f of this appendix, for a total weight of 4.22 lbs \pm 0.085 lbs. The test load can be adjusted to achieve proper weight by adding DOE test cloth stuffer cloths, but no more than **four** stuffer cloths may be added per load. If, through use, the bone dry weight of the load falls below 4.16 lbs, including the stuffer cloth weight, the load shall be discarded.

2.7.3.2 **Medium Supplemental Test Load.** Prepare a bone-dry test load of the supplemental test clothes composed of two of each article of supplemental test clothes, referenced in section 2.6.3 a-f of this appendix (a pair of socks constitutes one article), for a total weight of 8.45 lbs \pm 0.17 lbs. The test load can be adjusted to achieve proper weight by adding DOE test cloth stuffer cloths, but no more than **eight** stuffer cloths may be added per load. If, through use, the bone dry weight of the load falls below 8.28 lbs, including the stuffer cloth weight, the load shall be discarded.

2.7.3.3 **Large Supplemental Test Load.** Prepare a bone-dry test load of the supplemental test clothes composed of four of each article of supplemental test clothes (a pair of socks constitutes one article), referenced in section 2.6.3 a-f of this appendix, for a total weight of 16.90 lbs \pm 0.34 lbs. The test load can be adjusted to achieve proper weight by adding DOE test cloth stuffer cloths, but no more than **sixteen** stuffer cloths may be added per load. If, through use, the bone dry weight of the load falls below 16.56 lbs, including the stuffer cloth weight, the load shall be discarded.

2.7.4 **Method of wetting clothing.** Dampen the load by agitating it in water whose temperature is 60 °F \pm 5 °F and consists of 0 to 17 parts per million hardness for approximately 2 minutes to saturate the fabric. Then, extract water from the wet test load by spinning the load in a top-load washer or extractor until the moisture content of the load is at the test condition specific initial moisture content. If moisture target is not reached by the end of the damping process, DO NOT make any adjustments. Restart the damping process in washer from the start until desired moisture is reached.

2.7.4.1 **Tests one, two, three and four.** Initial moisture content must be between 62% \pm 2% (between 60% and 64%) of the bone dry weight of the test load.

2.7.5 **Method of loading.** Load the energy test cloths by grasping them in the center, shaking them to hang loosely, and then dropping them in the dryer as defined in Appendix A.

2.8 Clothes dryer preconditioning.

2.8.1 **Conventional non-heat pump clothes dryers.** Before any test cycle using conventional clothes dryers, operate the dryer without a test load in the non-heat mode for 15 minutes or until the discharge air temperature is varying less than 1 °F for 10 minutes—whichever is longer—in the test installation location with the ambient conditions within the specified test condition tolerances of section 2.2.

2.8.2 **Ventless and heat pump clothes dryers.** Before any test cycle using ventless and heat pump clothes dryers, the steady-state temperature measured at the compressor inlet and outlet must be within the ambient room temperature range described in section 2.2.1 of the appendix for a minimum of ten minutes. The machine may be left at ambient room conditions for at least 6 hours between tests as an alternative to measuring compressor inlet and outlet temperature.

3. TEST PROCEDURES AND MEASUREMENTS

3.1 Drum Capacity.

All tested machines must be tested under the DOE D2 test procedure to meet ENERGYSTAR specifications. Consequently, no additional drum capacity testing is needed. The drum capacity value shall be taken by from the EPA ENERGYSTAR web site, or provided by the manufacturer, and the results will be contingent until the DOE D2 test is completed and the certified drum capacity value is provided.

3.2 Dryer Loading.

Load the dryer as specified in 2.75.

3.3 Test Cycle.

3.3.1. Test Cycle Dryer Settings.

The following table provides a general description of the six different test cycles used. Refer to specific text in section 3.3.1 through 3.3.1.6 for explicit definitions.

Table 1 – Supplemental Dryer Tests

Test	Common Test Name	Load Type	Cycle Setting	Cycle Temp	Nominal Load Weight (lbs)	Start Moisture	Max End Moisture
DOE Test (3.3.1.1)	D2	Standard DOE Test Load (4ft3 and larger drum)	Default	High	8.45	57.5%± 0.33%	2%
One (3.3.1.2)	Small	Small Supplemental Test Load	Normal	Medium	4.22	62%± 2%	4% ¹
Two (3.3.1.3)	Large	Large Supplemental Test Load	Normal	Medium	16.9	62%± 2%	4% ¹
Three (3.3.1.4)	Eco	Medium Supplemental Test Load	Mfr Defined	Mfr Defined	8.45	62%± 2%	4% ¹
Four (3.3.1.5)	Fastest	Medium Supplemental Test Load	Heavy Duty	High	8.45	62%± 2%	4% ¹

3.3.1.1 DOE Test. For timer dryers, as defined in section 1.20 of this appendix, operate the clothes dryer at the maximum temperature setting and, if equipped with a timer, at the maximum time setting. Any other optional cycle settings that do not affect the temperature or time settings shall be tested in the as-shipped position. If the clothes dryer does not have a separate temperature setting selection on the control panel, the maximum time setting should be used for the drying test cycle.

For automatic termination control dryers, as defined in section 1.5 of this appendix, a “normal” program shall be selected for the test cycle using the DOE Medium Test Load defined in section 2.7.2 a. For dryers

¹ Test cycles that achieve final RMC between 4.0% and 6.0% or less are considered valid when the finishing extrapolation calculation is applied according to section 4.3. Test cycles that do not reach the 6% RMC are not valid and must be re-run at an increased dryness setting

that do not have a “normal” program, the cycle recommended by the manufacturer for drying cotton or linen clothes shall be selected. Where the drying temperature setting can be chosen independently of the program, it shall be set to the maximum.

Where the dryness level setting can be chosen independently of the program, it shall be set to the “normal” or “medium” dryness level setting. If such designation is not provided, then the dryness level shall be set at the mid-point between the minimum and maximum settings. Any other optional cycle settings that do not affect the program, temperature or dryness settings shall be tested in the as-shipped position. If the final moisture content is greater than the target RMC value of 2%, the test shall be invalid and a new run shall be conducted using the highest dryness level setting. If the final RMC is still above 2%, the test will be considered invalid.

3.3.1.2 Supplemental Test One. The purpose of this test condition is to evaluate dryer performance with a **small** supplemental test load operating in the dryer’s “normal” setting for cotton/linen loads. A “normal” mode, as defined in section 1.22, shall be selected for the test cycle using the Small Supplemental Test Load (4.22 lb) defined in section 2.7.3.1. For dryers that do not have a “normal” program, the cycle recommended by the manufacturer for drying cotton or linen clothes shall be selected. Where the drying temperature setting can be chosen independently of the program, it shall be set to medium.

Where the dryness level setting can be chosen independently of the program, it shall be set to the “normal” or “medium” dryness level setting. If such designation is not provided, then the dryness level shall be set at the mid-point between the minimum and maximum settings. Any other optional cycle settings that do not affect the program, temperature or dryness settings shall be tested in the as-shipped position. The clothing’s initial moisture content shall be $62\% \pm 2\%$. If the final moisture content is greater than the targeted RMC value of 6%, the test shall be invalid and a new run shall be conducted using the highest dryness level setting. If the final RMC is still above 6% when the highest dryness setting is used, the clothing shall be placed back into the dryer and dried using the 10 minute timed-dry cycle and maximum dryness settings.

3.3.1.3 Supplemental Test Two. The purpose of this test condition is to evaluate dryer performance with a **large** supplemental test load operating in the dryer’s “normal” setting for cotton/linen loads. A “normal” program, as defined in section 1.22, shall be selected for the test cycle using the Large Supplemental Test Load (16.90 lbs.) defined in section 2.7.3.3. For dryers that do not have a “normal” program, the cycle recommended by the manufacturer for drying cotton or linen clothes shall be selected. Where the drying temperature setting can be chosen independently of the program, it shall be set to medium.

Where the dryness level setting can be chosen independently of the program, it shall be set to the “normal” or “medium” dryness level setting. If such designation is not provided, then the dryness level shall be set at the mid-point between the minimum and maximum settings. Any other optional cycle settings that do not affect the program, temperature or dryness settings shall be tested in the as-shipped position. The clothing’s initial moisture content shall be $62\% \pm 2\%$. If the final moisture content is greater than the targeted RMC value of 6%, the test shall be invalid and a new run shall be conducted using the highest dryness level setting. If the final RMC is still above 6% when the highest dryness setting is used, the clothing shall be placed back into the dryer and dried using the 10 minute timed-dry cycle and maximum dryness settings.

3.3.1.4 Supplemental Test Three. The purpose of this test is to evaluate dryer performance with a medium supplemental test load operated in the dryer's **most efficient** operating setting for cotton/linen loads. In addition to evaluating a dryer's most efficient mode of operation, this test will also become the basis for any utility-imposed drying cycle time limit. An "Eco program", as defined in section 1.23 of this test procedure, shall be selected for the test cycle using the Medium Supplemental Test Load (8.45 lbs) defined in section 2.7.3.2. For dryers that do not have an "Eco" program efficient setting, the test shall be run by selecting a normal cycle setting and the lowest temperature setting available, excluding any no-heat settings.

Where the dryness level setting can be chosen independently of the program, it shall be set to the "normal" or "medium" dryness level setting. If such designation is not provided, then the dryness level shall be set at the mid-point between the minimum and maximum settings. Any other optional cycle settings that do not affect the program, temperature or dryness settings, shall be tested in the most efficient setting position. The clothing's initial moisture content shall be $62\% \pm 2\%$. If the final moisture content is greater than the targeted RMC value of 6%, the test shall be invalid and a new run shall be conducted using the highest dryness level setting. If the final RMC is still above 6% when the highest dryness setting is used, the clothing shall be placed back into the dryer and dried using the 10 minute timed-dry cycle and maximum dryness settings.

3.3.1.5 Supplemental Test Four. The purpose of this test is to evaluate dryer performance with a medium supplemental test load operated in the dryer's **most rapid drying rate** for cotton/linen loads. The "Fastest" program, as defined in section 1.24 of this test procedure, shall be selected for the test cycle using the Medium Supplemental Test Load (8.45 lbs.) defined in section 2.7.3.2.

Where the drying temperature setting can be chosen independently of the program, it shall be set to the maximum (highest temperature setting). Where the dryness level setting can be chosen independently of the program, it shall be set to the driest setting possible. If such designation is not provided. Any other optional cycle settings that do not affect the program, such as temperature or dryness settings, shall be tested in the as-shipped position. The clothing's initial moisture content shall be $62\% \pm 2\%$. If the final moisture content is greater than the targeted RMC value of 6%, the test shall be invalid and a new run shall be conducted using the highest dryness level setting. If the final RMC is still above 6% when the highest dryness setting is used, the clothing shall be placed back into the dryer and dried using the 10 minute timed-dry cycle and maximum dryness settings.

3.3.2 Timer dryers (DOE cloth test only). Dry the load until the moisture content of the test load is between 1 and 2.5 percent of the bone-dry weight of the test load, at which point the test cycle is stopped, but do not permit the dryer to advance into cool down. If required, reset the timer to increase the length of the drying cycle. After stopping the test cycle, remove and weigh the test load. The clothes dryer shall not be stopped intermittently in the middle of the test cycle for any reason. Record the data specified by section 3.4 of this appendix. If the dryer automatically stops during a cycle because the condensation box is full of water, the test is stopped, and the test run is invalid, in which case the condensation box shall be emptied and the test re-run from the beginning. For ventless dryers, as defined in section 1.21 of this appendix, during the time between two cycles, the door of the dryer shall be closed except for loading (and unloading).

3.3.3 Automatic termination control dryers. Operate the clothes dryer until the completion of the programmed cycle, including the cool down period. The cycle shall be considered complete when the dryer indicates to the user that the cycle has finished (by means of a display, indicator light, audible signal, or other signal) and the heater and drum/fan motor shuts off for the final time. If the clothes

dryer is equipped with a wrinkle prevention mode (*i.e.* a mode which continuously or intermittently tumbles the clothes dryer drum after the clothes dryer indicates to the user that the cycle has finished) that is activated by default in the as-shipped position, or if manufacturers' instructions specify that the feature is recommended to be activated for normal use, the cycle shall be considered complete after the end of the wrinkle prevention mode. After the completion of the test cycle, remove and weigh the test load. Record the data specified in section 3.4 of this appendix. If the final moisture content is greater than the target RMC value for the test, the test shall be invalid and a new run shall be conducted using the highest dryness level setting. The technician should empty the condensation box before running a test. If the dryer automatically stops during a cycle because the condensation box is full of water, the test is stopped, and the test run is invalid, in which case the condensation box shall be emptied and the test re-run from the beginning. During the time between two cycles, the door of the dryer shall be closed except for loading (and unloading).

3.4 Data recording.

Record for each test cycle:

- 3.4.1 Bone-dry weight of the test load described in section 2.7.
- 3.4.2 Moisture content of the wet test load before the test, as described in section 2.7.
- 3.4.3 Moisture content of the dry test load obtained after the test described in section 3.3.
- 3.4.4 Test room conditions, temperature, and percent relative humidity described in section 2.2.1, and record comment regarding dampness/dryness of load and condition of clothes if highly wrinkled.
- 3.4.5 **For electric dryers** — the total kilowatt-hours of electric energy, E_t , consumed during the test described in section 3.3.
- 3.4.6 **For gas dryers** —
 - 3.4.6.1 Total kilowatt-hours of electrical energy, E_{te} , consumed during the test described in section 3.3.
 - 3.4.6.2 Cubic feet of gas per cycle, E_{tg} , consumed during the test described in section 3.3.
 - 3.4.6.3 Correct the gas heating value, GEF, as measured in sections 2.3.2.1 and 2.3.2.2, to standard pressure and temperature conditions in accordance with U.S. Bureau of Standards, circular C417, 1938.
- 3.4.7 **Cycle settings.** Select clothing settings in accordance with the cycle setting determined in each specific test.
- 3.4.8 **Test duration.** Record the total duration of the test, T_A , described in section 3.3 from the start of the cycle to cycle completion.
- 3.4.9. **Clothing Dimensions.** Clothing dimensions are used to aid in selection of test clothes when model numbers or product descriptions change. To obtain the clothing dimensions, first shake and lay the articles flat, then measure the length and the width of all test articles as shown below in Table 2.

Table 2: Supplemental Test Clothing

Dimensions and measurement instructions.

Clothing Article	Measurement Instructions
V-Neck T-shirt 	X Measurement: along bottom edge of shirt
	Y Measurement: from bottom edge to bottom seam of sleeve
Boxer Shorts 	X Measurement: along waistband
	Y Measurement: from top of waistband to bottom corner of leg 'sleeve'
Blue Jeans 	X Measurement: along waistband
	Y Measurement: top of waistband to bottom of pants sleeve

Table 2 continued.

<p>Corduroy Leggings</p> 	<p>X Measurement: along waistband</p>
<p>Dress Socks</p> 	<p>X Measurement: from edge of heel to top of tip</p>
<p>Bath Towel</p> 	<p>X Measurement: along bottom edge of towel</p>
	<p>Y Measurement: along left edge of towel</p>

Individual articles should be within a $\pm 10\%$ range of specified article length and width, as referenced in the supplemental test clothes section 2.6.3 of this appendix.

3.5 Standby Mode and Off Mode Power.

Establish the testing conditions set forth in Section 2 “Testing Conditions” of this appendix. For clothes dryers that take some time to enter a stable state from a higher power state as discussed in Section 5, Paragraph 5.1, Note 1 of IEC 62301 (Second Edition) (incorporated by reference; see § 430.3), allow sufficient time for the clothes dryer to reach the lower power state before proceeding with the test measurement. Follow the test procedure specified in section 5, paragraph 5.3.2 of IEC 62301 (Second Edition) for testing in each possible mode as described in sections 3.5.1 and 3.5.2 of this appendix.

- 3.5.1 If a clothes dryer has an inactive mode, as defined in section 1.13 of this appendix, measure and record the average inactive mode power of the clothes dryer, P_{IA} , in watts.
- 3.5.2 If a clothes dryer has an off mode, as defined in section 1.16 of this appendix, measure and record the average off mode power of the clothes dryer, P_{OFF} , in watts.

4. CALCULATION OF DERIVED RESULTS FROM TEST MEASUREMENTS

4.1 DOE Test calculations.

Calculation of derived results for measurements gathered during the DOE Test as described in section 3.3.1.1.

4.1.1 Total per-cycle electric dryer energy consumption for DOE.

Calculate the total electric dryer energy consumption per cycle, E_{ce} , expressed in kilowatt-hours per cycle and defined as:

$$E_{ce} = E_t,$$

for automatic termination control dryers, and,

$$E_{ce} = [55.5/(W_w - W_d)] \times E_t \times \text{field use},$$

for timer dryers

Where:

55.5 = an experimentally established value for the percent reduction in the moisture content of the test load during a laboratory test cycle expressed as a percent.

E_t = the energy recorded in section 3.4.5 of this appendix.

Field use = 1.18, the field use factor for clothes dryers with time termination control systems only without any automatic termination control functions.

W_w = the moisture content of the wet test load in percent as recorded in section 3.4.2 of this appendix.

W_d = the moisture content of the dry test load in percent as recorded in section 3.4.3 of this appendix.

4.1.2 Per-cycle gas dryer electrical energy consumption for DOE.

Calculate the gas dryer electrical energy consumption per cycle, E_{ge} , expressed in kilowatt-hours per cycle and defined as:

$$E_{ge} = E_{te},$$

for automatic termination control dryers, and,

$$E_{ge} = [55.5/(W_w - W_d)] \times E_{te} \times \text{field use},$$

for timer dryers

Where:

E_{te} = the energy recorded in section 3.4.6.1 of this appendix.

Field use, 55.5, W_w , W_d as defined in section 4.1.1 of this appendix.

4.1.3 Per-cycle gas dryer gas energy consumption for DOE.

Calculate the gas dryer gas energy consumption per cycle, E_{ge} , expressed in Btu's per cycle and defined as:

$$E_{gg} = E_{tg} \times GEF$$

for automatic termination control dryers, and,

$$E_{gg} = [55.5 / (W_w - W_d)] \times E_{tg} \times \text{field use} \times GEF$$

for timer dryers

Where:

E_{tg} = the energy recorded in section 3.4.6.2 of this appendix.

GEF = corrected gas heat value (Btu per cubic foot) as defined in section 3.4.6.3 of this appendix, and

field use, 55.5, W_w , W_d as defined in section 4.1.1 of this appendix.

4.1.4 Total per-cycle gas dryer energy consumption expressed in kilowatt-hours for DOE.

Calculate the total gas dryer energy consumption per cycle, E_{cg} , expressed in kilowatt-hours per cycle and defined as:

$$E_{cg} = E_{ge} + (E_{gg} / 3412 \text{ Btu/kWh})$$

Where:

E_{ge} = the energy calculated in section 4.1.2 of this appendix.

E_{gg} = the energy calculated in section 4.1.3 of this appendix.

4.1.5 Per-cycle standby mode and off mode energy consumption for DOE.

Calculate the dryer inactive mode and off mode energy consumption per cycle, E_{TSO} , expressed in kWh per cycle and defined as:

$$E_{TSO} = [(P_{IA} \times S_{IA}) + (P_{OFF} \times S_{OFF})] \times K / 283$$

Where:

P_{IA} = dryer inactive mode power, in watts, as measured in section 3.5.1;

P_{OFF} = dryer off mode power, in watts, as measured in section 3.5.2.

If the clothes dryer has both inactive mode and off mode, S_{IA} and S_{OFF} both equal $8,620 \div 2 = 4,310$, where 8,620 is the total inactive and off mode annual hours;

if the clothes dryer has an inactive mode but no off mode, the inactive mode annual hours, S_{IA} , is equal to 8,620 and the off mode annual hours, S_{OFF} , is equal to 0;

if the clothes dryer has an off mode but no inactive mode, S_{IA} is equal to 0 and S_{OFF} is equal to 8,620

Where:

$K = 0.001$ kWh/Wh conversion factor for watt-hours to kilowatt-hours, and

283 = representative average number of clothes dryer cycles in a year.

4.1.6 Per-cycle combined total energy consumption expressed in kilowatt-hours for DOE.

Calculate the per-cycle combined total energy consumption, E_{CC} , expressed in kilowatt-hours per cycle and defined for an electric clothes dryer as:

$$E_{CC} = E_{ce} + E_{TSO}$$

Where:

E_{ce} = the energy calculated in section 4.1.1 of this appendix, and

E_{TSO} = the energy calculated in section 4.1.5 of this appendix, and defined for a gas clothes dryer as:

$$E_{CC} = E_{cg} + E_{TSO}$$

Where:

E_{cg} = the energy calculated in section 4.1.4 of this appendix, and

E_{TSO} = the energy calculated in section 4.1.5 of this appendix.

4.1.7 Per-cycle Energy Factor in pounds per kilowatt-hour for DOE.

Calculate the energy factor, EF, expressed in pounds per kilowatt-hour and defined for an electric clothes dryer as:

$$EF = W_{bonedry} / E_{ce}$$

Where:

$W_{bonedry}$ = the bone dry test load weight recorded in section 3.4.1 of this appendix, and

E_{ce} = the energy calculated in section 4.1.1 of this appendix, and defined for a gas clothes dryer as:

$$EF = W_{bonedry} / E_{cg}$$

Where:

$W_{bonedry}$ = the bone dry test load weight recorded in section 3.4.1 of this appendix, and

E_{cg} = the energy calculated in section 4.1.4 of this appendix.

4.1.8 Per-cycle Combined Energy Factor in pounds per kilowatt-hour for DOE.

Calculate the combined energy factor, CEF, expressed in pounds per kilowatt-hour and defined as follows:

$$CEF = W_{bonedry} / E_{cc}$$

Where:

$W_{bonedry}$ = the bone dry test load weight recorded in section 3.4.1 of this appendix, and

E_{cc} = the energy calculated in section 4.1.6 of this appendix.

If the test run was invalid, the CEF shall be given a value of 0.

4.1.9 Per-cycle Test Duration in minutes.

Calculate the per-cycle test duration, T_A , expressed in minutes and defined as follows:

$$T_A = T_D$$

for automatic termination dryers and

$$T_A = [55.5 / (W_w - W_d)] \times T_D$$

for timer dryers.

Where:

T_D = the duration of the dryer test case in minutes as measured in section 3.4.9

55.5, W_w , W_d as defined in section 4.1.1 of this appendix.

4.2 Supplemental Test calculations.

Note: Section 4.3 describes additional energy consumption that is added for supplemental tests 1-4 should the remaining moisture content at the end of the cycle not achieve the desired target moisture content. This adjustment allows tests to be considered valid if the RMC at the end of the cycle is below 8%. Higher than 8% RMC are not considered valid regardless of correction.

Repeat sections 4.2.1 through 4.2.9 a total of four times, once for each supplemental test (sections 3.3.1.2 through 3.3.1.5).

4.2.1 Total per-cycle electric dryer energy consumption.

Calculate the total electric dryer energy consumption per cycle, E_{ce} , expressed in kilowatt-hours per cycle and defined as:

$$E_{ce} = [PD/(W_w - W_{dt})] \times E_t$$

Where:

PD = 58% for tests conducted during sections 3.3.1.2 through 3.3.1.5, and

E_t = the energy recorded in section 3.4.5 of this appendix.

W_w = the moisture content of the wet test load in percent as recorded in section 3.4.2 of this appendix;

W_{dt} = target dry weight of 4% for tests conducted during sections 3.3.1.2 through 3.3.1.5.

4.2.2 Per-cycle gas dryer electrical energy consumption.

Calculate the gas dryer electrical energy consumption per cycle, E_{ge} , expressed in kilowatt-hours per cycle and defined as:

$$E_{ge} = [PD/(W_w - W_{dt})] \times E_{te}$$

Where:

E_{te} = the energy recorded in section 3.4.6.1 of this appendix.

PD, W_w , W_{dt} as defined in section 4.2.1 of this appendix.

4.2.3 Per-cycle gas dryer gas energy consumption.

Calculate the gas dryer gas energy consumption per cycle, E_{gg} , expressed in Btu's per cycle and defined as:

$$E_{gg} = [PD/(W_w - W_{dt})] \times E_{tg} \times GEF$$

Where:

E_{tg} = the energy recorded in section 3.4.6.2 of this appendix.

GEF = corrected gas heat value (Btu per cubic foot) as defined in section 3.4.6.3 of this appendix.

PD, W_w , W_{dt} as defined in section 4.2.1 of this appendix.

4.2.4 Total per-cycle gas dryer energy consumption expressed in kilowatt-hours.

Calculate the total gas dryer energy consumption per cycle, E_{cg} , expressed in kilowatt-hours per cycle and defined as:

$$E_{cg} = E_{ge} + (E_{gg}/3412 \text{ Btu/kWh})$$

Where:

E_{ge} = the energy calculated in section 4.2.2 of this appendix, and

E_{gg} = the energy calculated in section 4.2.3 of this appendix.

4.2.5 Per-cycle standby mode and off mode energy consumption.

Calculate the dryer inactive mode and off mode energy consumption per cycle, E_{TSO} , expressed in kWh per cycle and defined as:

$$E_{TSO} = [(P_{IA} \times S_{IA}) + (P_{OFF} \times S_{OFF})] \times K/283$$

Where:

P_{IA} = dryer inactive mode power, in watts, as measured in section 3.5.1, and

P_{OFF} = dryer off mode power, in watts, as measured in section 3.5.2.

If the clothes dryer has both inactive mode and off mode, S_{IA} and S_{OFF} both equal $8,620 \div 2 = 4,310$, where 8,620 is the total inactive and off mode annual hours;

if the clothes dryer has an inactive mode but no off mode, the inactive mode annual hours, S_{IA} , is equal to 8,620 and the off mode annual hours, S_{OFF} , is equal to 0; and

if the clothes dryer has an off mode but no inactive mode, S_{IA} is equal to 0 and S_{OFF} is equal to 8,620

Where:

$K = 0.001$ kWh/Wh conversion factor for watt-hours to kilowatt-hours; and

283 = representative average number of clothes dryer cycles in a year.

4.2.6 Per-cycle combined total energy consumption expressed in kilowatt-hours.

Calculate the per-cycle combined total energy consumption, E_{CC} , expressed in kilowatt-hours per cycle and defined for an **electric clothes dryer** as:

$$E_{CC} = E_{ce} + E_{TSO} + E_p$$

Where:

E_{ce} = the energy calculated in section 4.2.1, and

E_{TSO} = the energy calculated in section 4.2.5, and

E_p = the energy penalty applied to dryers that do not achieve the target RMC as calculated in section 4.3

and defined for a **gas clothes dryer** as:

$$E_{CC} = E_{cg} + E_{TSO} + E_p$$

Where:

E_{cg} = the energy calculated in section 4.2.4 of this appendix, and

E_{TSO} = the energy calculated in section 4.2.5 of this appendix.

E_p = the energy penalty applied to dryers that do not achieve the target RMC as calculated in section 4.3.

4.2.7 Per-cycle Energy Factor in pounds per kilowatt-hour.

Calculate the energy factor, EF, expressed in pounds per kilowatt-hour and defined for an electric clothes dryer as:

$$EF = W_{bonedry} / E_{ce}$$

Where:

$W_{bonedry}$ = the bone dry test load weight recorded in section 3.4.1 of this appendix, and

E_{ce} = the energy calculated in section 4.2.1 of this appendix, and defined for a gas clothes dryer as:

$$EF = W_{bonedry} / E_{cg}$$

Where:

$W_{bonedry}$ = the bone dry test load weight recorded in section 3.4.1 of this appendix, and

E_{cg} = the energy calculated in section 4.2.4 of this appendix.

4.2.8 Per-cycle Combined Energy Factor in pounds per kilowatt-hour.

Calculate the combined energy factor, CEF, expressed in pounds per kilowatt-hour and defined as follows:

$$CEF = W_{\text{bonedry}}/E_{\text{CC}}$$

Where:

W_{bonedry} = the bone dry test load weight recorded in section 3.4.1 of this appendix, and

E_{CC} = the energy calculated in section 4.2.6 of this appendix.

If the test run was invalid, the CEF shall be given a value of 0.

4.2.9 Per-cycle Test Duration in minutes.

Calculate the per-cycle test duration, T_A , expressed in minutes and defined as follows:

$$T_A = [PD/(W_w - W_{dt})] \times T_D$$

Where:

T_D = the duration of the dryer test case as measured in section 3.4.9.

PD , W_w , W_{dt} as defined in section 4.2.1 of this appendix.

4.3 Finish Extrapolation

These calculations are applied to the test cycle energy use in cases where the realistic clothing cycles (supplemental tests 1-4) fail to achieve the target RMC of 4%. The extrapolation adds additional energy consumption at a rate equal to the average conventional electric resistance dryer, from the end moisture point achieved in the test to a 2.0% RMC. Adding the energy to get to 2% RMC rather than just barely meeting the 4% target RMC ensures that there is some penalty, or disadvantage, to relying on an inaccurate auto-termination to achieve a good test result.

The energy use estimate is considered valid with this extrapolation if the dryer reaches a RMC less than 8%.

If the RMC achieved is less than the target RMC (4% for supplemental tests 1-4) the additional energy added is equal to zero.

$$E_p = 0$$

If the RMC achieved is between 8% and 4%, the following penalty energy use is added:

$$E_p = 0.63 \times W_{\text{bonedry}} \times (RMC_f - 0.02)$$

Where:

W_{bonedry} is the bone dry weight of the test load (lbs. of clothing).

W_d is the final remaining moisture content of the dried clothing (% water weight), and

W_d = weight at end of test ÷ bone dry weight.

Example

Dryer test of 8.45 lbs. (bone dry) of realistic clothes. Wet weight of 13.69 lbs. at the beginning of the dryer cycle and 8.86 lb.s at the end of the cycle. The cycle took 2.21 kWh to complete, and the dryer was determined to have a standby energy of 0.032 kWh/cycle.

$$E_{CE} = 2.210$$

$$E_{TSO} = 0.032$$

$$E_{cc} \text{ (before extrapolation)} = 2.242 \text{ kWh}$$

$$CEF \text{ (before extrapolation)} = 8.45/2.242 = 3.77 \text{ lbs./kWh}$$

$$RMC_f = 8.39/8.45 - 1 = 0.049 = 4.9\%$$

$$E_p = 0.63 \times 8.45 \times (.049 - 0.02) = 0.15 \text{ kWh}$$

$$E_{CC} = 2.393$$

$$CEF \text{ (with extrapolation)} = 8.39/2.393 = 3.53 \text{ lbs./kWh}$$

In this example, the validated CEF value is 6% lower than the uncorrected value.

4.4 Utility Combined Energy Factor (UCEF) in pounds per kilowatt-hour.

[NOTE – This section is provided herein for general reference from the dryer’s specification document and is not specifically related to dryer test procedure.]

Calculate the Utility Combined Energy Factor, UCEF, expressed in pounds per kilowatt-hour and defined as:

$$\text{UCEF} = W_0 \times \text{CEF}_0 + W_1 \times \text{CEF}_1 + W_2 \times \text{CEF}_2 + W_3 \times \text{CEF}_3 + W_4 \times \text{CEF}_4 + W_5 \times \text{CEF}_5 + \text{UCEF CREDIT}$$

Where:

UCEF = the Utility Combined Energy Factor, a weighted average of the CEF calculated for the five supplemental tests and DOE D2 CEFs.

W_0 = the DOE D2 weighting factor, see table below.

CEF_0 = the calculated combined energy factor for DOE D2, calculated in 4.1.8 for the test case described in section 3.3.1.1.

W_1 = the Supplemental Test One weighting factor, see table 3 below.

CEF_1 = the calculated combined energy factor for Supplemental Test One, calculated in section 4.2.8 for the test case described in section 3.3.1.2.

W_2 = the Supplemental Test Two weighting factor, see table 3 below.

CEF_2 = the calculated combined energy factor for Supplemental Test Two, calculated in section 4.2.8 for the test case described in section 3.3.1.3.

W_3 = the Supplemental Test Three weighting factor, see table 3 below.

CEF_3 = the calculated combined energy factor for Supplemental Test Three, calculated in section 4.2.8 for the test case described in section 3.3.1.4.

W_4 = the Supplemental Test Four weighting factor, see table 3 below.

CEF_4 = the calculated combined energy factor for Supplemental Test Four, calculated in section 4.2.8 for the test case described in section 3.3.1.5.

UCEF CREDIT

Functionality credits as defined by utility programs. Up to a +0.1 lb/kWh credit may be given by the utility program administrator for machines that provide users with information that enhance use of energy efficient settings or restore operation to the most efficient setting once a cycle is completed. This is a judgement call, as some machines may have interfaces that do not make this easy, or default cycles that are not substantially known. If there is substantial uncertainty, the credit should not be added.

Weighting Factors Table

Weighting factors are divided into different product categories. This is done because efficient dryers typically have settings designed to provide energy savings, whereas non-ENERGYSTAR dryers do not typically have such consumer options. Efficient dryers will be more likely used in their efficient mode (because they have them, and because consumers presumably purchased them at least in part because they wanted that feature). Table 3 below provides weighting factors based on current understanding of use. Other weightings may be considered in the future.

Table 3 – UCEF Weighting Factors

UCEF Weighting Factors					
	D2	Small	Large	Eco	Fast
Load Weight (lbs)	8.45	4.22	16.9	8.45	8.45
Starting Moisture	57.5% +/- 0.33%	62% +/- 2.0%	62% +/- 2.0%	62% +/- 2.0%	62% +/- 2.0%
End Target Moisture	2%	4%	4%	4%	4%
Moisture Delta	56%	58%	58%	58%	58%
	W0	W1	W2	W3	W4
Approved Weightings	10%	30%	10%	20%	30%

Note:

D2 = DOE Test load

Small = Supplemental test 1

Large = Supplemental test 2

Eco = Supplemental test 3

Fast = Supplemental test 4

Appendix A – Loading Order

This section provides guidance on loading for real clothing in tests 2-6

Jeans (unzipped) were folded in half lengthwise with fronts touching. Jeans were then folded in half (approximately at the knee area). The first pair of jeans was put into the dryer in the direction shown in picture below:



The second item is the towel. It is held by the center, then folded into an “S” shape.



The towel is then placed behind the jeans (near the back of the drum) with the “point” of the towel pointing to the left.



The remaining items (1 pair of corduroy leggings, one t-shirt, one pair of boxers, and one pair of socks) were shaken loose, being certain of no tangling or twisting and placed randomly on top of the jeans and towels.



If the load is a medium or large size...

...the next "layer" is a repeat of the first "layer" with the jeans being at the back of the drum and the towel at the front, putting both items in the dryer facing the opposite position of the first layer.



The next set of corduroy leggings, t-shirt, boxers and socks were placed randomly on top of the second layer of jeans and towel.



If the load is a large size, the next “layer” is a repeat of the first “layer”.