uses a cradle and/or adapter for power conversion and charging, then ''disconnecting the battery from the charger'' will require disconnection of the end-use product, which contains the batteries. The other enclosures of the battery charging system will remain connected to the main electricity supply, and standby mode power consumption will equal that of the cradle and/or adapter alone.

c. If the product is powered through a detachable AC power cord and contains integrated power conversion and charging circuitry, then only the cord will remain connected to mains, and standby mode power consumption will equal that of the AC power cord (*i.e.*, zero watts).

d. Finally, if the product contains integrated power conversion and charging circuitry but is powered through a non-detachable AC power cord or plug blades, then no part of the system will remain connected to mains, and standby mode measurement is not applicable.

5.12. Off Mode Energy Consumption Measurement

The off mode measurement depends on the configuration of the battery charger, as follows.

a. If the battery charger has manual on-off switches, record a measurement of off mode energy consumption while the battery charger is connected to the power source. Remove the battery from the charger, allow the charger to operate for at least 30 minutes, and record the power (*i.e.*, watts) consumed as the time series integral of the power consumed over a 10-minute test period, divided by the period of measurement, with all manual on-off switches turned off. If the battery charger does not have manual on-off switches, record that the off mode measurement is not applicable to this product.

b. Off mode may also apply to products with integral batteries. If the product uses a cradle and/or adapter for power conversion and charging, then ''disconnecting the battery from the charger'' will require disconnection of the end-use product, which contains the batteries. The other enclosures of the battery charging system will remain connected to the main electricity supply, and off mode power consumption will equal that of the cradle and/or adapter alone.

c. If the product is powered through a detachable AC power cord and contains integrated power conversion and charging circuitry, then only the cord will remain connected to mains, and off mode power consumption will equal that of the AC power cord (*i.e.*, zero watts).

d. Finally, if the product contains integrated power conversion and charging circuitry but is powered through a non-detachable AC power cord or plug blades, then no part of the system will remain connected to mains, and off mode measurement is not applicable.

[76 FR 31776, June 1, 2011]

Appendix Z to Subpart B of Part 430—Uniform Test Method for Measuring the Energy Consumption of External Power Supplies

1. *Scope*: This appendix covers the test requirements used to measure energy consumption of external power supplies.

2. *Definitions*: The following definitions are for the purposes of understanding terminology associated with the test method for measuring external power supply energy consumption. For clarity on any other terminology used in the test method, please refer to IEC Standard 60050 or IEEE Standard 100. (Reference for guidance only, see § 430.4.)

a. *Active mode* means the mode of operation when the external power supply is connected to the main electricity supply and the output is (or ''all outputs are'' for a multiple-voltage external power supply) connected to a load (or ''loads'' for a multiple-voltage external power supply).

b. *Active mode efficiency* is the ratio, expressed as a percentage, of the total real output power produced by a power supply to the real input power required to produce it. (Reference for guidance only, see IEEE Standard 1515–2000, 4.3.1.1, § 430.4.)

c. *Active power (P)* (also *real power*) means the average power consumed by a unit. For a two terminal device with current and voltage waveforms i(t) and v(t) which are periodic with period T, the real or active power P is:

$$P = \frac{1}{T}\int_0^T v(t)i(t)dt$$

d. *Ambient temperature* means the temperature of the ambient air immediately surrounding the unit under test.

e. *Apparent power* (S) is the product of RMS voltage and RMS current (VA).

f. *Instantaneous power* means the product of the instantaneous voltage and instantaneous current at a port (the terminal pair of a load).

g. *Manual on-off switch* is a switch activated by the user to control power reaching the device. This term does not apply to any mechanical, optical, or electronic switches that automatically disconnect mains power from the device when a load is disconnected from the device, or that control power to the load itself.

h. *Minimum output current* means the minimum current that must be drawn from an output bus for an external power supply to operate within its specifications.

i. *Multiple-voltage external power supply* means an external power supply that is designed to convert line voltage AC input into more than one simultaneous lower-voltage output.

j. *Nameplate input frequency* means the AC input frequency of the power supply as specified on the manufacturer's label on the power supply housing.

k. *Nameplate input voltage* means the AC input voltage of the power supply as specified on the manufacturer's label on the power supply housing.

l. *Nameplate output current* means the current output of the power supply as specified on the manufacturer's label on the power supply housing (either DC or AC) or, if absent from the housing, as provided by the manufacturer.

m. *Nameplate output power* means the power output of the power supply as specified on the manufacturer's label on the power supply housing or, if absent from the housing, as specified in documentation provided by the manufacturer.

n. *Nameplate output voltage* means the voltage output of the power supply as specified on the manufacturer's label on the power supply housing (either DC or AC).

o. *No-load mode* means the mode of operation when an external power supply is connected to the main electricity supply and the output is (or ''all outputs are'' for a multiple-voltage external power supply) not connected to a load (or ''loads'' for a multiple-voltage external power supply).

p. *Off mode* is the condition, applicable only to units with manual on-off switches, in which the external power supply is (1) connected to the main electricity supply; (2) the output is not connected to any load; and (3) all manual on-off switches are turned off.

q. *Output bus* means any of the outputs of the power supply to which loads can be connected and from which power can be drawn, as opposed to signal connections used for communication.

r. *Single-voltage external AC–AC power supply* means an external power supply that is designed to convert line voltage AC input into lower voltage AC output and is able to convert to only one AC output voltage at a time.

s. *Single-voltage external AC–DC power supply* means an external power supply that is designed to convert line voltage AC input into lower-voltage DC output and is able to convert to only one DC output voltage at a time.

t. *Standby mode* means the condition in which the external power supply is in no-load mode and, for external power supplies with manual on-off switches, all such switches are turned on.

u. *Switch-selectable single voltage external power supply* means a single-voltage AC–AC or AC–DC power supply that allows users to choose from more than one output voltage.

v. *Total harmonic distortion*, expressed as a percentage, is the RMS value of an AC signal after the fundamental component is removed and interharmonic components are ignored, divided by the RMS value of the fundamental component. THD of current is defined as:

$$THD_I = \frac{\sqrt{I_2^2 + I_3^2 + I_4^2 + I_5^2 + \ldots\ldots I_n^2}}{I_1}$$

where I_n is the RMS value of the nth harmonic of the current signal.

w. *True power factor* (PF) is the ratio of the active power (P) consumed in watts to the apparent power (S), drawn in volt-amperes.

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

This definition of power factor includes the effect of both distortion and displacement.

x. *Unit under test* is the external power supply being tested.

3. *Test Apparatus and General Instructions:*

(a) Single-Voltage External Power Supply. The test apparatus, standard testing conditions, and instructions for testing external power supplies shall conform to the requirements specified in section 4, ''General Conditions for Measurement,'' of the CEC's ''Test Method for Calculating the Energy Efficiency of Single-Voltage External AC–DC and AC–AC Power Supplies,'' August 11, 2004. The test voltage specified in section 4.d, ''Test Voltage,'' shall only be 115 volts, 60 Hz.

(b) Multiple-Voltage External Power Supply. Unless otherwise specified, measurements shall be made under test conditions and with equipment specified below.

(i) Verifying Accuracy and Precision of Measuring Equipment

(A) Measurements of power 0.5 W or greater shall be made with an uncertainty of ≤2 percent at the 95 percent confidence level. Measurements of power less than 0.5 W shall be made with an uncertainty of ≤0.01 W at the 95 percent confidence level. The power measurement instrument shall have a resolution of:

(1) 0.01 W or better for measurements up to 10 W;

(2) 0.1 W or better for measurements of 10 to 100 W; or

(3) 1 W or better for measurements over 100 W.

(B) Measurements of energy (Wh) shall be made with an uncertainty of ≤2 percent at the 95 percent confidence level. Measurements of voltage and current shall be made with an uncertainty of ≤1 percent at the 95 percent confidence level. Measurements of temperature shall be made with an uncertainty of ≤2 °C at the 95 percent confidence level.

(C) All equipment used to conduct the tests must be selected and calibrated to ensure that measurements will meet the above uncertainty requirements. For guidance on measuring low power levels, see IEC 62301, Section 5.3.2 and Annexes B and D (Reference for guidance only, see § 430.4).

(ii) Setting Up the Test Room

All tests shall be carried out in a room with an air speed immediately surrounding the UUT of ≤0.5 m/s. The ambient temperature shall be maintained at 20 °C ±5 °C throughout the test. There shall be no intentional cooling of the UUT such as by use of separately powered fans, air conditioners, or heat sinks. The UUT shall be conditioned, rested, and tested on a thermally non-conductive surface. A readily available material such as Styrofoam will be sufficient.

(iii) Verifying the UUT's Input Voltage and Input Frequency

(A) If the UUT is intended for operation on AC line-voltage input in the United States, it shall be tested at 115 V at 60 Hz. If the UUT is intended for operation on AC line-voltage input but cannot be operated at 115 V at 60 Hz, it shall not be tested. The input voltage shall be within ±1 percent of the above specified voltage.

(B) If the input voltage is AC, the input frequency shall be within ±1 percent of the specified frequency. The THD of the input voltage shall be ≤2 percent, up to and including the 13th harmonic. The crest factor of the input voltage shall be between 1.34 and 1.49.

4. *Test Measurement:*

(a) Single-Voltage External Power Supply

(i) Standby Mode and Active Mode Measurement—The measurement of standby mode (also no-load mode) energy consumption and active mode efficiency shall conform to the requirements specified in section 5, ''Measurement Approach'' of the CEC's ''Test Method for Calculating the Energy Efficiency of Single-Voltage External Ac-Dc and Ac-Ac Power Supplies,'' August 11, 2004, (incorporated by reference, see § 430.3). Switch-selectable single-voltage external power supplies shall be tested twice—once at the highest nameplate output voltage and once at the lowest.

(A) If the product has more than two output wires, including those that are necessary for controlling the product, the manufacturer shall supply a connection diagram or test fixture that will allow the testing laboratory to put the unit under test into active mode.

(B) For those external power supplies that cannot sustain output at 100 percent loading condition, this efficiency metric shall not be included. For these external power supplies, the average efficiency is the average of the efficiencies measured at 25 percent, 50 percent, and 75 percent of maximum load.

(C) In the case where the external power supply lists both an instantaneous and continuous output current, it shall be tested at the continuous condition only.

(ii) Off-Mode Measurement—If the external power supply unit under test incorporates manual on-off switches, the unit under test shall be placed in off mode, and its power consumption in off mode measured and recorded. The measurement of the off mode energy consumption shall conform to the requirements specified in section 5, ''Measurement Approach,'' of the CEC's ''Test Method for Calculating the Energy Efficiency of Single-Voltage External Ac-Dc and Ac-Ac Power Supplies,'' August 11, 2004 (incorporated by reference, see § 430.3), with two exceptions. In section 5.a, ''Preparing UUT [Unit Under Test] for Test,'' all manual on-off switches shall be placed in the ''off'' position for the measurement. In section 5.d, ''Testing Sequence,'' the technician shall consider the UUT stable if, over 5 minutes with samples taken at least once every second, the AC input power does not drift from the maximum value observed by more than 1 percent or 50 milliwatts, whichever is greater. The only loading condition that will be measured for off mode is ''Load Condition 5'' in Table 1 of the CEC's test procedure. Switch-selectable single-voltage external power supplies shall have their off mode power consumption measured twice— once at the highest nameplate output voltage and once at the lowest.

(b) Multiple-Voltage External Power Supply—Power supplies must be tested with the output cord packaged with the unit for sale to the consumer, as it is considered part of the unit under test. There are two options for connecting metering equipment to the output of this type of power supply: cut the cord immediately adjacent to the output connector or attach leads and measure the efficiency from the output connector itself. If the power supply is attached directly to the product that it is powering, cut the cord immediately adjacent to the powered product and connect output measurement probes at that point. The tests should be conducted on the sets of output wires that constitute the output busses. If the product has additional wires, these should be left electrically disconnected unless they are necessary for controlling the product. In this case, the manufacturer shall supply a connection diagram or test fixture that will allow the testing laboratory to put the unit under test into active mode.

(i) Standby-Mode and Active-Mode Measurement—The measurement of the multiple-voltage external power supply standby mode (also no-load-mode) energy consumption and active-mode efficiency shall be as follows:

(A) Loading conditions and testing sequence. (1) If the unit under test has on-off switches, all switches shall be placed in the ''on'' position. Loading criteria for multiple-voltage external power supplies shall be based on nameplate output current and not on nameplate output power because output voltage might not remain constant.

(2) The unit under test shall operate at 100 percent of nameplate current output for at least 30 minutes immediately before conducting efficiency measurements.

(3) After this warm-up period, the technician shall monitor AC input power for a period of 5 minutes to assess the stability of the unit under test. If the power level does not drift by more than 1 percent from the maximum value observed, the unit under test can be considered stable and measurements can be recorded at the end of the 5-minute period. Measurements at subsequent loading conditions, listed in Table 1, can then be conducted under the same 5-minute stability guidelines. Only one warm-up period of 30 minutes is required for each unit under test at the beginning of the test procedure.

(4) If AC input power is not stable over a 5-minute period, the technician shall follow the guidelines established by IEC Standard 62301 for measuring average power or accumulated energy over time for both input and output. (Reference for guidance only, see §430.4).

(5) The unit under test shall be tested at the loading conditions listed in Table 1, derated per the proportional allocation method presented in the following section.

TABLE 1—LOADING CONDITIONS FOR UNIT UNDER TEST

Loading Condition 1	100% of Derated Nameplate Output Current ±2%.
Loading Condition 2	75% of Derated Nameplate Output Current ±2%.
Loading Condition 3	50% of Derated Nameplate Output Current ±2%.
Loading Condition 4	25% of Derated Nameplate Output Current ±2%.
Loading Condition 5	0%.

(6) Input and output power measurements shall be conducted in sequence from Loading Condition 1 to Loading Condition 4, as indicated in Table 1. For Loading Condition 5, the unit under test shall be placed in no-load mode, any additional signal connections to the unit under test shall be disconnected, and input power shall be measured.

(B) Proportional allocation method for loading multiple-voltage external power supplies. For power supplies with multiple voltage busses, defining consistent loading criteria is difficult because each bus has its own nameplate output current. The sum of the power dissipated by each bus loaded to its nameplate output current may exceed the overall nameplate output power of the power supply. The following proportional allocation method must be used to provide consistent loading conditions for multiple-voltage external power supplies. For additional explanation, please refer to section 6.1.1 of the California Energy Commission's ''Proposed Test Protocol for Calculating the Energy Efficiency of Internal Ac-Dc Power Supplies Revision 6.2,'' November 2007.

(1) Consider a multiple-voltage power supply with N output busses, and nameplate output voltages V_1, * * *, V_N, corresponding output current ratings I_1, * * *, I_N, and a nameplate output power P. Calculate the derating factor D by dividing the power supply nameplate output power P by the sum of the nameplate output powers of the individual output busses, equal to the product of bus nameplate output voltage and current I_iV_i, as follows:

$$D = \frac{P}{\sum_{i=1}^{N} V_i I_i},$$

(2) If $D \geq 1$, then loading every bus to its nameplate output current does not exceed the overall nameplate output power for the power supply. In this case, each output bus will simply be loaded to the percentages of its nameplate output current listed in Table 1. However, if $D < 1$, it is an indication that loading each bus to its nameplate output current will exceed the overall nameplate output power for the power supply. In this case, and at each loading condition, each output bus will be loaded to the appropriate percentage of its nameplate output current listed in Table 1, multiplied by the derating factor D.

(C) Minimum output current requirements. Depending on their application, some multiple-voltage power supplies may require a minimum output current for each output bus of the power supply for correct operation. In these cases, ensure that the load current for each output at Loading Condition 4 in Table 1 is greater than the minimum output current requirement. Thus, if the test method's calculated load current for a given voltage bus is smaller than the minimum output current requirement, the minimum output current must be used to load the bus. This load current shall be properly recorded in any test report.

(D) Test loads. Active loads such as electronic loads or passive loads such as rheostats used for efficiency testing of the unit under test shall be able to maintain the required current loading set point for each output voltage within an accuracy of ±0.5 percent. If electronic load banks are used, their settings should be adjusted such that they provide a constant current load to the unit under test.

(E) Efficiency calculation. Efficiency shall be calculated by dividing the measured active output power of the unit under test at a given loading condition by the active AC input power measured at that loading condition. Efficiency shall be calculated at each Loading Condition (1, 2, 3, and 4, in Table 1) and be recorded separately.

(F) Power consumption calculation. Power consumption of the unit under test at Loading Conditions 1, 2, 3, and 4 is the difference between the active output power at that Loading Condition and the active AC input power at that Loading Condition. The power consumption of Loading Condition 5 (no-load) is equal to the AC active input power at that Loading Condition.

(ii) Off Mode Measurement—If the multiple-voltage external power supply unit under test incorporates any on-off switches, the unit under test shall be placed in off mode and its power consumption in off mode measured and recorded. The measurement of the off mode energy consumption shall conform to the requirements specified in paragraph (4)(b)(i) of this appendix. Note that the only loading condition that will be measured for off mode is ''Loading Condition 5'' in paragraph (A), ''Loading conditions and testing sequence'', except that all manual on-off switches shall be placed in the off position for the measurement.

[71 FR 71366, Dec. 8, 2006, as amended at 74 FR 12066, Mar. 23, 2009; 74 FR 13334, Mar. 27, 2009; 76 FR 31782, June 1, 2011]

Subpart C—Energy and Water Conservation Standards

§ 430.31 Purpose and scope.

This subpart contains energy conservation standards and water conservation standards (in the case of faucets, showerheads, water closets, and urinals) for classes of covered products that are required to be administered by the Department of Energy pursuant to the Energy Conservation Program for Consumer Products Other Than Automobiles under the Energy Policy and Conservation Act, as amended (42 U.S.C. 6291 *et seq.*).

[63 FR 13317, Mar. 18, 1998, as amended at 78 FR 62993, Oct. 23, 2013]

§ 430.32 Energy and water conservation standards and their compliance dates.

The energy and water (in the case of faucets, showerheads, water closets, and urinals) conservation standards for the covered product classes are:

(a) *Refrigerators/refrigerator-freezers/freezers*. These standards do not apply to refrigerators and refrigerator-freezers with total refrigerated volume exceeding 39 cubic feet (1104 liters) or freezers with total refrigerated volume exceeding 30 cubic feet (850 liters). The energy standards as determined by the equations of the following table(s) shall be rounded off to the nearest kWh per year. If the equation calculation is halfway between the nearest two kWh per year values, the standard shall be rounded up to the higher of these values.

The following standards remain in effect from July 1, 2001 until September 15, 2014:

Product class	Energy standard equations for maximum energy use (kWh/yr)
1. Refrigerators and refrigerator-freezers with manual defrost	8.82AV + 248.4 0.31av + 248.4
2. Refrigerator-freezers—partial automatic defrost	8.82AV + 248.4 0.31av + 248.4
3. Refrigerator-freezers—automatic defrost with top-mounted freezer without through-the-door ice service and all-refrigerator—automatic defrost.	9.80AV + 276.0 0.35av + 276.0
4. Refrigerator-freezers—automatic defrost with side-mounted freezer without through-the-door ice service	4.91AV + 507.5 0.17av + 507.5
5. Refrigerator-freezers—automatic defrost with bottom-mounted freezer without through-the-door ice service.	4.60AV + 459.0 0.16av + 459.0
6. Refrigerator-freezers—automatic defrost with top-mounted freezer with through-the-door ice service	10.20AV + 356.0 0.36av + 356.0
7. Refrigerator-freezers—automatic defrost with side-mounted freezer with through-the-door ice service	10.10AV + 406.0 0.36av + 406.0
8. Upright freezers with manual defrost	7.55AV + 258.3 0.27av + 258.3