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Title 10 - Energy

Chapter II - Department of Energy

Subchapter D - Energy Conservation

Part 431 - Energy Efficiency Program for Certain Commercial and Industrial Equipment

Subpart R - Walk-in Coolers and Walk-in Freezers

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Appendix A to Subpart R of Part 431 - Uniform Test Method for the Measurement of Energy Consumption of the Components of Envelopes of Walk-In Coolers and Walk-In Freezers

1.0 Scope

This appendix covers the test requirements used to measure the energy consumption of the components that make up the envelope of a walk-in cooler or walk-in freezer.

2.0 Definitions

The definitions contained in § 431.302 are applicable to this appendix.

3.0 Additional Definitions

3.1 Automatic door opener/closer means a device or control system that “automatically” opens and closes doors without direct user contact, such as a motion sensor that senses when a forklift is approaching the entrance to a door and opens it, and then closes the door after the forklift has passed.

3.2 [Reserved]

3.3 [Reserved]

3.4 Surface area means the area of the surface of the walk-in component that would be external to the walk-in cooler or walk-in freezer as appropriate.

3.5 Rated power means the electricity consuming device's power as specified on the device's nameplate. If the device does not have a nameplate or such nameplate does not list the device's power, then the rated power must be read from the device's product data sheet.

3.6 Rating conditions means, unless explicitly stated otherwise, all conditions shown in Table A.1 of this section.

3.7 Percent time off (PTO) means the percent of time that an electrical device is assumed to be off.

Table A.1 - Temperature Conditions

Internal Temperatures (cooled space within the envelope)	
Cooler Dry Bulb Temperature	35 °F
Freezer Dry Bulb Temperature	-10 °F
External Temperatures (space external to the envelope)	
Freezer and Cooler Dry Bulb Temperatures	75 °F.

4.0 Calculation Instructions

4.1 Display Panels

- Calculate the U-factor of the display panel in accordance with section 5.3 of this appendix, Btu/h-ft²-°F.
- Calculate the display panel surface area, as defined in section 3.4 of this appendix, A_{dp}, ft², with standard geometric formulas or engineering software.
- Calculate the temperature differential, ΔT_{dp}, °F, for the display panel, as follows:

$$\Delta T_{dp} = |T_{DB,ext,dp} - T_{DB,int,dp}| \quad (4-1)$$

Where:

T_{DB,ext,dp} = dry-bulb air external temperature, °F, as prescribed in Table A.1; and

T_{DB,int,dp} = dry-bulb air temperature internal to the cooler or freezer, °F, as prescribed in Table A.1.

- Calculate the conduction load through the display panel, Q_{cond-dp}, Btu/h, as follows:

$$Q_{cond,dp} = A_{dp} \times \Delta T_{dp} \times U_{dp} \quad (4-2)$$

Where:

A_{dp} = surface area of the walk-in display panel, ft²;

ΔT_{dp} = temperature differential between refrigerated and adjacent zones, °F; and

U_{dp} = thermal transmittance, U-factor, of the display panel in accordance with section 5.3 of this appendix, Btu/h-ft²-°F.

- Select Energy Efficiency Ratio (EER), as follows:

- For coolers, use EER = 12.4 Btu/W-h

- For freezers, use EER = 6.3 Btu/W-h

- Calculate the total daily energy consumption, E_{dp}, kWh/day, as follows:

$$E_{dp} = \frac{Q_{cond,dp}}{EER} \times \frac{24 \text{ h} \times 1 \text{ kW}}{1 \text{ day} \times 1000 \text{ W}} \quad (4-3)$$

Where:

$Q_{\text{cond, dp}}$ = the conduction load through the display panel, Btu/h; and EER = EER of walk-in (cooler or freezer), Btu/W-h.

4.2 [Reserved]

4.3 [Reserved]

4.4 Display Doors

4.4.1 Conduction Through Display Doors

- (a) Calculate the U-factor of the door in accordance with section 5.3 of this appendix, Btu/h-ft²-°F
- (b) Calculate the surface area, as defined in section 3.4 of this appendix, of the display door, A_{dd} , ft², with standard geometric formulas or engineering software.
- (c) Calculate the temperature differential, ΔT_{dd} , °F, for the display door as follows:

$$\Delta T_{\text{dd}} = |T_{\text{DB,ext,dd}} - T_{\text{DB,int,dd}}| \quad (4-18)$$

Where:

$T_{\text{DB,ext,dd}}$ = dry-bulb air temperature external to the display door, °F, as prescribed in Table A.1; and

$T_{\text{DB,int,dd}}$ = dry-bulb air temperature internal to the display door, °F, as prescribed in Table A.1.

- (d) Calculate the conduction load through the display doors, $Q_{\text{cond-dd}}$, Btu/h, as follows:

$$Q_{\text{cond,dd}} = A_{\text{dd}} \times \Delta T_{\text{dd}} \times U_{\text{dd}} \quad (4-19)$$

Where:

ΔT_{dd} = temperature differential between refrigerated and adjacent zones, °F;

A_{dd} = surface area walk-in display doors, ft²; and

U_{dd} = thermal transmittance, U-factor of the door, in accordance with section 5.3 of this appendix, Btu/h-ft²-°F.

4.4.2 Direct Energy Consumption of Electrical Component(s) of Display Doors

Electrical components associated with display doors could include, but are not limited to: heater wire (for anti-sweat or anti-freeze application); lights (including display door lighting systems); control system units; and sensors.

- (a) Select the required value for percent time off (PTO) for each type of electricity consuming device, PTO_t (%)

- (1) For lights without timers, control system or other demand-based control, PTO = 25 percent. For lighting with timers, control system or other demand-based control, PTO = 50 percent.
 - (2) For anti-sweat heaters on coolers (if included): Without timers, control system or other demand-based control, PTO = 0 percent. With timers, control system or other demand-based control, PTO = 75 percent. For anti-sweat heaters on freezers (if included): Without timers, control system or other auto-shut-off systems, PTO = 0 percent. With timers, control system or other demand-based control, PTO = 50 percent.
 - (3) For all other electricity consuming devices: Without timers, control system, or other auto-shut-off systems, PTO = 0 percent. If it can be demonstrated that the device is controlled by a preinstalled timer, control system or other auto-shut-off system, PTO = 25 percent.
- (b) Calculate the power usage for each type of electricity consuming device, $P_{dd-comp,u,t}$, kWh/day, as follows:

$$P_{dd-comp,u,t} = P_{rated,u,t} \times (1 - PTO_{u,t}) \times n_{u,t} \times \frac{24h}{day} \quad (4-20)$$

Where:

u = the index for each of type of electricity-consuming device located on either (1) the interior facing side of the display door or within the inside portion of the display door, (2) the exterior facing side of the display door, or (3) any combination of (1) and (2). For purposes of this calculation, the interior index is represented by $u = int$ and the exterior index is represented by $u = ext$. If the electrical component is both on the interior and exterior side of the display door then $u = int$. For anti-sweat heaters sited anywhere in the display door, 75 percent of the total power is be attributed to $u = int$ and 25 percent of the total power is attributed to $u = ext$;

t = index for each type of electricity consuming device with identical rated power;

$P_{rated,u,t}$ = rated power of each component, of type t , kW;

$PTO_{u,t}$ = percent time off, for device of type t , %; and

$n_{u,t}$ = number of devices at the rated power of type t , unitless.

- (c) Calculate the total electrical energy consumption for interior and exterior power, $P_{dd-tot, int}$ (kWh/day) and $P_{dd-tot, ext}$ (kWh/day), respectively, as follows:

$$P_{dd-tot,int} = \sum_1^t P_{dd-comp,int,t} \quad (4-21)$$

$$P_{dd-tot,ext} = \sum_1^t P_{dd-comp,ext,t} \quad (4-22)$$

Where:

t = index for each type of electricity consuming device with identical rated power;

$P_{dd-comp,int,t}$ = the energy usage for an electricity consuming device sited on the interior facing side of or in the display door, of type t, kWh/day; and

$P_{dd-comp,ext,t}$ = the energy usage for an electricity consuming device sited on the external facing side of the display door, of type t, kWh/day.

- (d) Calculate the total electrical energy consumption, P_{dd-tot} , (kWh/day), as follows:

$$P_{dd-tot} = P_{dd-tot,int} + P_{dd-tot,ext} \quad (4-23)$$

Where:

$P_{dd-tot,int}$ = the total interior electrical energy usage for the display door, kWh/day; and

$P_{dd-tot,ext}$ = the total exterior electrical energy usage for the display door, kWh/day.

4.4.3 Total Indirect Electricity Consumption Due to Electrical Devices

- (a) Select Energy Efficiency Ratio (EER), as follows:

(1) For coolers, use EER = 12.4 Btu/Wh

(2) For freezers, use EER = 6.3 Btu/Wh

- (b) Calculate the additional refrigeration energy consumption due to thermal output from electrical components sited inside the display door, $C_{dd-load}$, kWh/day, as follows:

$$C_{dd-load} = P_{dd-tot,int} \times \frac{3.412 \text{ Btu}}{\text{EER W-h}} \quad (4-24)$$

Where:

EER = EER of walk-in cooler or walk-in freezer, Btu/W-h; and

$P_{dd-tot,int}$ = The total internal electrical energy consumption due for the display door, kWh/day.

4.4.4 Total Display Door Energy Consumption

- (a) Select Energy Efficiency Ratio (EER), as follows:

(1) For coolers, use EER = 12.4 Btu/W-h

(2) For freezers, use EER = 6.3 Btu/W-h

- (b) Calculate the total daily energy consumption due to conduction thermal load, $E_{dd,thermal}$, kWh/day, as follows:

$$E_{dd,thermal} = \frac{Q_{cond,dd}}{\text{EER}} \times \frac{24 \text{ h} \times 1 \text{ kW}}{1 \text{ day} \times 1000 \text{ W}} \quad (4-25)$$

Where:

$Q_{cond,dd}$ = the conduction load through the display door, Btu/h; and

EER = EER of walk-in (cooler or freezer), Btu/W-h.

- (c) Calculate the total energy, $E_{dd,tot}$, kWh/day,

$$E_{dd,tot} = E_{dd,thermal} + P_{dd-tot} + C_{dd-load} \quad (4-26)$$

Where:

$E_{dd,thermal}$ = the total daily energy consumption due to thermal load for the display door, kWh/day;

P_{dd-tot} = the total electrical load, kWh/day; and

$C_{dd-load}$ = additional refrigeration load due to thermal output from electrical components contained within the display door, kWh/day.

4.5 Non-Display Doors

4.5.1 Conduction Through Non-Display Doors

- (a) Calculate the surface area, as defined in section 3.4 of this appendix, of the non-display door, A_{nd} , ft², with standard geometric formulas or with engineering software.
- (b) Calculate the temperature differential of the non-display door, ΔT_{nd} , °F, as follows:

$$\Delta T_{nd} = |T_{DB,ext,nd} - T_{DB,int,nd}| \quad (4-27)$$

Where:

$T_{DB,ext,nd}$ = dry-bulb air external temperature, °F, as prescribed by Table A.1; and

$T_{DB,int,nd}$ = dry-bulb air internal temperature, °F, as prescribed by Table A.1. If the component spans both cooler and freezer spaces, the freezer temperature must be used.

- (c) Calculate the conduction load through the non-display door: $Q_{cond-nd}$, Btu/h,

$$Q_{cond-nd} = \Delta T_{nd} \times A_{nd} \times U_{nd} \quad (4-28)$$

Where:

ΔT_{nd} = temperature differential across the non-display door, °F;

U_{nd} = thermal transmittance, U-factor of the door, in accordance with section 5.3 of this appendix, Btu/h-ft²-°F; and

A_{nd} = area of non-display door, ft².

4.5.2 Direct Energy Consumption of Electrical Components of Non-Display Doors

Electrical components associated with a walk-in non-display door comprise any components that are on the non-display door and that directly consume electrical energy. This includes, but is not limited to, heater wire (for anti-sweat or anti-freeze application), control system units, and sensors.

- (a) Select the required value for percent time off for each type of electricity consuming device, PTO_t (%)
- (1) For lighting without timers, control system or other demand-based control, $PTO = 25$ percent. For lighting with timers, control system or other demand-based control, $PTO = 50$ percent.
 - (2) For anti-sweat heaters on coolers (if included): Without timers, control system or other demand-based control, $PTO = 0$ percent. With timers, control system or other demand-based control, $PTO = 75$ percent. For anti-sweat heaters on freezers (if included): Without timers, control system or other auto-shut-off systems, $PTO = 0$ percent. With timers, control system or other demand-based control, $PTO = 50$ percent.
 - (3) For all other electricity consuming devices: Without timers, control system, or other auto-shut-off systems, $PTO = 0$ percent. If it can be demonstrated that the device is controlled by a preinstalled timer, control system or other auto-shut-off system, $PTO = 25$ percent.
- (b) Calculate the power usage for each type of electricity consuming device, $P_{nd-comp,u,t}$, kWh/day, as follows:

$$P_{nd-comp,u,t} = P_{rated,u,t} \times (1 - PTO_{u,t}) \times n_{u,t} \times \frac{24h}{day} \quad (4-29)$$

Where:

u = the index for each of type of electricity-consuming device located on either (1) the interior facing side of the display door or within the inside portion of the display door, (2) the exterior facing side of the display door, or (3) any combination of (1) and (2). For purposes of this calculation, the interior index is represented by $u = int$ and the exterior index is represented by $u = ext$. If the electrical component is both on the interior and exterior side of the display door then $u = int$. For anti-sweat heaters sited anywhere in the display door, 75 percent of the total power is be attributed to $u = int$ and 25 percent of the total power is attributed to $u = ext$;

t = index for each type of electricity consuming device with identical rated power;

$P_{rated,u,t}$ = rated power of each component, of type t , kW;

$PTO_{u,t}$ = percent time off, for device of type t , %; and

$n_{u,t}$ = number of devices at the rated power of type t , unitless.

- (c) Calculate the total electrical energy consumption for interior and exterior power, $P_{nd-tot, int}$ (kWh/day) and $P_{nd-tot, ext}$ (kWh/day), respectively, as follows:

$$P_{nd-tot,int} = \sum_i^t P_{nd-comp,int,t} \quad (4-30)$$

$$P_{nd-tot,ext} = \sum_i^t P_{nd-comp,ext,t} \quad (4-31)$$

Where:

t = index for each type of electricity consuming device with identical rated power;

$P_{nd-comp,int,t}$ = the energy usage for an electricity consuming device sited on the internal facing side or internal to the non-display door, of type t, kWh/day; and

$P_{nd-comp,ext,t}$ = the energy usage for an electricity consuming device sited on the external facing side of the non-display door, of type t, kWh/day. For anti-sweat heaters,

- (d) Calculate the total electrical energy consumption, P_{nd-tot} , kWh/day, as follows:

$$P_{nd-tot} = P_{nd-tot,int} + P_{nd-tot,ext} \quad (4-32)$$

Where:

$P_{nd-tot,int}$ = the total interior electrical energy usage for the non-display door, of type t, kWh/day; and

$P_{nd-tot,ext}$ = the total exterior electrical energy usage for the non-display door, of type t, kWh/day.

4.5.3 Total Indirect Electricity Consumption Due to Electrical Devices

- (a) Select Energy Efficiency Ratio (EER), as follows:

(1) For coolers, use EER = 12.4 Btu/Wh

(2) For freezers, use EER = 6.3 Btu/Wh

- (b) Calculate the additional refrigeration energy consumption due to thermal output from electrical components associated with the non-display door, $C_{nd-load}$, kWh/day, as follows:

$$C_{nd-load} = P_{nd-tot,int} \times \frac{3.412 \text{ Btu}}{\text{EER W-h}} \quad (4-33)$$

Where:

EER = EER of walk-in cooler or freezer, Btu/W-h; and

$P_{nd-tot,int}$ = the total interior electrical energy consumption for the non-display door, kWh/day.

4.5.4 Total Non-Display Door Energy Consumption

- (a) Select Energy Efficiency Ratio (EER), as follows:

(1) For coolers, use EER = 12.4 Btu/W-h

(2) For freezers, use EER = 6.3 Btu/W-h

(b) Calculate the total daily energy consumption due to thermal load, $E_{nd, thermal}$, kWh/day, as follows:

$$E_{nd, thermal} = \frac{Q_{cond-nd}}{EER} \times \frac{24 \text{ h} \times 1 \text{ kW}}{1 \text{ day} \times 1000 \text{ W}} \quad (4-34)$$

Where:

$Q_{cond-nd}$ = the conduction load through the non-display door, Btu/hr; and

EER = EER of walk-in (cooler or freezer), Btu/W-h.

(c) Calculate the total energy, $E_{nd, tot}$, kWh/day, as follows:

$$E_{nd, tot} = E_{nd, thermal} + P_{nd- tot} + C_{load} \quad (4-35)$$

Where:

$E_{nd, thermal}$ = the total daily energy consumption due to thermal load for the non-display door, kWh/day;

$P_{nd- tot}$ = the total electrical energy consumption, kWh/day; and

$C_{nd-load}$ = additional refrigeration load due to thermal output from electrical components contained on the inside face of the non-display door, kWh/day.

5.0 Test Methods and Measurements

5.1-5.2 [Reserved]

5.3 U-factor of Doors and Display Panels

(a) Follow the procedure in NFRC 100, (incorporated by reference; see § 431.303), exactly, with these exceptions:

(1) The average surface heat transfer coefficient on the cold-side of the apparatus shall be 30 Watts per square-meter-Kelvin ($\text{W}/\text{m}^2 \cdot \text{K}$) $\pm 5\%$. The average surface heat transfer coefficient on the warm-side of the apparatus shall be 7.7 Watts per square-meter-Kelvin ($\text{W}/\text{m}^2 \cdot \text{K}$) $\pm 5\%$.

(2) Cold-side conditions:

(i) Air temperature of 35 °F (1.7 °C) for cooler doors and -10 °F (-23.3 °C) for freezer doors

(ii) Mean inside radiant temperature must be the same as shown in section 5.3(a)(2)(i), above.

(3) Warm-side conditions

(i) Air temperature of 75 °F (23.9 °C)

(ii) Mean outside radiant temperature must be the same as section 5.3(a)(3)(i), above.

(4) Direct solar irradiance = 0 W/m^2 ($\text{Btu}/\text{h} \cdot \text{ft}^2$).

(b) Required Test Measurements

(i) Display Doors and Display Panels

1. Thermal Transmittance: U_{dd}

(ii) Non-Display Door

1. Thermal Transmittance: U_{nd}

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