DOCKETED

Docket Number:	17-AAER-01
Project Title:	Appliance Efficiency Pre-Rulemaking for Commercial Tumble Dryers
TN #:	219982
Document Title:	Commercial Dryer Test Protocol_v2.6_ChangesTracked
Description:	N/A
Filer:	System
Organization:	Kannah Consulting
Submitter Role:	Public
Submission Date:	6/30/2017 9:08:33 AM
Docketed Date:	6/30/2017

Commercial Dryer Test Protocol_v2.6_ChangesTracked

This test procedure was developed by the Investor-owned utilities in the state of California so that it may be adopted by the California Energy Commission. Its purpose is to enable commercial tumble dryer appliance standards and utility incentive programs.

Updates from Version 2.5 include: 1) special instructions for â€œstackingâ€ (dual-pocket) dryers and washer-dryer appliances; 2) revisions of the calculations section to separate out values reported for gas and electric and to define an average power factor for the test series; 3) special instructions for the largest tumble dryers covered under the protocol, including a method for cost-effectively creating large textile loads; 4) refinements to the instructions for the automatic termination test for the purposes of clarification; 5) correction of typographical errors and small clarifications to the existing test language.

This is version 2.6 with changes marked relative to version 2.5. There is another document posted to this docket that is a clean copy of version 2.6 without changes marked in detail.

Additional submitted attachment is included below.

Energy Efficiency Test Procedure for
Commercial Tumble Dryers

This test procedure was developed by the Investor-owned utilities in the state of California so that it may be adopted by the California Energy Commission. Its purpose is to enable commercial tumble dryer appliance standards and utility incentive programs.

Prepared by: Suzanne Foster Porter, Kannah Consulting; Dr. David Denkenberger, Denkenberger Inventing and Consulting; Ed Elliott, Ed Jerome and Meg Hunt, Pacific Gas and Electric

Version 2.6
Last revision: June 29, 2017

Updates from Version 2.5 include: 1) special instructions for "stacking" (dual-pocket) dryers and washer-dryer appliances; 2) revisions of the calculations section to separate out values reported for gas and electric and to define an average power factor for the test series; 3) special instructions for the largest tumble dryers covered under the protocol, including a method for cost-effectively creating large textile loads; 4) refinements to the instructions for the automatic termination test for the purposes of clarification; 5) correction of typographical errors and small clarifications to the existing test language.

More information about development of this test procedure, including a description of the data collected, can be found in the California Investor-owned utility (IOU) CASE Report, December 16, 2016 entitled "Commercial Tumble Dryers, Codes and Standards Enhancement (CASE) Initiative for PY 2016: Title 20 Standards Development. Analysis of Test Procedure Proposal for Commercial Tumble Dryers Docket #12-AAER-2D" authored by California IOU consultants Suzanne Foster Porter and Dr. David Denkenberger.

| Deleted: 5 |
| Deleted: December 15, 2016 |
| Deleted: 6 |

1

CONTENTS

1. SCOPE

1.1 ***Introduction.*** This test procedure measures the energy efficiency of commercial dryers with a tumble-type drum that use forced air circulation to dry clothes, uniforms, sheets, towels, pillowcases and other textiles. They are commonly used in apartment buildings, coin-operated laundromats, hotels and motels, health clubs, nursing homes, jails and prisons, universities and colleges, fire and law enforcement stations, hospitals, restaurants, dry cleaners, and laundry service companies.

1.2 ***Scope.*** The test procedure applies to commercial **tumble dryers** with drum volumes equal to or less than 65.0 cubic feet (approximately 210 lb. load rating) that operate on electricity, natural gas and/or propane (liquefied petroleum) gas. The test procedure covers machines built on residential platforms but sold for commercial use, and machines whose platforms are designed for commercial and light industrial use. Dual pocket or "stacked" tumble dryers, stacked washer-dryers sold as one appliance, and appliances that wash and dry textiles in the same drum are included in the test protocol. The test procedure excludes dryers that are sold into the consumer market as defined by 42 U.S.C. 6291(16), and excludes those dryers that operate entirely or in part on external steam heat.

2. REFERENCES

The following documents, in whole, or in part, are referenced in this test protocol and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the reference document (including any amendments) applies.

IEC 60456:2010 (Fifth Edition) The test standard published by the International Electrotechnical Commission ("IEC") titled "Clothes washing machines for household use – Methods for measuring the performance."

IEC 62301 The test standard published by the International Electrotechnical Commission ("IEC") titled "Household electrical appliances—Measurement of standby power."

UL 181:2013 (Eleventh Edition) The standard published by UL titled "Standard for Factory-Made Air Ducts and Air Connectors."

UL 181A:2013 (Fourth Edition) The standard published by UL titled "Standard for Closure Systems for Use With Rigid Air Ducts."

UL 181B: 2013 (Third Edition) The standard published by UL title "Standard for Closure Systems for Use With Flexible Air Ducts and Air Connectors."

Deleted: industrial use.

Deleted: power

Deleted: ," Publication 60456:2010.

Deleted: :2011 (Second Edition) means the

Deleted: ," Publication 62301.

3.   DEFINITIONS

3.1   **Active mode:** Mode in which the **tumble 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 textiles.

3.2   **Adaptive control system**: A dryer system which is capable of automatically adjusting dryer operation or drying conditions based on characteristics of the textile load placed in the drum without allowing or requiring **tumble dryer** operator intervention or action. This can be done by means of a system assessing, directly or indirectly, the **moisture content** of the load. The automatic adjustments may, for example, include automatic selection, modification or control of any of the following: airflow through the drum (fan speed), the burner rate, and/or percent of air recirculated through the drum.

3.3   **AHAM:** Association of Home Appliance Manufacturers.

3.4   **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.

3.5   **Basic dryer model:** The model with unique characteristics that serves to represent one or more configurations of dryers in a manufacturer's product line.

3.6   **Bone dry:** Condition of a load of test cloths 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 0.2 percent or less. This shall be performed in a natural gas dryer in a space at the ambient conditions described in section 5.2.1.

3.7   **Conventional tumble dryer:** a textile dryer that exhausts the evaporated moisture from the cabinet. A **tumble dryer** may be a **natural gas tumble dryer,** a **propane tumble dryer** or an **electric tumble dryer**.

3.8   **Cool down:** Portion of the tumble-drying **cycle** when the added gas or electric heat is terminated and the test cloths continue to tumble and dry within the drum. The number of minutes in this part of the **cycle** is sometimes default based on the **program** selected and sometimes may be set independently.

3.9   **Cycle:** Sequence of operation of a **tumble dryer** which performs a textile drying operation, and may include variations or combinations of the functions of heating, tumbling, and drying.

3.10   **Drum reversal:** optional setting on a **tumble dryer** that enables the drum containing the textile load to alternate clockwise with counterclockwise spin, with the goal of enabling improved load mixing in the drum.

3.11   **Electric tumble dryer:** a **tumble dryer** that uses only electrical service to power its operation.

3.12   **End of the program:** moment in time when the **tumble dryer** indicates the **program** is complete and the load is accessible to the user.

NOTE   Cool down occurs before the **end of the program,** and **wrinkle-prevention mode** occurs after **end of program.**

4

3.13 **Error** refers to ± the allowable error stated by this procedure over a 95 percent confidence interval.

3.14 **Full-sized load:** a load that is considered the full dryer capacity, as calculated by this test procedure.

3.15 **Gas tumble dryer:** a **tumble dryer** that is designed to use natural gas as a fuel for heating during dryer operation. Electrical service to the dryer powers other **tumble dryer** operations, such as the fan and controls.

3.16 **Network mode:** mode where the **tumble dryer** is connected to line voltage and at least one network function is activated (such as reactivation via network command or network integrity communication) but where the primary function (drying textiles) is not active.

NOTE   Where a network function is provided but is not active and/or not connected to a network, then this mode is not applicable. A network function could become active intermittently according to a fixed schedule or in response to a network requirement. A "network" in this context includes communication between two or more separate independently powered devices or products and could occurred wirelessly or via a wired interface. A network does not include one or more controls which are dedicated to a single product. **Network mode** may include one or more standby functions.

3.17 **Initial moisture content (IMC):** Ratio of the weight of water contained by the test load to the bone-dry weight of the test load, expressed as a percent at the beginning of a dry **cycle**.

3.18 **Load size drum capacity**: Volume of the drying drum in cubic feet used to determine the textile load sizes in this test procedure.

3.19 **Measured drum capacity:** Volume of the drying drum in cubic feet as measured and calculated by this procedure.

3.20 **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.

3.21 **Normal Program:** Product mode in which the **tumble 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 textiles shall be considered as "normal".

3.22 **Off mode:** Mode in which the **tumble dryer** is connected to line voltage power source and is not providing any active (drying), **network mode**, 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**.

3.23 **Partial load:** a load that is one-half capacity for the dryer, as defined by this test procedure

3.24 **Power factor**: usually expressed as a percent, **power factor** (PF) is the ratio of the active power (P) consumed (in watts) to the apparent power (S), expressed in volt-amperes (VA) and equal to the product of rms voltage and rms current).

$$PF = \frac{P}{S}$$

NOTE   This definition of **power factor** includes the effect of both harmonic distortion and phase angle displacement between the current and voltage.

3.25 **Program:** series of operations which are pre-defined within the **tumble dryer** which are declared by the manufacturer as suitable for drying certain types of textiles, including periods when heat is applied to the textiles and periods of cool down.

3.26 **Program time:** measured period of time from the initiation of the **program** (excluding any user-programmed delay) until the **end of the program.**

NOTE   Program time may include **cool down**.

3.27   **Propane tumble dryer:** a **tumble dryer** that can operates with propane as the fuel for heating during dryer operation and is not designed to operate with natural gas. Electrical service to the dryer powers other **tumble dryer** operations, such as the fan and controls.

3.28   **Remaining moisture content (RMC):** Ratio of the weight of water contained by the test load to the bone-dry weight of the test load, expressed as a percent at the end of the drying **cycle.**

3.29   **Reported drum capacity:** Volume of the drying drum in cubic feet reported by the manufacturer.

3.30   **Stacked tumble dryer:** A **tumble dryer** with two independently-operated tumble-type drums that use forced air circulation and a heat source to dry textiles. Usually configured with one drum above the other to maximize load capacity in a small footprint.

3.31   **Standby mode:** Any product mode where the energy using product is connected to line voltage 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.

3.32   **Test run (or run):** a single energy efficient assessment on a **cycle** of a **tumble dryer** where data is collected and reported under this test procedure.

3.33   **Test series:** a group of **test runs** on a dryer which, collectively, are used to assess the performance of that **tumble dryer**.

3.34   **Tumble dryer:** commercial dryer with a tumble-type drum that uses forced air circulation and a heat source to dry clothes, uniforms, sheets, towels, pillowcases and other textiles.

3.35   **User-entered cycle time:** The total time, in minutes, selected on the control panel of the commercial tumble dryer operating in timed dry. If there are two timers that separately control the number of minutes of heat and the number of minutes of **cool down,** then the **user-entered cycle time** is the sum of values entered for those two timers (expressed in minutes).

3.36   **Ventless tumble dryer: Tumble 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.

3.37   **Weighted average test load age**: the weighted average article age of a load used for a **test run** (see section 5.6.4).

3.38   **Wrinkle-prevention mode:** a low power mode of operation that may be initiated at the conclusion of a **cycle** to reduce the prevalence of wrinkles when the textile load is not removed immediately from the **tumble dryer.**

4.   BASIC DRYER MODEL SELECTION

4.1   ***Definition of a basic dryer model for the purposes of the test.*** The **test series** shall be performed on every **basic dryer model**. Generally, a **basic dryer model** has a unique model number given by the manufacturer. However, in cases where the following characteristics do not change, the **test series** for the **basic dryer model** can be reported for another dryer with a different manufacturer-assigned model number:

1) Fuel type (natural gas/electric, propane/electric or electric only)
2) Drum capacity
3) Burner BTU output rating
4) Fan volumetric rating (e.g. cubic feet per minute)
5) **Adaptive control system,** including the hardware, firmware, and software controls
6) Operator control package (coin-op, on-premises, etc.)
7) Reversing drum capability presence or absence
8) Automatic termination presence or absence
9) Exhaust or air inlet configuration/placement
10) Physical design, including motor model, fan model, heat exchanger model, and other characteristics of the design that impact energy use.

If any one of the above listed characteristics changes, then that dryer should be considered a new **basic dryer model** for the purposes of this test protocol. This is a new **basic dryer model**, regardless of whether the manufacturer assigns or does not assign a new model number for that dryer.

Note that if the distributor makes any software changes or updates and that software update results in either 1) increases in energy use of that **tumble dryer** under this protocol or 2) reductions in energy efficiency of the **tumble dryer** under this protocol, then that dryer is considered, for the purposes of this test procedure, a new **basic dryer model** and must be retested to verify the energy use of the new model.

NOTE   This includes changes to the default conditions of the dryer that could impact the energy efficiency measurements under this protocol.

The following characteristics about a dryer can change and the **test series** for the **basic dryer model** can be reported for the alternate model:

1) Input voltage and frequency (for **gas tumble dryers** and **propane tumble dryers** only)
2) Brand name
3) Model number
4) Door closure mechanism (if the drum volume does not change)

NOTE   Per the test procedure, the **basic dryer model** is tested at the highest input voltage available for a particular model.

4.2   ***Dryer models designed to operate on natural gas or propane gas.*** If the dryer can operate on natural gas or propane, then the dryer shall be tested with natural gas and tested again with propane. If the dryer is capable of being operated with propane, but is not able to operate with natural gas, then the dryer is considered a **propane tumble dryer** and shall only be tested with propane per this test procedure.

4.3   *Stacked tumble dryers.* If the two tumble-type drums (also known as pockets) in a **stacked tumble dryer** have identical characteristics one through ten listed below, then the lower pocket shall be tested and reported for the purposes of this test procedure.

1) Fuel type (natural gas/electric, propane/electric or electric only)
2) Drum capacity
3) Burner BTU output rating
4) Fan volumetric rating (e.g. cubic feet per minute)
5) **Adaptive control system,** including the hardware, firmware, and software controls
6) Operator control package (coin-op, on-premises, etc.)
7) Reversing drum capability presence or absence
8) Automatic termination presence or absence
9) Exhaust or air inlet configuration/placement
10) Physical design, including motor model, fan model, heat exchanger model or configuration, and other characteristics of the design that impact energy use.

If any one of the above listed characteristics changes, then both pockets shall be tested under the test protocol, and the energy performance of each pocket shall be separately reported.

4.4   *Dryer-washer combination appliances.* Stacked two-drum washer-dryers sold as one appliance or combination washer-dryers that have washing and drying in the same drum shall be tested with the function of a dryer for the purposes of this test procedure.

5.   TESTING CONDITIONS

5.1   Installation

5.1.1   *All tumble dryers.* For both **conventional dryers** and **ventless tumble dryers** install the **tumble 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. If there are multiple ways that a **tumble dryer**'s air intake or exhaust duct may be configured, then the dryer shall be tested with the air intake and/or exhaust configuration that it is shipped with. If any of the manufacturer's instructions for installation conflict with any part of the requirements of the test procedure, the dryer shall be tested per the provisions of the test procedure. 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**. Testing shall be performed at an atmospheric pressure at least 13.7 pounds per square inch absolute (psia). The dryer should be near new and shall have undergone fewer than 200 dryer **cycles**.

For **tumble dryers** with water service, the water service shall be attached for the purposes of the testing. For tumble dryers with compressed air service, compressed air service that meets manufacturer's specifications shall be attached for the purposes of testing.

NOTE   Water service is usually used for fire suppression systems or for washing textiles in second stacked washing machine drum or in the dryer drum itself. Compressed air service is often used to clean lint from air blowers and other components.

For **standby**, **network**, and **off mode** testing, the **tumble dryer** shall also be installed in accordance with section 5, paragraph 5.2 of IEC 62301 (Second Edition) (incorporated by reference), disregarding the provisions regarding batteries and the determination, classification, and testing of relevant modes. For **standby**, **network** and **off mode** testing, all lighting systems shall remain connected.

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 5.1.2 of this test procedure.

NOTE   Some dryers give the installer the ability to alter the outlet temperature control of the exhaust. This shall be tested in the as-shipped condition unless specific installation directions for the dryer require adjustment of the control of the outlet temperature.

5.1.2   *Conventional tumble dryers.* For **conventional tumble dryers,** the **tumble** dryer exhaust shall be restricted using the duct simulator described herein. All exhaust ports of a **stacked tumble dryer** shall be restricted by attaching the duct simulator. If there is a dedicated inlet port used for air intake into the dryer, this shall be restricted by attaching a second duct simulator to that inlet port for air intake. This means that dryers with both exhaust ducts and air intake ducts, simulators will be attached to both the inlet and the exhaust during installation. Each duct simulator shall be configured as described below. All joints between the dryer outlet and the duct simulator shall be taped to avoid air leakage.

The simulator attached to the **conventional** **tumble dryer** shall match the applicable duct diameter specified by the manufacturer. If no specification is given, the diameter of the duct shall match the diameter of the applicable outlet or inlet. The duct shall be constructed according to Figure 5.1.2a with additional dimensions and tolerances shown in Table 5.1.2. It shall be constructed of 22 to 26-gauge galvanized sheet metal with a linear seam of either snap-lock or permanent construction. To avoid air leakage, all joints in the duct shall be welded or taped with tape that meets the applicable requirements of UL 181, UL 181A, and UL 181B.
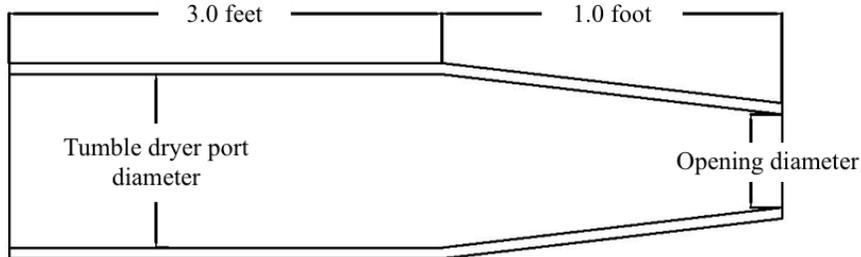
| Deleted: All |
| Deleted: , taped with duct tape, |
| Deleted: aluminum tape to avoid air leakage |

Figure 5.1.2a — Duct simulator geometry (not to scale). Modified from Figure 1, ANSI/AHAM HLD-1-2010.

9

Table 5.1.2 shows the dimensions and allowable **error** that shall be used for the duct simulator. Axial length is along the length of the duct. For fabrication convenience, the third column is shown in fractions of an inch. For all duct sizes, the straight axial length shall be 3.00 feet ±1.0 inch and the taper axial length shall be 1.00 foot ± $\frac{1}{4}$ inch. The axial overlap of the simulator and the dryer port shall be 1.5 inches ±1.0 inch.

Table 5.1.2—Dimensions of the duct simulator for each air intake and exhaust port size

Air intake/ exhaust port diameter (inches)	Opening diameter (d), decimal (inches)	Opening diameter (d), fraction (inches)	Opening diameter +/- allowable error (inches)
4	2.88	$2\frac{7}{8}$	$\pm\frac{1}{32}$
6	4.69	$4\frac{11}{16}$	$\pm\frac{1}{32}$
8	6.58	$6\frac{19}{32}$	$\pm\frac{1}{16}$
10	8.62	$8\frac{20}{32}$	$\pm\frac{1}{16}$
12	10.55	$10\frac{5}{8}$	$\pm\frac{1}{16}$
14	12.52	$12\frac{1}{2}$	$\pm\frac{1}{16}$
16	14.48	$14\frac{15}{32}$	$\pm\frac{1}{16}$
18	16.47	$16\frac{15}{32}$	$\pm\frac{1}{16}$
20	18.51	$18\frac{1}{2}$	$\pm\frac{1}{8}$
22	20.51	$20\frac{1}{2}$	$\pm\frac{1}{8}$
24	22.55	$22\frac{18}{32}$	$\pm\frac{1}{8}$

NOTE   The duct simulator is approximately equivalent to 50 linear feet of straight smooth duct.

The opening (outlet) of the duct simulator may be placed one opening diameter (d) away from a solid surface (often the floor) that is in a plane parallel to the flow of the air exhausting from the simulator. All other obstructions (including, but not limited to, temperature, airflow, and humidity measurement instruments, walls or solid surfaces perpendicular or parallel to the exhaust stream) shall be a placed at a radial distance greater than or equal to the product of three (3) and the opening diameter (d) for the relevant simulator (not the dryer outlet diameter). In other words, all obstructions must be on the outside of the semicircle shown in the overhead view of the simulator in Figure 5.1.2b, where the radius of the semicircle is the product of 3 and d, where d is the opening diameter of the duct simulator shown in the second and third columns of Table 5.1.2, and the center point of that semicircle is the center of the outlet of the simulator.
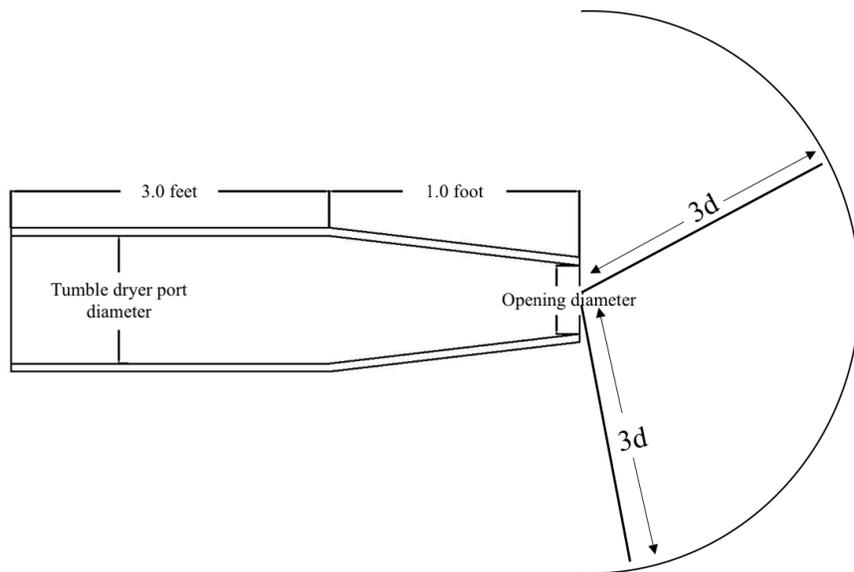

Figure 5.1.2b — Distance from outlet duct simulator to any obstruction (overhead view, not to scale). Modified from Figure 1, ANSI/AHAM HLD-1-2010.

5.1.3 *Ventless tumble dryers.* For **ventless tumble dryers** the dryer shall be tested without the duct. If the manufacturer gives the option to use a **ventless tumble dryer**, with or without a condensation box, the dryer shall be tested with the condensation box installed.

5.1.4 *Tumble dryer drum cleaning.* For all **tumble dryers**, the drum, door, and any other surfaces on the dryer that may come in contact with the test textiles over the course of the test procedures described herein shall be cleaned thoroughly before the start of the test series to remove any oily or chemical manufacturing residue. For safety, the dryer shall be at the temperature of the ambient conditions specified is section 5.2.1 or cooler when it is

11

cleaned. The interior surfaces shall be cleaned with one or more soft cloths that have been dampened with a solution of approximately 91 percent isopropyl alcohol and 9 percent purified water. The cleaning shall be complete when no more residue is apparent on a cloth and the cloth has been wiped on every surface that will come in contact with the textiles over the course of the test (drum, door, etc.). This cleaning is done once before any tests are conducted.

5.2   Ambient temperature and humidity

5.2.1   For **active mode tumble dryer** testing, maintain the room ambient air temperature at 65 ± 1.5 ºF and the room relative humidity at 50 ± 5 percent on average and for at least 95 percent of the time. The sensors measuring the room ambient air temperature and humidity shall be placed 3.0 to 12.0 inches from the air intake of the dryer. The sensors shall be shielded from radiant heat coming from the burner, combustion enclosure and the dryer housing.

5.2.2   For **wrinkle-prevention**, **standby**, **network,** and **off mode** testing, maintain room ambient air temperature conditions as specified in section 4, paragraph 4.2 of IEC 62301 (Second Edition).

5.3   Energy supply

5.3.1   *Electrical supply.* If the **basic dryer model** for an **electric tumble dryer**, **gas tumble dryer,** or **propane tumble dryer** has a multiple voltage conversion and/or input frequency capability or configurability, conduct the test with 60 hertz at the highest input voltage available for that model. For **electric tumble dryers**, maintain the electrical supply at the **tumble dryer** terminal block within 1 percent of voltage specified by the manufacturer for that **basic dryer model** and within 1 percent, for at least 95 percent of the time, of the nameplate frequency as specified by the manufacturer. For **gas tumble dryers** and **propane tumble dryers**, it is acceptable to operate on grid-supplied line voltage and frequency as long as voltage is maintained within 10 percent of nameplate voltage.

NOTE   Depending on the size of the dryer, input voltage may be single or three phase and may be 120 V up to 460 V or higher.

5.3.1.1   *Supply voltage waveform for standby, network, and off mode testing.* For the **tumble dryer standby mode**, **network 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).

5.3.2   *Gas supply.*

5.3.2.1   *Natural gas.* Maintain the gas supply immediately ahead of the **tumble dryer** at a pressure of 7 to 10 inches of water column. The natural gas supplied should have a higher heating value of $1,025 \pm 100$ BTUs per standard cubic foot. The actual heating value, H_n, in BTUs per standard cubic foot for the natural gas to be used in the test shall be obtained either from measurements made by the laboratory using test instrumentation that meets **error** requirements described in section 5.4 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 instruments with allowed **error** described in section 5.4.

Careful attention must be paid to the pressure drop between the pressure measurement probe and the gas intake of the dryer if the measurement probe is not immediately ahead of the dryer's gas intake. Larger diameter pipe and fittings or multiple gas line pressure probes may be needed to confirm required supply pressure.

5.3.2.2 *Propane (liquefied petroleum) gas.* Maintain the gas supply immediately ahead of the **tumble dryer** a pressure of 11 to 13 inches of water column. The propane gas supplied shall have a higher heating value of 2,500 ±250 BTUs per standard cubic foot. The actual heating value, H $_p$, in BTUs per standard cubic foot for the propane gas to be used in the test shall be obtained either from measurements made by the laboratory using test instrumentation that meets **error** requirements described in section 5.4 or by the purchase of bottled propane gas whose BTU rating is certified to be at least as accurate a rating as could be obtained from instruments with allowable **error** described in section 5.4.

NOTE 2 Careful attention must be paid to the pressure drop between the pressure measurement probe and the gas intake of the dryer if the measurement probe is not immediately ahead of the dryer's gas intake. Larger diameter pipe and fittings or multiple gas line pressure probes may be needed to confirm required supply pressure.

5.4 Instrumentation

5.4.1 *General instructions on instrumentation and error.* All measurements shall be made to **error** tolerances described in this section. Unless otherwise specified, the resolution of the instruments shall be no larger than one quarter (¼) of the maximum allowable **error**.

5.4.2 *Scale for test cloth weight.* The weight of all test load textiles shall be reported in pounds with an **error** no greater than 0.1 percent of any measured value above three pounds.

NOTE 1 In order to maintain the **error** tolerance required for the weight of the test cloth, careful attention must be paid to the range of the scale. It is possible that in order to implement the requirements of the test procedure for all the test load textiles encountered in this test procedure, multiple scales will need to be employed for different ranges of textile weights.

NOTE 2 When determining the appropriate size scale, note that the scale must accurately measure the **bone dry** weight and the wet weight of the textiles loads. The wet weight can be as much as twice the dry weight, given the range of the **initial moisture contents (IMCs)** for this procedure and the weight of the container. The approximate scale range needed to perform the full scope of textile loads described in this test procedure is from 4 to 400 lbs.

5.4.3 *Weighing scale for commercial dryer drum capacity measurement of irregular drums.* The scale shall have a range of 0 to a maximum of at least 1000 pounds with resolution of 0.50 pounds and a maximum **error** no greater than 0.5 percent of the measured value.

5.4.4 *Kilowatt-hour meter.* For **electric tumble dryers**, the kilowatt-hour meter shall have a resolution of 0.2 percent of the **cycle** energy use or smaller and a maximum **error** no greater than 1 percent of the **cycle** energy use for electric dryers. For **gas tumble dryers** and **propane tumble dryers**, ±5 percent **error** is acceptable.

5.4.5 *Gas flow rate meter.* The gas flow rate meter shall have a resolution of 0.2 percent of the **cycle** energy use and a maximum **error** no greater than 1.0 percent (uncompensated for temperature and pressure) of the **cycle** energy use.

NOTE The tolerance of the gas flow rate meter is a maximum **error** on the **cycle** energy use value recorded in this test procedure. The **error** of the gas flow rate meter is usually specified by the meter manufacturer at the maximum range (highest throughput) of the meter, so at partial flow rates, the **error** of the meters is larger. Given this, in order to measure the gas flow rate for the range of **tumble dryers** covered by this test procedure it is very likely that different flow rate meters will need to be employed to meet these tolerances for the range of dryers covered under this test procedure.

5.4.6   *Relative humidity meter.* The relative humidity meter (dry and wet bulb psychrometer or other instrument) with a maximum **error** tolerance of ± 2 percent relative humidity acceptable for measuring the ambient humidity. If the **error** tolerance of the psychrometer is given in temperatures, it shall be maximum ±1°F.

5.4.7   *Temperature.* All temperature sensors employed for test shall have an **error** no greater than ±1 °F.

NOTE   The **error** tolerance on temperature includes the temperature measured to conduct the temperature compensation for the **gas flow rate meter.**

5.4.8   *Gas pressure.* Atmospheric pressure sensors shall have a maximum **error** of 0.01 psia. Gas supply pressure sensors shall have a maximum **error** of 0.001 psig (0.4 inches of water).

NOTE   The **error** tolerance on atmospheric pressure includes the temperature measured to conduct the temperature compensation for the **gas flow rate meter.**

5.4.9   *Gas energy content meter.* The gas energy content meter shall have an operating range of at least 750 to 3,500 BTU per cubic foot. The maximum **error** shall be no greater than 1 percent of the actual higher heating value of the gas used in the test.

NOTE   A continuous flow calorimeter or a gas chromatograph are two instruments that can be used to meet the requirements of the test procedure.

5.4.10   *Standby mode, network mode, and off mode watt meter.* The watt meter used to measure **standby mode**, **network 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).

5.4.11   *Measurements of time.* All time measurements, including measurements of **program time** used in the test procedure shall have a maximum **error** of +/- 5 seconds.

NOTE   Using the data acquisition system or other instrument time stamp is recommended to determine the **program time** as required by the test procedure. A minimum of 5 second interval data on the electrical energy meter is one method to easily achieve this maximum **error** of +/- 5s. Gas flow often does not begin immediately at the start of a dryer **cycle**; however, the tumbling motor and fan turn on immediately upon start. Other timepieces are suitable for ensuring that the textiles are not exposed to the ambient air conditions for longer than allowed by the test procedure.

5.4.12   *Measurements of distance.* Unless otherwise specified, all distances measured in the test procedure shall be +/- one-eighth (1/8) of an inch with a resolution of one-sixteenth (1/16) of an inch.

5.5   Test textiles

This section specifies the energy performance test textiles used under this procedure, and methods for pre-conditioning and regularly normalizing the textiles to ensure repeatable and consistent test results.

14

5.5.1 **_Energy performance test textiles._** The textiles used during the course of energy performance testing of commercial **tumble dryers** shall be bed sheets, pillowcases and hand towels as described in IEC 60456:2010, Annex C, section C.1 and table C.1 (cotton base load). They shall not be used for any purpose other than testing under this protocol or other dryer energy performance protocols.

5.5.2 **_General requirements for preconditioning, normalizing, and wetting textiles._** Any time a textile is wetted for the purposes of washing, rinsing, or dampening under this procedure, the textile load must be placed in a washing machine capable of applying a volume of water to the textiles in gallons that is at least half as many as the number of pounds of the test load (i.e. the water weighs at least four times as much as the clothing).

5.5.4 **_Energy performance test textile preconditioning_.** Before textiles are used for a dryer **test run**, the textiles shall be treated as follows:
 (1) **Bone dry** the textiles to a weight change of ± 0.2 percent, or less, as prescribed in section 3.6 of this test procedure.
 (2) Wash the textiles for 10 minutes in soft water that shall have 17 parts per million hardness or less using 3.6 grams of **AHAM** standard test detergent Formula 3 per pound of bone dry load. Wash water temperature at service point on the washer shall be 140 °F ±5 °F (60.0 °C ±2.7 °C) (hot water). Rinse water temperature is to be controlled at 100 °F ±5 °F (37.7 °C ±2.7 °C) (warm water).
 (3) Rinse the textiles again at the same water temperature.
 (4) **Bone dry** the textiles as prescribed in section 3.6 of this test procedure and weigh the load.
 (5) Steps (2) through (4) are repeated until there is a weight change of 0.5 percent or less when compared to the prior **bone dry** measurement performed.
 (6) A final hot water wash with no detergent shall be performed, followed by two warm water rinses.
 (7) **Bone dry** the textiles once again, as prescribed in section 3.6 of this test procedure, and weigh the load. This weight shall also change 0.5 percent or less from the prior measurement. If the weight change is greater than 0.5 percent, then steps 6-7 shall be repeated.
 (8) Once the weight change has been verified to be 0.5 percent or less, then the textiles shall be rinsed with warm 100 °F ±5 °F (37.7 °C ±2.7 °C) controlled electrical conductivity water at 100-200 microSiemens per centimeter (µS/cm) three times. The load may be dried in any manner or not at all before using for testing.

5.5.5 **_Energy performance test textile article life._** The number of **test runs** performed with any individual test textile article used in this procedure shall be tracked using a reliable system. The number of **test runs** on any article shall not exceed 80, excluding preconditioning drying runs described in section 5.5.4 and normalization runs described in section 5.5.6 (1 though 3 only). Any **bone drying** after the textile preconditioning sequence or the normalization sequence shall be counted as one **cycle**. **Test runs** that result in data that are outside of the specifications of the test procedure and cannot therefore be used as a valid **run** for the purposes of reporting energy performance under this procedure are also considered a test **run** on an article. The **weighted average test load age** for the articles in each **test run** performed shall be reported according to section 7.4.

15

5.5.6 *Test textile article normalization.* In order to maintain consistent performance of the textiles, the test textiles shall be normalized every 9 to 12 **test runs**, not including preconditioning **cycles**. For normalization, the textiles shall be treated as follows:

 (1) Wash the textiles for 10 minutes in soft water that shall have 17 parts per million hardness or less using 3.6 grams of **AHAM** standard test detergent Formula 3 per pound of **bone dry** load. Wash water temperature at service point on the washer shall be 140 °F ±5 °F (60.0 °C ±2.7 °C) (hot water). Rinse water temperature is to be controlled at 100 °F ±5 °F (37.7 °C ±2.7 °C) (warm water).

 (2) Rinse with warm 100 °F ±5 °F (37.7 °C ±2.7 °C) controlled electrical conductivity water (100-200 µS/cm) three times.

 (3) Dry the textiles using the procedure for **bone dry** or in a **tumble dryer** on high heat for the purposes of storage and future use.

 (4) If the textiles are dried for future use, then before conducting subsequent **test runs**, the articles shall be **bone dried** as part of the load in according to section 3.7 to reestablish the **bone-dry** weight. This second drying after normalization shall be counted towards the 80 allowed **runs** on the textiles.

NOTE   After normalization, the textiles may be **bone dried** and used immediately for the purposes of testing a dryer. In this case, the textile load would be assembled before the normalization sequence normalized, and then **bone dried** to establish the weight. The load may also be normalized, dried, and stored for future testing. Then, future **bone drying** would be counted in the total number of allowable **runs** on the test cloths.

5.6 Test Loads

5.6.1 *Weight determination for full-sized load.* To determine the target weight (W_{full}) for the **full-sized load** (in pounds), take the product of two and a half (2.5) and **load size drum capacity** (V_{drum}) in cubic feet as determined in section 6.

$$W_{full} = 2.5V_{drum}$$

5.6.2 *Weight determination for a partial load.* To determine the target weight ($W_{partial}$) for the **partial load** (in pounds), take the product of one and one quarter (1.25) and the **load size drum capacity** (V_{drum}) in cubic feet as determined in section 6.

$$W_{partial} = 1.25V_{drum}$$

5.6.3 *Composition of test load.* Using the target full load weight (W_{full}) or the target **partial load** weight ($W_{partial}$) determined by section 5.6.1 or 5.6.2, respectively, prepare a load with sheets, pillowcases and hand towels. The contributing weight of the of sheets is approximately equal to the contributing weight of the pillowcases, which is approximately equal to the contributing weight of the hand towels, such that each type of article contributes to approximately one-third of the total weight.

First, assemble the part of the load that will be made up by sheets. The target **bone dry** weight of the sheets (w_{sheets}) is equal to:

$$w_{sheets} = 0.33 * W$$

16

where W is the target load weight (either full or partial). Sheets shall be added or removed until the **bone dry** weight of the sheets (w_{sheets}) $\pm$ 0.80 pounds is achieved. Sheets shall only be added in full, and not altered in any way to achieve the target (such as cutting the sheet).

Second, assemble the part of the load that will be made up by pillowcases. The target **bone dry** weight of the pillowcases ($w_{pillowcases}$) is equal to

$$w_{pillowcases} = 0.33 * W$$

where W is the target load weight (either full or partial). Pillowcases shall be added or removed until the **bone dry** weight $w_{pillowcases}$ $\pm$ 0.26 pounds is achieved. Pillowcases shall not be altered or cut in any way to achieve the target and tolerance.

Once the individual weights and tolerances of the sheets and pillowcases have been separately verified, then the load is combined. Towels are then added to make up the remainder of the load up to the target weight (W).

The actual **bone dry** load weight shall be within +/- 0.25 pounds of the target weight. Once combined, the weight shall be adjusted to this final tolerance only by adding or removing hand towels.

The **bone dry** weight of the load shall be reestablished every 9 to 12 **runs**, after the normalization sequence (section 5.5.6) is complete. If necessary at that time, the load will be adjusted to stay within the average age of the test load and within the overall **bone dry** load weights for sheets (w_{sheets}), pillowcases ($w_{pillowcases}$), and overall (W) required in this section.

5.6.4　*Average age of the test load*. The **weighted average test load age** shall be equal to or between 30 and 50 **runs**. The **weighted average test load age** (A), expressed as the number of **runs**) is defined as:

$$A = \frac{1}{\sum n_i \, w_i} * \sum n_i w_i \, a_i$$

17

where a_i is the age of the test article in number of **test runs** (not including preconditioning or normalization **runs**), n_i is the number of articles (of the same type and age), w_i is the nominal mass per article given in pounds in table 5.6.4.

Table 5.6.4—Nominal test textile article weight for use in calculating the average age of the test load.

Article	Nominal mass (in pounds)
Sheet	1.60
Pillowcase	0.529
Hand towel	0.243

NOTE   The mass of the test load is expected to decline slightly with increasing age. If performing a number of **test runs** with a single load, care should be taken to select an initial load that is not expected to fall outside of the **bone dry** weight tolerances specified herein over the course of the full **test series**.

5.7   Test load handling

5.7.1   *Method of wetting textiles with one washer cycle.* If the washer can accommodate the full dryer load, then the load shall be prepared with one washer cycle. Dampen the load by agitating it in water whose temperature is 60 °F ± 5 °F and consists of 100-200 µS/cm conductivity for approximately 2 minutes to saturate the fabric. The amount of the water shall consist of a volume of water in gallons that is at least half as many as the number of pounds of the test load (i.e. the water weighs at least four times as much as the clothing). Then, extract water from the wet test load by spinning the load in until the **moisture content** of the load meets the target **IMC** of the test load +/- 2.0 percentage points. The textiles shall be handled as specified in section 5.7.3.

If moisture target is above the target range (**IMC** +/- 0.02) by the end of the first damping and spinning process, the textiles may immediately be placed back into the washer and spun a second time to try to achieve the target **IMC**. If, after a second spin cycle of the washer, the textiles continue to be outside the target **moisture content**, then restart the wetting method from the beginning.

If the final **IMC** is lower than the target **moisture content** range, restart the wetting method from the beginning, starting with wetting the textiles in the washer.

5.7.2   *Method of wetting textiles with two washer cycles.* The preferred method for wetting textiles is to dampen and spin the entire textile load (5.7.1). However, if the washer in use is of smaller capacity than the load required for dryer testing, and the **bone dry** load weight is greater than 80.0 pounds, it is permissible to prepare the dryer load with no more than two washer cycles. Separate the load into two groups such that each group contains one-half of the number of each type of article (sheets, pillowcases, and towels). In the case where there is an odd number of articles of a single type, then use those articles to make the weight of the groups as equal as possible to one another.

18

Dampen and prepare the first half of the load (the first load group) per section 5.7.1, and use an insulated vessel specified in section 5.7.3.2 to transfer, weigh, and maintain the condition of the first group of textiles. The first group of textiles must meet the moisture content range (**IMC** +/- 0.02) of the whole load.

Next, dampen and prepare the second half of the load (the second load group) per section 5.7.1, and use a standard vessel and time limits specified in section 5.7.3.1 to transfer and weigh the second group of textiles. The second group of textiles must meet the moisture content range (**IMC** +/- 0.02) of the whole load. The total time the wetted textiles are exposed to the atmosphere in the process of loading, unloading and weighing shall be less than five (5) minutes for an uninsulated tub.

The time that the first group exits the washer to the time that both groups enter the dryer can be no more than 30 minutes in total time. If this time is exceeded, then the load cannot be used for the test.

The weights of the two loads shall be summed to calculate the IMC of the full textile load.

5.7.3 **_Method of handling textiles before and after weighing._** In general, the impact of the ambient conditions on the textiles while loading the dryer, unloading the dryer, and weighing the textiles shall be minimized as much as practical. Handling textiles properly reduces small changes to the **moisture content** of the textile load as well as small changes to the temperature of the textiles when they come out of the washer and are placed into the dryer. There are two methods allowed for handling textiles: using a standard vessel and using an insulated vessel.

5.7.3.1 **_Using a standard vessel to transfer wet textiles_**. Before the start of a dryer **test run**, the total time the wetted textiles are exposed to the atmosphere in the process of loading, unloading and weighing shall be less than five (5) minutes for an uninsulated tub. When not in the washer nor in the dryer, the textiles shall be kept in a vessel that has all sides and bottom that are impermeable to water vapor. The vessel may have an open or closed top. If using a vessel that has an open top (with no lid or other means for reducing water vapor transfer between the air and the textiles, textiles are considered exposed to the atmosphere from the time the washer door is opened to the time the dryer door is closed.

5.7.3.2 **_Using an insulated vessel to transfer wet textiles._** An alternative to using a standard tub is to use an insulated vessel with a tight-fitting lid. The textiles shall fill 50% or more of the total volume of the tub. The insulated vessel shall have an insulation value of at least R-4 h·ft^2·°F/BTU. Using this method, the textiles can be kept in the sealed insulated tub in the conditioned room for an additional 15 minutes (for a total of 20 minutes). The time that the textiles are exposed to the air (without the lid) shall be no more than 5 minutes.

5.7.3.3 **_Using a standard vessel to transfer dry (low RMC) textiles._** After the completion of the **test run** or a **bone drying** sequence, the textiles shall be unloaded from the dryer into a vessel impermeable to water vapor with a tight-fitting lid (standard or insulated) and

19

immediately weighed. The total time from the time the dryer door opens and the time the tight-fitting lid is applied shall be less than one minute.

5.7.3.4 ***Using an insulated vessel to transfer textiles after automatic termination run.*** For automatic termination **runs** that require additional 10-minute high heat timed segments to obtain the target **RMC** required by the procedure, an insulated vessel that has all sides and bottom that are impermeable to water vapor that also has a tight-fitting lid shall be used. The insulated vessel shall have an insulation value of at least R-4 h·ft^2·°F/BTU. Using this method, the total time the textiles are exposed to the atmosphere in the process of loading, unloading and weighing shall be less than five (5) minutes each time the textiles are transferred from the dryer to the scale and back again.

NOTE   In practice, these requirements will require the test lab to identify an appropriate vessel with and without a lid, depending on whether they are wet or dry, weighing the textiles and the tub, and then subtracting off of weight of the tub with a tare function on the scale or by hand.

5.7.4 ***Method of loading textiles into the tumble dryer****.* Load the textiles by placing them into the drum in an evenly distributed fashion that also allows completion of the loading within the time limits specified in section 5.7.3.

5.8   Tumble dryer preconditioning.

5.8.1 ***General preconditioning before any dryer test run.*** Clean the lint trap(s) thoroughly before each **test run**. Before each **run**, any sensors in the drum, including moisture sensors, shall be inspected. If lint is observed on the sensor area, the senor shall be wiped with a dry soft cloth to remove any lint build up.

5.8.2 ***Conventional tumble dryers standard start****.* For **conventional tumble dryers**, before every test **run**, 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 5.2.1.

5.8.3 ***Ventless and heat pump tumble dryers standard start****.* For **ventless tumble dryers** and heat pump **tumble dryers**, before every test **run**, the steady-state temperature measured at the compressor or heat exchanger inlet and outlet must be within the ambient room temperature range described in section 5.2.1 for a minimum of ten minutes. **Tumble dryers** with **load size drum capacity** less than 7.5 cubic feet may be left at ambient room conditions for at least 6 hours between tests as an alternative to measuring dryer component temperatures. A **tumble dryer** with **load size drum capacity** greater than 7.5 cubic feet but less than or equal to 13 cubic feet may be left at ambient room conditions for at least 12 hours between tests as an alternative to measuring dryer component temperatures. A **tumble dryer** with **load size drum capacity** greater than 13 cubic feet may be left at ambient room conditions for at least 24 hours between tests as an alternative to measuring dryer component temperatures.

20

6. DRUM CAPACITY DETERMINATION

6.1 *General instructions for dryer drum capacity determination.* The purpose of the drum capacity measurement is to determine the appropriate drum volume for calculating textile load sizes used in this test procedure (the **load size drum capacity** or V_{drum}).

The **measured drum capacity** (*C*) of the dryer shall be determined according to the appropriate method in this section (6.2 or 6.3). If the **measured drum capacity** is within +/- 5.0 percent of the **reported drum capacity**, then the **reported drum capacity** shall be the **load size drum capacity** (V_{drum})**.**

If the **measured drum capacity** (*C*) is <u>NOT</u> within +/- 5 percent of the **reported drum capacity**, then the measurement shall be repeated and the drum capacity values (in cubic feet) shall be averaged. If the average of the **two measured drum capacity** (*C*) values is within +/- 5 percent of the **reported drum capacity**, then the **reported drum capacity** shall be equal to the **load size drum capacity** (V_{drum}). If the average of the two **measured drum capacity** (*C*) values is NOT within +/- 5 percent of the **reported drum capacity**, then the average of the **measured drum capacity** (*C*) values shall be the **load size drum capacity** (V_{drum}).

6.2 *Commercial dryer drum capacity measurement for irregular drums.* This measurement method is for tumble dryers with **reported drum capacity** less than or equal to 9.5 cubic feet. To determine the **measured drum capacity**, measure the drum capacity by sealing all openings in the drum except the loading port with a plastic bag, and ensuring that all corners and depressions are filled and that there are no extrusions of the plastic bag through any openings in the interior of the drum. Fill the drum with water to a level determined by the intersection of the door plane and the loading port (i.e., the uppermost edge of the drum that is in contact with the door seal). Record the temperature of the water and then the weight of the dryer with the added water and then determine the weight of the water in pounds. Next, determine the appropriate *volume adjustment:* add the appropriate volume to account for any space in the drum interior not measured by water fill (e.g., the space above the uppermost edge of the drum within a curved door) and subtract the appropriate volume to account for the space that is measured by water fill but cannot be used when the door is closed (e.g., space occupied by the door when closed). The **measured drum capacity** is calculated as follows:

$$C = \frac{w}{\rho} + volume\ adjustment$$

where *C* is the **measured drum capacity** in cubic feet, *w* is the mass of water in pounds and ρ is the density of water at the measured temperature in pounds per cubic foot.

6.3 *Commercial Dryer drum capacity measurement with uniform drums*. This measurement method is for tumble dryers with **reported drum capacity** greater than 9.5 cubic feet. The **measured drum capacity** in cubic feet (*C*) shall be determined using a tape measurement

method. Unless otherwise noted, measurements inside the drum shall be made with a ½"
or narrower metal tape measure. Measurements of the interior of the drum shall be
measured to the nearest 1/16 of an inch. All measurements shall be made twice and
averaged for that measurement. The following shall be recorded:

(a) The number of baffles (n) shall be counted.
(b) Drum diameter (d). If the drum is perforated, a stiff metal rod that is at least 2
inches longer than the diameter of the drum shall be placed through the open
mesh of the drum on one end and through the open mesh of the drum directly
across from the first insertion. Care shall be taken to ensure the rod crosses the
center line of the drum. Using a fine line pen, mark the rod exactly where the
rod meets the drum on both ends of the rod. Then, remove the rod and measure
the distance between the marks. If the drum is not perforated, then a tape
measure or other instrument with error equal to or less than 1/16 of an inch shall
be used.

NOTE   In the case that the drum is perforated, to ensure the rod will cross the centerline, you may use the uniform mesh as a
guide. Count the holes in the mesh to locate a position centered between two baffles and a specific distance (number of
holes) from the door. Mark this location with a pen and do the same on the opposite side of the drum (this only works if
there is an even number of baffles). Then, insert the rod into the two marked locations and proceed with using a fine lined
pen to mark the distance.

NOTE   For drums that are not perforated, if the dryer has an even number of baffles that are opposite from one another in the drum,
using opposite sides of opposing baffles as guide may help to ensure the diameter measurement passes through center.

NOTE   Other instruments, such as a radius gauge, may be used if the resulting error is less than or equal to 1/16 of an inch on
the diameter measurement.

NOTE   Particular attention shall be paid to the diameter of the drum (d), as its value is more difficult to ascertain and its value
impacts the volume measurement.

(c) Drum depth (l): the distance from the back plane of the drum to the front plane
of the drum.
(d) Baffle base width (b_b): the widest part of the baffle where it connects with the
drum. This shall be measured with a spring caliper.
(e) Baffle top width (b_t): width of the baffle where the narrow "tip" of the baffle
starts to curve to the top. This shall be measured with a spring caliper.
(f) Baffle side length (s): This is the distance between the place where the baffle
connects to the drum and the place where the baffle starts to curve to a rounded
tip. Each side will be the same dimension.
(g) Baffle length (l_b): Measure the length of the baffle at its base. This is likely the
same dimension as the drum depth measured earlier.

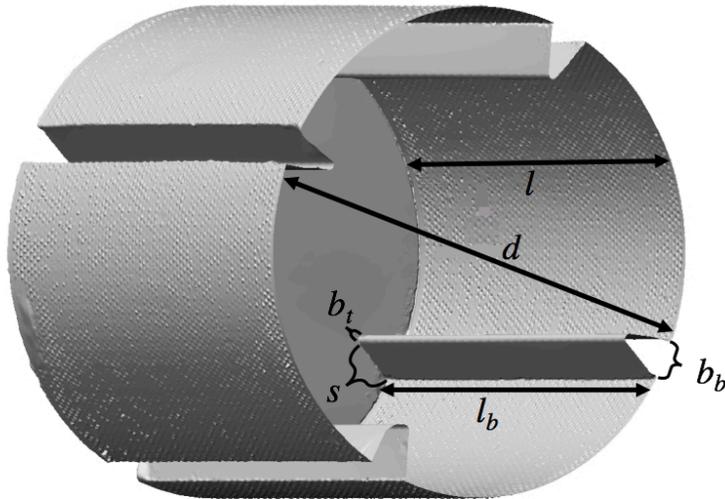Figure 6.3 gives diagram to illustrate the various measurements required.

Figure 6.3—Diagram of a uniform drum with measurements required.

Determine V_{pr} by measuring any other recesses or protrusions in the drum. Study the door and how it mates to the drum when closed. Does the door protrude into the volume of the drum? If so, measure the volume of the protrusion. Does the door surface add volume to the drum interior? If so, measure the added volume. Calculate V_{pr}, which is equal to the sum of the protrusions and recesses other than the baffles, given in cubic inches.

To calculate the dryer volume, first find the volume of the drum cylinder (V_c) in cubic inches:

$$V_c = \pi\, l (\frac{d}{2})^2$$

Then, subtract off the volume of the baffles (V_b) (in cubic inches), which is equal to the following:

$$V_b = \frac{1}{2} n\, l_b h (b_b + b_t)$$

where n is the number of baffles and the radial baffle height, h, is given by:

$$h = \sqrt{s^2 - (0.5(b_b - b_t))^2}$$

To find the volume of the **measured drum capacity** (*C*), combine the volumes of the protrusions (positive volume) and recesses (negative volume), not including the volume of the baffles. Finally, divide cubic inches used in the measurements by 1728 to calculate cubic feet.

The complete equation to calculate the **measured drum capacity** (*C*) in cubic feet with measurements in inches is given by the following:

$$C = \frac{1}{1728} \left\{ \pi\, l \left(\frac{d}{2}\right)^2 - \left[\frac{1}{2} n\, l_b \left(\sqrt{s^2 - (0.5(b_b - b_t))^2}\right)(b_b + b_t)\right] + V_{pr} \right\}$$

and values in the equation are defined in this section (Section 6.3).

7. ENERGY PERFORMANCE TEST

7.1 Active mode test series

A complete energy performance test for a **tumble dryer** (or the **test series**) is comprised of the following five to six test **runs** (**runs** A through F) on a single **tumble dryer** (Table 7.1). If the dryer does not have automatic termination in the as-shipped condition, then then Run F shall be omitted from the **test series.** Note that Table 7.1 is intended to be a summary and shall not substitute for the more detailed instructions given in sections 7.2.2 through 7.2.7.

Table 7.1—Summary of test runs making up the test series.

Run	Run sequence	Load size	IMC	Settings	RMC
A	Shortest timed (7.2.2)[a]	**Full-sized**	58% to 62% target: 60%	Timed, high heat **Cool down**: 0 or minimum number of minutes selectable	1.5 % - 4%
B					4% - 8%
C	Over dry timed (7.2.4)	**Full-sized**	58% to 62% target: 60%		≤ 4%
D	Challenging timed (7.2.5)	**Partial**	73% to 77% target: 75%		2% - 7% target: 3%
E	Favorable timed (7.2.6)	**Full-sized**	58% to 62% target: 60%	Timed, low heat **Cool down**: Default or other procedure[b] if no default is given.	4% - 7% target: 5.5%
F	Automatic termination (7.2.7)	**Partial**	58% to 62% target: 60%	Automatic termination, medium heat	≤ 4%

[a] The **RMC** of Run A shall be at least three percentage points away from the **RMC** of Run B. The **user-entered cycle time** of Run A must be longer than the **user-entered cycle time** of Run B.

[b] If the dryer has a separate timer for a **cool down** period in the as-shipped condition and if that timer (with no modification to the menu or programming of the dryer) is able to be independently set and does not always default to the same number of minutes of **cool down** for the lowest heat setting where heat is applied continuously or periodically from the burner, then the dryer **cool down** period shall be set to the greater of the two options: option 1: five (5) minutes; option 2: twice that of the minimum number of minutes the operator is able to select.

NOTE The automatic termination **run** (Run F) is only performed if the dryer has this feature available in the as-shipped condition. If additional programing or menu-based adjustment is required to enable the automatic termination, then the **tumble dryer** shall not be subjected to Run F.

7.2   Test run sequence

7.2.1   *General instructions to complete valid test run.* For all **test runs** described in this section, the **tumble dryer** shall not be stopped intermittently in the middle of the test **cycle** for any reason. 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, including the dryer pre-conditioning period. Record the data for each **run** specified in this section (7.2) in the manner outlined in section 7.4 of this test procedure.

The **program time** shall be measured from the moment the start is initiated on the control panel of the dryer to the moment that the dryer terminates the **program** and the textile load

25

is accessible to the user (**end of the program**). Energy use associated with **wrinkle-prevention mode** shall not be counted in the time or energy of the **cycle** tests, as it is measured separately in section 7.3.1.

NOTE Using the data acquisition system or other instrument time stamp is recommended to determine the duration of the **cycle** as required by the test procedure. Please see the instrumentation section for suggestions for obtaining accurate **program** time data.

For all **tests runs** in the **test series**, the dryer shall be operated in the as-shipped default condition. No additional changes in available programming menus or user manuals to intentionally alter the **programs** or setting shall be made. Specifically, the programming menus shall not be used to change the temperature set points, nor default number of minutes of **cool down**, nor any other setting. The intention of this protocol is to test the dryer in the as-shipped default condition.

If the **tumble dryer** also includes a wash function, any dedicated control function for the washer shall be turned off through the standard user control panel, if it is possible to do so without entering a programming menu. If it is not possible to turn off the wash control function, then the controls shall remain in the default as-shipped condition. The wash function integrated with the tumble dryer shall not be used to prepare the test load textiles (as described in 5.7.1 and 5.7.2).

Before every test run, the dryer shall be preconditioned with ambient conditions (the standard start preconditioning sequence in section 5.8).

Anytime textiles prepared for a test run are being transferred from the washer to the scale, from the scale to the dryer, or from the dryer to the scale (before and after the dryer cycle), they shall be handled according to section 5.7.3.

If, by default, a **wrinkle-prevention mode** starts after the completion of the **cycle**, then the load shall be removed for weighing when the **tumble dryer** has indicated the load is complete and before the start of the **wrinkle-prevention mode**. The energy use associated with any heat or tumbling during the **wrinkle-prevention mode** shall not be included for the purposes of this measurement.

7.2.2 *Shortest timed dry runs (Run A and B).* The purpose of these two **test runs** is to measure the **program time** and energy use associated with the shortest length of time required to dry a **full-sized load** to a target **RMC** of 4.0 percent in the timed dry setting. This requires data from two dryer **test runs** with **RMC** ranges on either side of 4.0 percent **RMC** and then linear interpolation according to section 7.2.3 between the two **runs** to find the 4.0 percent time and energy value. Run A shall have an **RMC** between 1.5 percent and 4.0 percent. Run B shall have an **RMC** between 4.0 percent and 8.0 percent. The RMC of Run A shall be *at least three percentage points* below the RMC of run B. Run B shall be a shorter time duration than Run A. The combination of the two **runs** verifies that the shortest time duration has been achieved, enables development of a

26

unique **RMC** correction factor for each dryer, and facilitates a comparison of all dryers to an exact **RMC** value of 4.0 percent.

Load preparation: Prepare a **full-sized load** of textiles with 60.0 percent **IMC**.

Settings: For this **test run**, the dryer shall self-terminate at the end of the **cycle** with its own timer. Depending on the **tumble dryer** design, the **tumble dryer** <u>may or may not</u> employ its **adaptive control system** to optimize conditions for short **program time** and energy use.

Operate the **tumble dryer** at the maximum/high heat setting. If, in the as-shipped condition, the dryer has a separate timer control that sets a **cool down** period available the operator without the use of menus or additional user-manual programming, then **cool down** shall be turned off or set to zero minutes. If eliminating **cool down** is not an available option in the as-shipped condition, then the minimum time for the **cool down** period shall be selected. If the dryer has an optional **drum reversal** function that is enabled by default when the maximum/high-heat setting is selected, then the **drum reversal** feature shall be enabled during the test.

Any other optional **cycle** settings that do not affect the temperature or time settings shall be tested in the as-shipped position. If other settings other than dryer heat settings are available to select, a **normal program** or regular **program** shall be selected for the test **cycle**. For dryers that do not have a **normal program** or regular **program**, the **cycle** recommended by the manufacturer for drying cotton or linen textiles shall be selected.

User-entered cycle time and *RMC:* Select a **user-entered cycle time** (usually given in minutes), that is expected to be near to the minimum time required to dry the textile load to the target **RMC** range of 1.5 percent to 8.0 percent **RMC**.

Upon the completion of the **cycle**, if the measured **RMC** of the textile load is higher than the range (wetter), then the **run** is not valid and shall be repeated with more time added according to the judgment of the technician.

If the **RMC** is lower than the range (drier), then the **run** is not valid and shall be repeated by setting the timed dry duration for less time than the prior **cycle** time.

If the measured **RMC** is between 1.5 percent and 8.0 percent in the first **run**, then the dryer shall be **run** again with a shorter or longer time duration to obtain a second **run** with measured **RMC** that falls within the target range that was not obtained with the first **run.** The second **run** must also have an **RMC** is <u>three</u> percentage points away from the first run.

NOTE   For example, if the first dryer **cycle** concludes with a measured **RMC** value of 2.5 percent, then the time duration of the **cycle** shall be reduced for the second **run** in an attempt to obtain a **run** with final measured **RMC** that is between 5.5 percent and 8.0 percent.

27

The iterative process shall be continued until two **runs** are obtained where the **run** with the target **RMC** between 1.5 percent and 4.0 percent (Run A) has a <u>longer</u> **user-entered cycle time** than the **user-entered cycle time** associated with the **run** that obtained target **RMC** between 4.0 percent and 8.0 percent (Run B). Additionally, the **RMC** of Run A shall be at least three percentage points away from the **RMC** of Run B. In other words, if the absolute value of the difference between the RMC value of Run A and Run B is less than 0.03 (3.0%), then the iterative process shall be continued until a valid result is reached.

When complete, record the data specified in section 7.4 for each **run,** A and B.

7.2.3 ***Shortest timed dry run 4.0 percent RMC energy use and user-entered cycle time interpolation method.***

The purpose of this section is to provide the interpolation method to enable the determination of the **user-entered cycle time** associated with a 4.0 percent **RMC** for the shorted timed dry energy test. This will enable other **user-entered cycle time** to be determined for other **test runs** in sections 7.2.4, 7.2.5 and 7.2.6.

The **user-entered cycle time** for the 4.0 percent **RMC** ($U_{4\%}$) is given by the following:

$$U_{4\%} = U_A' - (U_A' - U_B')\left(\frac{0.04 - R_A}{R_B - R_A}\right)$$

and U_A' is the **IMC**-corrected **user-entered cycle time** for Run A and calculated as follows:

$$U_A' = U_A + 1.2U_A(0.60 - I_A)$$

and U_B' is the **IMC**-corrected **user-entered cycle time** for Run B and calculated as follows:

$$U_B' = U_B + 1.2U_B(0.60 - I_B)$$

where R_A is the measured **RMC** of Run A converted from a percent to decimal format, and R_B is the measured **RMC** of Run B converted from a percent to decimal format, U_A is **user-entered cycle time** for **run** A given in minutes, U_B is **user-entered cycle time** for **run** B given in minutes, I_A is the measured **IMC** of Run A converted from a percent to decimal format, and I_B is the measured **IMC** of Run B converted from a percent to decimal format, and 1.2 is the standard adjustment factor for **IMC** correction to **program time**.

7.2.4 ***Over dry timed run (Run C).*** The purpose of this **run** is to measure the energy use of the dryer in the scenario where the **tumble dryer** may be set for a **user-entered cycle**

28

time longer than required to thoroughly dry the textiles and measure the energy used by the **tumble dryer**.

Load preparation: Prepare the **full-sized load** of textiles with 60.0 percent **IMC**.

Settings: For this **test run**, the dryer shall self-terminate at the end of the **cycle** with its own timer. Depending on the **tumble dryer** design, the **tumble dryer** may or may not employ its **adaptive control system** to optimize conditions for short duration and energy use.

The temperature, **program**, and other optional **cycle** setting shall be set exactly as in the *shortest time dry test* specified in section 7.2.2, including instructions for the **cool down** period and **drum reversal**.

User-entered cycle time *and **RMC**:* The dryer shall be set for a time which is equal to the product of 1.2 and $U_{4\%}$ (section 7.2.3) rounded to the nearest minute. Specifically, the **user-entered cycle time** for the over dry test is equal to the following:

$$U_{over\ dry} = round(1.2 * U_{4\%})$$

where $U_{over\ dry}$ is the **user-entered cycle time** for the over dry test.

Upon the completion of the **cycle**, if the measured **RMC** of the textile load is higher than 4.0% **RMC**, then the **run** is not valid and shall be repeated with five minutes added to the calculated $U_{over\ dry}$ time. If, upon the completion of the second **run**, the measured **RMC** of the textile load continues to be higher than 4.0% **RMC**, then two times $U_{4\%}$ (**user-entered cycle time** for the 4.0 percent **RMC** defined in 7.2.3) the shall be recorded for the **program time** and zero shall be recorded for the **CBF** for this **run**. If the **RMC** is less than 4.0%, then record the data specified in section 7.4 for this **run**.

7.2.5   ***Challenging timed run (Run D).*** The purpose of this **run** is to measure the **program time** and energy use associated with drying a damper (75.0 percent **IMC**) **partial load** to the target **RMC** of 3.0 percent (range: 2.0 to 7.0 percent) using high heat and timed dry settings.

Load preparation: Prepare a **partial load** of textiles with 75.0 percent **IMC.**

Settings: For this **run**, the dryer shall self-terminate at the end of the **cycle** with its own timer. Depending on the **tumble dryer** design, the **tumble dryer** may or may not employ its **adaptive control system** to optimize conditions for short **program time** and energy use.

Operate the **tumble dryer** at the maximum/high heat setting. If, in this as shipped condition, the dryer has a separate timer for a **cool down** period without additional

programming or menu entry, then **cool down** shall be turned off or set to zero minutes. If eliminating **cool down** is not an available option in the as-shipped condition, then the minimum time for the **cool down** period shall be selected. If the dryer has an optional **drum reversal** function that is enabled by default when the maximum/high-heat setting is selected, then the **drum reversal** feature shall be enabled during the test.

Any other optional **cycle** settings that do not affect the temperature or time settings shall be tested in the as-shipped position. If other than dryer heat settings are available to select, a **normal program** shall be selected for the test **cycle**. For dryers that do not have a **normal program**, the **cycle** recommended by the manufacturer for drying cotton or linen textiles shall be selected.

User-entered cycle time and RMC: Select a **user-entered cycle time** (usually given in minutes), that is expected to be near to the minimum time required to dry the textile load to the target **RMC** range of 2.0 percent to 7.0 percent **RMC**.

NOTE   The formula below, based on $U_{4\%}$ (calculated in section 7.2.3), may be used to determine a reasonable **user-entered cycle time** for this run.

$$U_D = 0.26 * U_{4\%} + 14.4$$

Where U_D is the estimated user-entered cycle time for Run D, and the constants are experimentally determined values.

Upon the completion of the **cycle**, if the measured **RMC** of the textile load is greater than 7.0 percent (wetter), then the **run** is not valid and shall be repeated with more time added to the **user-entered cycle time** according to the judgment of the technician.

If the **RMC** is lower than 2.0 percent (drier), then the **run** is not valid and shall be repeated by setting the **user-entered cycle time** for a shorter duration than the prior **user-entered cycle time**. The number of minutes selected shall be according to the judgment of the technician.

If the measured **RMC** is between 2.0 and 7.0 percent, then the **run** is considered valid. Record the data specified in section 7.4 for this **run**.

7.2.6   *Favorable timed run (Run E).* The purpose of this test is to measure the **program time** and energy use associated with drying a **full-sized load** to the target **RMC** of 5.5 percent (range: 4.0 to 7.0 percent) using low heat and **cool down** in the timed dry setting.

Load preparation: Prepare a **full-sized load** of textiles with 60.0 percent **IMC.**

Settings: For this **run**, the dryer shall self-terminate at the end of the **cycle** with its own timer. Depending on the **tumble dryer** design, the **tumble dryer** <u>may or may not</u> employ its **adaptive control system** to optimize conditions for **program time** and energy use.

Operate the **tumble dryer** at the lowest heat setting where heat is applied continuously or periodically from the burner. If the dryer has a "no heat" setting, the tumble dryer shall be set to the heat setting just above "no heat".

If the dryer has a separate timer for a **cool down** period in the as-shipped condition and if that timer (with no modification to the menu or programming of the dryer) <u>always defaults</u> to a set number of **cool down** minutes when the **tumble dryer** is set to lowest heat setting where heat is applied continuously or periodically from the burner, then the default number of **cool down** minutes shall be used for this **run**.

If the dryer has a separate timer for a **cool down** period in the as-shipped condition and if that timer (with no modification to the menu or programming of the dryer) is able to be independently set and <u>does not</u> always default to the same number of minutes of **cool down** for the lowest heat setting where heat is applied continuously or periodically from the burner, then the dryer **cool down** period shall be set to the greater of the two options below:

- five (5) minutes
- twice that of the minimum number of minutes the operator can select.

If the dryer has an optional **drum reversal** function that is enabled by default when the heat setting just above "no heat" is selected, then the **drum reversal** feature shall be enabled during the test.

Any other optional **cycle** settings that do not affect the temperature or time settings shall be tested in the as-shipped position. If settings other than dryer heat settings are available to select, a "delicate" **program** shall be selected for the test **cycle**. For dryers that do not have a "delicate" **program**, the **cycle** recommended by the manufacturer for drying delicates. If there is not a recommendation for delicates, then then the **cycle** recommended for synthetics shall be selected.

User-entered cycle time and RMC: Select a **user-entered cycle time** (usually given in minutes), that is expected to be near to the minimum time required to dry the textile load to the target **RMC** range of 4.0 to 7.0 percent **RMC**.

NOTE   The formula below, based on $U_{4\%}$ (calculated in section 7.2.3), may be used to determine a reasonable **user-entered cycle time** for this run.

$$U_E = 1.24 * U_{4\%} + 5.19$$

Where U_E is the estimated user-entered cycle time for Run E, and the constants are experimentally determined values.

Upon the completion of the **cycle**, if the measured **RMC** of the textile load is greater than 7.0 percent (wetter), then the **run** is not valid and shall be repeated with more time added to the **user-entered cycle time** according to the judgment of the technician.

31

If the **RMC** is lower than 4.0 percent (drier), then the **run** is not valid and shall be repeated by setting the **user-entered cycle time** for a shorter duration than the prior **user-entered cycle time**. The number of minutes selected shall be according to the judgment of the technician.

If the measured **RMC** is between 4.0 percent and 7.0 percent, then the **run** is considered valid. Record the data specified in section 7.4 for this **run**.

7.2.7   *Automatic termination run (Run F)*. The purpose of this **run** is to measure the energy use of the dryer when it operates with automatic termination engaged (a non-timed dry **program**).

Load preparation: Prepare a **partial** **load** of textiles with 60.0 percent **IMC**.

Settings: For this **run**, the dryer shall self-terminate at the end of the **cycle** using automatic termination. Depending on the **tumble dryer** design, the **tumble dryer** may or may not employ its **adaptive control system** to optimize conditions for energy use.

The goal of the following setting selection steps is to measure the cycle energy use of the dryer with a preset automatic termination **program** that most closely aligns with medium heat (approximate operation temperature of 145° F) and a dryness level (**RMC**) of 4% or less. To select the **program** for Run F, follow instructions in Route 1. Only if Route 1 does not lead to the selection of a **program**, select a **program** for Run F using instructions in Route 2. Only if both Route 1 and Route 2 do not lead to the selection of a **program**, then use program selection instructions in Route 3.

Route 1: Route 1 is the preferred method of selecting the **program** to use for this test. Review the **tumble dryer** operation manual and identify all **programs** that utilize automatic termination. Of those automatic termination **programs,** identify those programs containing a reference to "medium" or "medium heat." If there are no **programs** containing a reference to "medium" or "medium heat," proceed to Route 2.

Within the "medium" or "medium heat" **programs** identified, the dryness level (RMC) setting shall be used to determine which specific **program** to use for the test. Where non-quantitative descriptive categories of dryness (e.g. extra dry, dry, damp, iron, etc.) are used to describe the program dryness level, then a "medium" or "medium heat" **program** that uses these non-quantitative descriptive categories shall be selected for this test (instructions under (a) below). Where quantitative values are the only available description of dryness level for "medium" or "medium heat" **programs,** then use instructions under (b) below.

   (a) The **program** that employs a dryness level at the mid-point of the available minimum and maximum dryness level categories shall be used. If there are an even number of non-quantitative descriptive categories for dryness level, such that there is no midpoint descriptive category, then the **program** with the

32

category that is the highest dryness level (most dry) of the two middle dryness level categories shall be used.

(b) Where quantitative values are the only available description of dryness level for "medium" or "medium heat" **programs**, then a **program** with dryness level of 3.0% RMC shall be used. If there is no **program** with 3.0% RMC, then the **program** with the midpoint of the RMC range shall be used. If there is no midpoint, then the program with the lower of the two middle RMC values (more dry value) shall be selected.

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 dryer has an optional **drum reversal** function that is enabled by default when the program and dryness levels are set as required in this section, then the **drum reversal** feature shall be enabled during the test.

Operate the **tumble dryer** until the **end of program**, including any **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 load is accessible to the user.

If a **program** is selected using Route 1, then Route 2 and Route 3 for selecting the **program** shall be ignored. Instructions for this test can be continued in this section (7.2.7) under heading *Program time* and **RMC.**

Route 2: If there are automatic termination **program(s)** containing a reference to "medium" or "medium heat," then use Route 1 to select the program. Only when there are no **programs** containing a reference to "medium" or "medium heat" shall Route 2 instructions for **program** selection be followed.

Use the **tumble dryer** operation manual to identify all **programs** that utilize automatic termination and have an operation temperature (as listed in the operation manual or other documentation) that is at 145 degrees F or close (+/- 10 degrees) to 145 degrees F.

Within these identified **programs,** the dryness level (RMC) setting shall be used to determine which specific **program** to use for the test. Where non-quantitative descriptive categories of dryness (e.g. extra dry, dry, damp, iron, etc.) are used to describe **program** dryness levels, then a **program** that uses these non-quantitative descriptive categories shall be selected for this test. If there are no categorical descriptions of dryness level, but only quantitative descriptions of dryness level (RMC) given, then proceed to Route 3 to select the **program**.

(a) The **program** that employs a dryness level at the mid-point of the available minimum and maximum dryness level categories shall be used. If there are an even number of non-quantitative descriptive categories for dryness level, such that there is no midpoint descriptive category, then the **program** with the category that is the highest dryness level of the two middle dryness level categories shall be used.

33

(b) If there are multiple **programs** that are at 145 degrees F or close (+/- 10 degrees) to 145 degrees F and have identical midpoint dryness categories (as described in (a) above, then select the program that is at 145 degrees F. If no programs are listed with operation temperature at 145 degrees F, then select the program with operation temperature nearest to 145 degrees F. If more than one program is nearest to 145 degrees, select the program that is of the higher operation temperature. If there are two programs with different **program** names, the same operation temperature, and the same midpoint descriptive dryness category as determined in (a) above, then the **program** with the program name alphabetically closer to "A" shall be selected.

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 dryer has an optional **drum reversal** function that is enabled by default when the program and dryness levels are set as required in this section, then the **drum reversal** feature shall be enabled during the test.

Operate the **tumble dryer** until the **end of program**, including any **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 load is accessible to the user.

If a **program** is selected using Route 2, then Route 3 for selecting the **program** shall be ignored. Instructions for this test can be continued in this section (7.2.7) under heading *Program time* and **RMC.**

Route 3: Route 3 shall be used only if neither Route 1 nor Route 2 yield the selection of a **program** to use for Run F.

Use the **tumble dryer** operation manual to identify all **programs** that utilize automatic termination and have an operation temperature (as listed in the operation manual or other documentation) that is at 145 degrees F or close (+/- 10 degrees) to 145 degrees F. Among those **programs**, select the **program** with operation temperature and RMC combination that appears first in the following list:
(a) **Program** with 145 degrees F operation temperature and 3.0 percent RMC
(b) **Program** with 145 degrees F operation temperature and the midpoint of the RMC range
(c) Only if there is no midpoint RMC, **program** with 145 degrees F and the lower of the two middle RMC values (more dry value)
(d) **Program** with the operation temperature nearest to 145 degrees F and 3.0 percent RMC. If two **programs** have operation temperatures that are equidistant from 145 degrees F, then select the **program** with the highest operation temperature.
(e) **Program** with operation temperature nearest to 145 degrees F and the midpoint of the RMC range. If two **programs** have operation temperatures that are equidistant from 145 degrees F, then select the **program** with the highest operation temperature.

(f) Only if there is no midpoint RMC, **program** nearest to 145 degrees F and the lower of the two middle RMC values (more dry value). If two **programs** have operation temperatures that are equidistant from 145 degrees F, then select the program with program with the highest operation temperature.

If there are two **programs** of different names that otherwise match a description (a) through (f) in the list above (same operation temperatures and identical dryness level (RMC) settings), then the **program** with the **program** name alphabetically closer to the letter "A" shall be selected.

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 dryer has an optional **drum reversal** function that is enabled by default when the program and dryness levels are set as required in this section, then the **drum reversal** feature shall be enabled during the test.

Operate the **tumble dryer** until the **end of program**, including any **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 load is accessible to the user.

Program time and RMC: There is no **user-entered cycle time** for this test, but the **program time** shall be measured and recorded per section 7.4.

Upon the completion of the test **cycle**, if the measured **RMC** is greater than 4.0 percent, then proceed with one of the two options below:
1) If the measured **RMC** is greater than 5.0 percent, the **run** shall be invalid and a new **run** shall be conducted. Where non-quantitative descriptions of dryness (e.g. extra dry, dry, damp, iron, etc.) are available for selection by the user, then these non-quantitative descriptions shall be used to set the dryness level. The dryness level shall be set at the "high" or "maximum" dryness level setting. If no such dryness level is available by name, then the dryness level shall be set at the maximum or highest dryness level settings. Where quantitative RMC values are the only available option for setting the dryness level, then dryness level (RMC) shall be set to the lowest available RMC value.
2) If the final **moisture content** is greater than 4.0 percent **RMC** but less than 5.0 percent **RMC**, the **run** shall be conducted a second time in the same manner, including the dryer preconditioning period.
   a. If this second **run** terminates with a final **moisture content** greater than the target **RMC** value for the **run**, the **run** shall be invalid and a new **run** shall be conducted. Where non-quantitative descriptions of dryness (e.g. extra dry, dry, damp, iron, etc.) are available for selection by the user, then these non-quantitative descriptions shall be used to set the dryness level. The dryness level shall be set at the "high" or "maximum" dryness level setting. If no such dryness level is available by name, then the dryness level shall be set at the

35

maximum or highest dryness level settings. Where quantitative RMC values are the only available option for setting the dryness level, then dryness level (RMC) shall be set to the lowest available RMC value.

b. If the second **run** terminates with a final **moisture content** less than 4.0% **RMC**, the **RMC** values of the current **run** and the prior **run** shall be averaged. If this average is greater than 4.0 percent, then both **runs** shall be invalid and a new **run** shall be conducted. Where non-quantitative descriptions of dryness (e.g. extra dry, dry, damp, iron, etc.) are available for selection by the user, then these non-quantitative descriptions shall be used to set the dryness level. The dryness level shall be set at the "high" or "maximum" dryness level setting. If no such dryness level is available by name, then the dryness level shall be set at the maximum or highest dryness level settings. Where quantitative RMC values are the only available option for setting the dryness level, then dryness level (RMC) shall be set to the lowest available RMC value.

c. If the average **RMC** of the two **runs** is less than 4.0 percent, then the average of the tests shall be considered valid. All reported values of the **run** shall be averaged for the purposes of reporting.

If the final **RMC** is still above the maximum **RMC** value when the lowest quantitative RMC value or the highest dryness level setting is used, the textiles shall be placed back into the dryer and dried using 10-minute timed-dry **cycle** and maximum temperature settings. At the end of the timed-dry **cycle**, the textiles shall be removed and **RMC** measured. The textiles shall be placed back into the dryer and the 10-minute timed-dry repeated until the target **RMC** is reached. Final energy use and drying time calculations shall include all 10-minute timed-dry **runs** needed to reach the target **RMC**. If the additional 10-minute **cycle**(s) is needed, every transfer of the textiles in and out of the dryer shall be made in an insulated vessel as specified in 5.7.3.4. This insulated vessel minimizes the changes to temperature and moisture of the load.

The valid test data for this **run** shall be recorded according to section 7.4.

7.3   Low power mode tests

7.3.1   *Wrinkle-prevention mode test.* The purpose of this test is to establish the energy use associated with the wrinkle-prevention function that is sometimes available as an option in the as-shipped condition and is sometimes enabled by default in the as-shipped condition. If the **wrinkle-prevention mode** is not available in the as-shipped condition, and the user manual and/or programming menus must be employed to enable **wrinkle-prevention mode**, then this **wrinkle-prevention mode** test shall not be conducted.

For this **run**, the dryer shall self-terminate at the end of the cycle with its own timer and then enter into the **wrinkle-prevention mode**.

| Deleted: the target |
| Deleted: using the highest dryness level setting. |
| Deleted: 2 |

Establish the testing conditions set forth in Section 5 "Testing Conditions" of this test procedure for these tests. Note that preconditioning with ambient air is not required. Prepare a full-sized load of textiles with a confirmed **IMC** of 4.0 percent or less. Operate the **tumble dryer** at the maximum/high heat setting with a time of 5 minutes. Wrinkle prevention mode shall be enabled or turned on. The dryer shall be otherwise operated in the as-shipped default condition. No additional changes in available programming menus or user manuals to intentionally alter the **programs** or settings shall be made. If, in this as shipped condition, the dryer has a separate timer for a cool down period without additional programming or menu entry, then cool down shall be turned off or set to zero minutes. If eliminating cool down is not an available option in the as-shipped condition, then the minimum time for the cool down period shall be selected.

Any other optional cycle settings that do not affect the temperature or time settings shall be tested in the as-shipped position. If other than dryer heat settings are available to select, a "normal" **program** shall be selected for the test cycle. For dryers that do not have a "normal" **program**, the cycle recommended by the manufacturer for drying cotton or linen textiles shall be selected.

The period of energy use (electricity and gas) measurement shall begin when the cycle (including high heat time and any associated cool down time) is complete and the dryer signals the textiles are available for removal. The period of energy use measurement shall end at one (1) hour. If the dryer signals the end of wrinkle prevention mode before the one-hour measurement period is complete, the measurement period shall continue.

Record the total electrical energy use over the one-hour period. The average electrical power (in watts) shall be determined as an average over the one-hour period. Details of data that shall be recorded for this test are listed in section 7.4.

7.3.2 *Standby mode, network mode, and off mode power.* Establish the testing conditions set forth in Section 5 "Testing Conditions" of this test procedure for these tests. For **tumble 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), allow sufficient time for the **tumble 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 7.3.2.1, 7.3.2.2, and 7.3.2.3 of this test procedure. For all tests of network mode, **standby mode** and **off mode**, the door of the **tumble dryer** shall be closed.

7.3.2.1 *Network mode.* If a **tumble dryer** has a **network mode,** measure and record the average **network mode** power of the **tumble dryer** in watts. Care shall be taken to properly set up the network connection in this mode. Guidance for set up is given in Annex A, section A.2 of IEC 62301 (Second Edition) (incorporated by reference). If multiple power levels for **network mode** are possible due to variations in network speed, then the greatest network speed possible by the dryer shall be tested and recorded for the purposes of this measurement.

7.3.2.2 *Standby mode.* If a **tumble dryer** has a **standby mode**, measure and record the average **standby mode** power of the **tumble dryer** in watts.

7.3.2.3 *Off mode.* If a **tumble dryer** has an **off mode**, measure and record the average **off mode** power of the **tumble dryer** in watts.

7.4   Data recording

7.4.1   *Record for each unique dryer model the following information*:

   (a)   Manufacturer and model number, including details about the specific configuration of the dryer (control package), and other unique features.

   (b)   Heat source of the dryer: natural gas, propane gas, or electric.

   (c)   **Measured drum capacity**, in cubic feet, per section 6

   (d)   **Load size drum capacity**, in cubic feet (may be equal to measured or manufacturer-reported drum volume)

   (e)   For **gas tumble dryers** and **propane tumble dryers**: manufacturer-reported burner BTU input rating.

   (g)   Presence or absence of **automatic termination** in the as-shipped condition.

   (h)   Presence or absence of **wrinkle-prevention mode** in the as-shipped condition.

   (i)   If the **tumble dryer** has a **wrinkle-prevention mode**, the average wrinkle-mode electric power of the **tumble dryer**, P_w, in watts and the average **power factor** PF_w over the measurement period.

   (j)   If a **tumble dryer** has a **network mode,** the average **network mode** power of the **tumble dryer**, P_n, in watts and the average **power factor** PF_n over the measurement period.

   (k)   If the **tumble dryer** has a **standby mode**, the average **standby mode** power of the **tumble dryer**, P_s, in watts and the average **power factor** PF_s over the measurement period.

   (l)   If the **tumble dryer** has an **off mode**, the average **off mode** power of the **tumble dryer**, P_{off}, in watts, and the average **power factor** PF_{off} over the measurement period.

7.4.2   *Record the following information for all dryers for each active mode test run:*

   (a)   **Moisture content** (**IMC**) of the wet test load before the **run**, as described in sections 3.17 and 5.7.1 (expressed as a percent).

   (b)   **Moisture content** of the dry test load obtained after the **run** (**RMC**) described in section 3.28 (expressed as a percent).

   (c)   For the period of duration of the **run**, the average room atmospheric pressure, gas meter average temperature, average test room temperature and the percent of time within tolerance (section 5.2), and test room average percent relative humidity and the percent of time within tolerance (section 5.2).

   (d)   **Cycle** settings. The test report shall include a photograph of the **cycle** settings taken just before the beginning of the **cycle** of the **run**. If the photograph does not explicitly capture the number of minutes in cool-down

38

Deleted: $P_{WRINKLE}$, in watts.

for that **run**, then the number of minutes of **cool down** shall be recorded separately.

NOTE   This number of **cool down** minutes shall not change the way that the total **program time** is recorded. The number of **cool down** minutes will be inclusive in the **program time**.

(e)   **Program time** as described in section 7.2.1. Record the total duration of the **run**, T_x, in minutes.

(f)   Average age of the load for the **run** as determined by section 5.6.4 (in number of **runs**).

(g)   **Bone dry** weight (W_{bone}) of the load for that **run** (in pounds).

(i)   The applicable **run** that was performed. Options are: Run A, Run B, Run C, Run D, Run E, Run F).

7.4.3   *Record for each active mode test run the following information for electric dryers:*

(a)   The total kilowatt-hours of electric energy, E_t, consumed during the **run** described in section 7.2.

(b)   Average **power factor**, $PF_{cycle(x)}$ over the **Program Time** of the **run**.

7.4.4   *Record for each active mode test run the following information for natural gas tumble dryers and propane tumble dryers:*

(a)   Total kilowatt-hours of electrical energy, E_x, consumed during the applicable **run** in section 7.2.

(b)   Average **power factor** over the **Program Time** of the **run**.

(c)   Actual cubic feet of gas per **cycle**, CF_{actual}, consumed during the **run** described in section 7.2.

(d)   Standard cubic feet of gas per **cycle**, $CF_{standard}$. Actual cubic feet shall be corrected to standard cubic feet of gas per **cycle** to standard pressure and temperature conditions of 14.696 psia and 60 °F.

(e)   The gas heating value, GHV, given in Btu per cubic foot, corrected to standard pressure and temperature conditions of 14.696 psia and 60 °F.

8.   CALCULATION OF DERIVED RESULTS FROM TEST MEASUREMENTS

This section contains calculations of derived results for measurements gathered in section 7.4

Tumble dryers operate on both gas and electricity, and in order to assess the total applicable cost of operating the appliance, the energy use of these two sources must be combined. Some calculations in this section combine the energy measurements by simply adding the gas and the electrical energy together to give a value for **tumble dryer** energy use at the site of installation. But, the energy use of gas and electricity can also be

combined using other methods. The test procedure provides separate constants for gas and electrical energy sources to enable these other methods of combination. Throughout this section, α is a constant that weights the relative societal and environmental cost of gas energy and β is a constant that weights the relative societal and environmental cost of electricity. α and β are not provided by the test procedure, but would be assigned by another entity using the procedure (policymakers, utility program administrators, etc.) α and β may have units other than energy to convert measured energy values to some other more relevant cost (dollars, greenhouse gas emissions, etc.).

NOTE   Separate equations and constants are not given for **propane tumble dryers,** which operate on propane (not natural gas). The gas constant (α) for **gas tumble dryers** is expected to differ from **propane tumble dryers.**

8.1   Active mode test series calculations

8.1.1   *Gas energy adjustment for Btu content, standard conditions, and kWh conversion*
To simplify calculations, for **gas tumble dryers** and **propane tumble dryers**, all **runs** involving measurement with propane or natural gas (Runs A through F), the measured Btu per cycle shall be converted to site kWh per cycle. The calculation shall be performed for each "X" **run** of a gas dryer (A through F). Wherever an "x" is shown, the applicable **run** letter may be inserted.

$$G_x = CF_{standard} * GHV * \frac{1}{3412}$$

where G_x is the adjusted gas energy use of the cycle used in the remaining calculations in this section, given in kWh, $CF_{standard}$ is the standard corrected cubic feet of the gas per cycle, GHV is the corrected gas heating value described in section 7.4.4 and given in Btu per cubic foot, and $\frac{1}{3412}$ is the standard conversion of Btu to kWh and is given in the units kWh per Btu.

NOTE   For electric dryers, this calculation is not necessary.

8.1.2   *Custom gas and electricity **RMC** correction factors for each tumble dryer.*
These calculations shall be performed once for each **tumble dryer** under test. Using Runs A and B, the test procedure enables a custom **RMC** adjustment factor for gas site energy use (G_{Radj}) and electrical site energy use (E_{Radj}) for each dryer under the active mode test.

The **RMC** adjustment factor for gas site energy use (G_{Radj}) is given by the following equation.

$$G_{Radj} = \frac{(G'_A - G'_B)}{(R_A - R_B)}$$

where G'_A is the IMC-corrected gas site energy use (in kWh) for each dryer under the active mode test for Run A and calculated as follows

$$G'_A = G_A + 1.3G_A(0.60 - I_A)$$

and G'_B is the IMC-corrected gas site energy use (in kWh) for Run B and calculated as follows

$$G'_B = G_B + 1.3G_B(0.60 - I_B)$$

and where G_A is the site gas energy used in Run A, given in kWh, G_B is the site gas energy used in Run B, given in kWh, R_A is the measured **RMC** of Run A converted from a percent to decimal format, R_B is the measured **RMC** of Run B converted from a percent to decimal format, I_A is the measured **IMC** of Run A converted from a percent to decimal format, I_B is the measured **IMC** of Run B converted from a percent to decimal format, and 1.3 is the standard factor for **IMC** correction of **run** energy use.

The custom RMC adjustment of electrical site energy use (E_{Radj}) is given by the following equation.

$$E_{Radj} = \frac{(E'_A - E'_B)}{(R_A - R_B)}$$

where E'_A is the IMC-corrected electrical site energy use (in kWh) for each dryer under the active mode test for Run A and calculated as follows

$$E'_A = E_A + 1.3E_A(0.60 - I_A)$$

and E'_B is the IMC-corrected gas site energy use (in kWh) for Run B and calculated as follows

$$E'_B = E_B + 1.3E_B(0.60 - I_B)$$

where E_A is the site electrical energy used in Run A given in kWh, and E_B is the site electrical energy used in Run B given in kWh. All other variables and terms used to calculate E_{Radj} are as defined earlier in this section (8.1.2).

8.1.3 *Gas and electric site energy use for shortest time dry active mode cycle Run AB (4.0 percent RMC interpolated site energy use).*

These calculations of gas ($G_{cycle\,(AB)}$) and electric ($E_{cycle\,(AB)}$) site energy use for 4.0 percent **RMC** interpolation for **runs** A and B is completed only once for each **tumble dryer** under test.

The gas site energy use ($G_{cycle\,(AB)}$) for 4.0 percent RMC for **runs** A and B is given by

$$G_{cycle\,(AB)} = G'_A - (G'_A - G'_B)\left(\frac{0.04 - R_A}{R_B - R_A}\right)$$

and the electrical site energy use $(E_{cycle\,(AB)})$ for 4.0 percent RMC for **runs** A and B is given by

$$E_{cycle\,(AB)} = E'_A - (E'_A - E'_B)\left(\frac{0.04 - R_A}{R_B - R_A}\right)$$

where G'_A is the IMC-corrected gas site energy use for Run A given in 8.1.2,

G'_B is the IMC-corrected gas site energy use for Run B given in 8.1.2, R_A is the measured **RMC** of Run A converted from a percent to decimal format, R_B is the measured **RMC** of Run B converted from a percent to decimal format, E'_A is the IMC-corrected gas site energy use for Run A given in 8.1.2, E'_B is the IMC-corrected gas site energy use for Run B given in 8.1.2.

8.1.4 **Gas and electric site energy use per active mode cycle for runs D and E.**
These calculations of gas $(G_{cycle\,(x)})$ and electric $(E_{cycle\,(x)})$ site energy use shall be performed for each "X" **run** (D and E). Wherever an "*x*" is shown, the applicable **run** letter may be inserted.

The gas site energy use $(G_{cycle\,(x)})$ for **runs** D and E is given by

$$G_{cycle\,(x)} = G_x + 1.3G_x(I_T - I_x) + G_{Radj}(R_T - R_x)$$

and the electrical site energy use $(E_{cycle\,(x)})$ for **runs** D and E is given by

$$E_{cycle\,(x)} = E_x + 1.3E_x(I_T - I_x) + E_{Radj}(R_T - R_x)$$

where G_x is the site gas energy used for the **run**, given in kWh, I_T is the target **IMC** of the **run** converted from a percent to decimal format, I_x is the measured **IMC** of the **run** converted from a percent to decimal format, G_{Radj} is the custom **RMC** gas energy use correction for the dryer calculated in 8.1.2, R_T is the target **RMC** of the **run** converted from a percent to decimal format, R_x is the measured **RMC** of the **run** converted from a percent to decimal format, 1.3 is the standard factor for **IMC** correction of **run** energy use, E_x is the site electrical energy used for the **run**, given in kWh, E_{Radj} is the custom **RMC** electrical energy use correction for the dryer calculated in 8.1.2.

8.1.5 **Gas and electric site energy use per active mode cycle for runs C and F.**
These calculations of gas $(G_{cycle\,(x)})$ and electric $(E_{cycle\,(x)})$ site energy use shall be performed for each "X" **run** (C and F). Wherever an "*x*" is shown, the applicable **run** letter may be inserted.

42

Deleted: C'_A
Deleted: C'_B

Deleted: C'_A
Deleted: cycle cost
Deleted: and
Deleted: C'_B
Deleted: cycle cost
Deleted: also
Deleted: and
Deleted: .

Deleted: *Societal*
Deleted: *environmental cost*
Deleted: The calculation of societal and environmental cost $(C_{cycle\,(x)})$

Deleted: $C_{cycle\,(x)} = \propto [G_x + 1.3G_x(I_T - I_x)] + \beta[E_x + 1.3E_x(I_T - I_x)] + C_{Radj}(R_T - R_x)$

Deleted: energy used for the **run**, given in kWh, E_x is the site electrical

Deleted: C_{Radj}

Deleted: adjusting for **IMC**, α is a constant that weights the relative societal and environmental cost of gas energy and β is a constant that weights the relative societal and environmental cost of electricity. Setting α and β to one (1) makes $C_{cycle\,(x)}$ applicable to site energy

Deleted: *Societal*
Deleted: *environmental cost*
Deleted: The calculation of societal and environmental cost $(C_{cycle\,(x)})$

The gas site energy use ($G_{cycle\,(x)}$) for **runs** C and F is given by

$$G_{cycle\,(x)} = G_x + 1.3G_x(I_T - I_x)$$

and the electrical site energy use ($E_{cycle\,(x)}$) for **runs** D and E is given by

$$E_{cycle\,(x)} = E_x + 1.3E_x(I_T - I_x)$$

where G_x is the adjusted site gas energy used for the **run**, given in kWh, I_T is the target **IMC** of the **run** converted from a percent to decimal format, I_x is the measured **IMC** of the **run** converted from a percent to decimal format, 1.3 is the standard factor for **IMC** correction of **run** energy use, and E_x is the site electrical energy used for the **run**, given in kWh.

NOTE   For these **runs,** the test procedure only confirms that the dryer does not exceed a maximum **RMC** for the **run**, so no adjustment for **RMC** is required to determine the cycle cost.

8.1.6   ***Determination of custom RMC program time correction factor for each tumble dryer.***
This calculation shall be performed once for each **tumble dryer** under test. Using Runs A and B, the test procedure enables a custom **RMC** adjustment of **program time** for each dryer under the active mode test. That adjustment (T_{Radj}) is given as follows:

$$T_{Radj} = \frac{(T'_A - T'_B)}{(R_A - R_B)}$$

where T'_A is the IMC-corrected **program time** for each dryer under the active mode test for Run A and calculated as follows

$$T'_A = T_A + 1.2T_A(0.60 - I_A)$$

and T'_B is the IMC-corrected **program time** for Run B and calculated as follows

$$T'_B = T_B + 1.2T_B(0.60 - I_B)$$

where R_A is the measured **RMC** of Run A converted from a percent to decimal format, and R_B is the measured **RMC** of Run B converted from a percent to decimal format, T_A is **program time** for Run A given in minutes, T_B is **program time** for Run B given in minutes, I_A is the measured **IMC** of Run A converted from a percent to decimal format, and I_B is the measured **IMC** of Run B converted from a percent to decimal format, and 1.2 is the standard adjustment factor for **IMC** correction to **program time**.

8.1.7   ***Determination of shortest time dry Run AB 4.0 percent interpolated program time, corrected for IMC and RMC***
The purpose of this calculation is to determine the **program time** for 4.0 percent **RMC** for the shortest timed dry energy test (Runs A and B). $T_{cycle\,(AB)}$ is given by the following:

43

$$T_{cycle\,(AB)} = T_A' - (T_A' - T_B') \left(\frac{0.04 - R_A}{R_B - R_A} \right)$$

and T_A' is the IMC-corrected **program time** for Run A and calculated as follows:

$$T_A' = T_A + 1.2T_A(0.60 - I_A)$$

and T_B' is the IMC-corrected **program time** for Run B and calculated as follows:

$$T_B' = T_B + 1.2T_B(0.60 - I_B)$$

where R_A is the measured **RMC** of Run A converted from a percent to decimal format, and R_B is the measured **RMC** of Run B converted from a percent to decimal format, T_A is **program time** for Run A given in minutes, T_B is **program time** for Run B given in minutes, I_A is the measured **IMC** of Run A converted from a percent to decimal format, and I_B is the measured **IMC** of Run B converted from a percent to decimal format, and 1.2 is the standard adjustment factor for **IMC** correction to **program time**.

8.1.8 *IMC and RMC-adjusted program time for runs D and E.*
The calculation of the IMC and **RMC**-adjusted **program time** $(T_{cycle\,(x)})$ shall be performed for each "X" **run** (D and E). Wherever an "*x*" is shown, the applicable **run** letter may be inserted.

$$T_{cycle\,(x)} = 1.2T_x(I_T - I_x) + T_x + T_{Radj}(R_T - R_x)$$

where T_x is the measured **program time** for **run** X, given in minutes, I_T is the target **IMC** of the **run** converted from a percent to decimal format, I_x is the measured **IMC** of the **run** converted from a percent to decimal format, T_{Radj} is the custom **RMC program time** correction for the dryer calculated in 8.1.6, R_T is the target **RMC** of the **run** converted from a percent to decimal format, R_x is the measured **RMC** of the **run** converted from a percent to decimal format, and 1.2 is the standard adjustment factor for **IMC** correction to **program time**.

8.1.9 *IMC-adjusted program time for runs C and F.*
The calculation of the IMC-adjusted **program time** $(T_{cycle\,(x)})$ shall be performed for each "X" **run** (C and F). Wherever an "*x*" is shown, the applicable **run** letter may be inserted.

$$T_{cycle\,(x)} = 1.2T_x(I_T - I_x) + T_x$$

where T_x is the measured **program time** for **run** X, given in minutes, I_T is the target **IMC** of the **run** converted from a percent to decimal format, I_x is the measured **IMC** of the **run** converted from a percent to decimal format, and 1.2 is the standard adjustment factor for **IMC** correction to **program time**.

44

NOTE   For these **runs**, the test procedure only confirms that the dryer does not exceed a maximum **RMC** for the **run**, so no adjustment for **RMC** is required to determine the **program time**.

8.2   Low power mode calculations

8.2.1   ***Average low power mode site energy per cycle.***
This calculation shall be performed once for each **tumble dryer** under test. The average site energy use of the low power modes per cycle, E_{low}, is calculated as follows:

$$E_{low} = \frac{0.001}{1460} \left[h_s P_s + h_n P_n + h_{off} P_{off} + h_w P_w \right]$$

where 0.001 is the factor that converts watt-hours to kilo-watt hours, 1460 is the average number of cycles per dryer per year, P_s is the measured power in **standby mode**, given in watts, P_n is the average measured power in network mode, given in watts, P_{off} is the average measured power in **off mode**, given in watts, and P_w is the average measured power in **wrinkle-prevention mode**, given in watts, h_s is the time in **standby mode** per year, given in hours, h_n is the time in network mode per year, given in hours, h_{off} is the time in **off mode** per year, given in hours, and h_w is the time in **wrinkle-prevention mode** per year, given in hours.

The values for h_s, h_n, h_{off} and h_w are dependent on which low power modes the dryer has present. If the **tumble dryer** has a **wrinkle-prevention mode**, the value for h_w is 241 hours. The h values for **off, standby, and network modes** (h_s, h_n, h_{off}) are determined by the presence of **wrinkle-prevention mode** and the total number of the three other low power modes. Values for h for all present low power modes other than **wrinkle-prevention mode** are given in Table 8.2.1.

	All modes (standby, network and **off mode**) present	Two of the three (standby, network, **off mode**) present	One of the three (standby, network, **off mode**) present
Wrinkle-prevention mode present	$h_s = h_n = h_{off} =$ 2531 hours	$h_1 = h_2 =$ 3797 hours	$h = 7594$ hours
Wrinkle-prevention mode absent	$h_s = h_n = h_{off} =$ 2612 hours	$h_1 = h_2 =$ 3918 hours	$h = 7835$ hours

If the mode is not present, then the h value for that mode shall be zero (0).

45

8.3   Site Energy Factor, Cost-benefit Factor, and test series average calculations

8.3.1   *Site* **Energy Factor for each Run "AB", C, D, E, and F.**
This calculation shall be performed for each **run** ("AB", C through F). Wherever an "*x*" is shown, the applicable **run** letter may be inserted. The site energy factor of Run *x* (EF_x) is expressed in pounds of dried clothing per kWh and is given by the following equation:

$$EF_x = \frac{W_{bone\,(x)}}{(G_{cycle\,(x)} + E_{cycle\,(x)} + E_{low})}$$

where $W_{bone(x)}$ is the measured **bone dry** weight of **run** X, $G_{cycle\,(x)}$ is the gas site energy use per cycle for **run** X (in kWh) given by either 8.1.3 or 8.1.4, $E_{cycle\,(x)}$ is the electric site energy use per cycle for **run** X (in kWh) given by either 8.1.3 or 8.1.4, and E_{low} is the average low power mode site energy use per cycle (in kWh) given in 8.2.1.

NOTE W_{bone} will likely be identical for Run A and Run B. In the case that it is not, then
$W_{bone\,(AB)} = \frac{1}{2}\left(W_{bone\,(A)} + W_{bone\,(B)}\right)$

8.3.2   *Cost-benefit Factor* **for each Run "AB", C, D, E, and F.**
This calculation may be performed for each **run** ("AB", C through F). Wherever an "*x*" is shown, the applicable **run** letter may be inserted. The cost benefit factor of Run *x* (CBF_x) is expressed in pounds of dried clothing per unit of cost (dollars, GHGs, BTUs, etc.) and is given by the following equation:

$$CBF_x = \frac{W_{bone\,(x)}}{(\alpha G_{cycle\,(x)} + \beta E_{cycle\,(x)} + \beta E_{low})}$$

where $W_{bone(x)}$ is the measured **bone dry** weight of **run** X, α is a constant that weights the relative societal and environmental cost of gas energy, $G_{cycle\,(x)}$ is the gas site energy use per cycle for **run** X (in kWh) given by either 8.1.3 or 8.1.4, β is a constant that weights the relative societal and environmental cost of electricity, $E_{cycle\,(x)}$ is the electric site energy use per cycle (in kWh) given by either 8.1.3 or 8.1.4, and E_{low} is the average low power mode site energy use per cycle (in kWh) given in 8.2.1.

NOTE W_{bone} will likely be identical for Run A and Run B. In the case that it is not, then
$W_{bone\,(AB)} = \frac{1}{2}\left(W_{bone\,(A)} + W_{bone\,(B)}\right)$

8.3.3   *Average Site* **Energy Factor for a basic dryer model**
This calculation shall be performed once for each **tumble dryer** under test. The average site energy factor ($Avg\ EF$) is expressed in pounds of dried clothing per kWh of site

46

energy. For **tumble dryers** with automatic termination, *Avg EF* is given by the following equation:

$$Avg\ EF = \frac{1}{5}[EF_{AB} + EF_C + EF_D + EF_E + EF_F]$$

For **tumble dryers** without automatic termination, *Avg EF* is given by the following equation:

$$Avg\ EF = \frac{1}{4}[EF_{AB} + EF_C + EF_D + EF_E]$$

8.3.4 *Average Cost-benefit Factor for a basic dryer model*

This calculation shall be performed once for each **tumble dryer** under test. The average cost benefit factor (*Avg CBF*) is expressed in pounds of dried clothing per unit of cost (dollars, GHGs, BTUs, etc.). For **tumble dryers** with automatic termination, *Avg CBF* is given by the following equation:

$$Avg\ CBF = \frac{1}{5}[CBF_{AB} + CBF_C + CBF_D + CBF_E + CBF_F]$$

For **tumble dryers** without automatic termination, *Avg CBF* is given by the following equation:

$$Avg\ CBF = \frac{1}{4}[CBF_{AB} + CBF_C + CBF_D + CBF_E]$$

8.3.5 *Average program time for a basic dryer model*

This calculation shall be performed once for each **tumble dryer** under test. The average **program time**, $Avg\ T_{cycle}$, is expressed in minutes. For **tumble dryers** with automatic termination, $Avg\ T_{cycle}$ is given by the following equation:

$$Avg\ T_{cycle} = \frac{1}{5}\left[T_{cycle(AB)} + T_{cycle(C)} + T_{cycle(D)} + T_{cycle(E)} + T_{cycle(F)}\right]$$

For **tumble dryers** without automatic termination, $Avg\ T_{cycle}$ is given by the following equation:

$$Avg\ T_{cycle} = \frac{1}{4}\left[T_{cycle(AB)} + T_{cycle(C)} + T_{cycle(D)} + T_{cycle(E)}\right]$$

8.3.6 *Average power factor a basic dryer model*

This calculation shall be performed once for each **tumble dryer** under test. The average **power factor**, $Avg\ PF_{cycle}$, is a dimensionless value. For **tumble dryers** with automatic termination, $Avg\ PF_{cycle}$ is given by the following equation:

$$Avg\ PF_{cycle} = \frac{1}{5}\left[PF_{cycle(AB)} + PF_{cycle(C)} + PF_{cycle(D)} + PF_{cycle(E)} + PF_{cycle(F)}\right]$$

For **tumble dryers** <u>without</u> automatic termination, $Avg\ PF_{cycle}$ is given by the following equation:

$$Avg\ PF_{cycle} = \frac{1}{4}\left[PF_{cycle(AB)} + PF_{cycle(C)} + PF_{cycle(D)} + PF_{cycle(E)}\right]$$

48

$$C_A' = \alpha G_A + \beta E_A + 1.3(\alpha G_A + \beta E_A)(0.60 - I_A)$$

$$C_B' = \alpha G_B + \beta E_B + 1.3(\alpha G_B + \beta E_B)(0.60 - I_B)$$

$$C_{cycle\,(x)} = \propto [G_x + 1.3 G_x (I_T - I_x)] + \beta [E_x + 1.3 E_x (I_T - I_x)]$$

$$CBF_x = \frac{W_{bone\,(x)}}{(C_{low} + C_{cycle\,(x)})}$$

$$Average\ T_{cycle} = \frac{1}{5}\left[T_{cycle(AB)} + T_{cycle(C)} + T_{cycle(D)} + T_{cycle(E)} + T_{cycle(F)}\right]$$