Building Technologies Program

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Test Procedures for
Walk-in Coolers and Freezers
Notice of Proposed Rulemaking

March 24, 2010

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Overview >> Welcome

Welcome

- Introductions
- Role of the Facilitator
- Ground Rules (norms)
  - Listen as an ally
  - Use short, succinct statements/keep to the point
  - Hold sidebar conversations outside the room
  - One person speaks at a time (raise hand to be recognized; state your name for the record)
  - Set cell phones to silent/vibrate
- Housekeeping Items
- Agenda Review
- Opening Remarks

Overview >> Agenda

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9:00 – 9:15 am	Welcome and Introductions
9:15 – 9:30 am	Rulemaking Overview
9:30 – 10:00 am	Opening Remarks from Interested Parties
10:00 – 11:00 am	Test Procedures Approach
11:00 – 11:15 am	Break
11:15 – 12:30 pm	Proposed Envelope Test Procedure
12:30 – 1:30 pm	Lunch
1:30 – 3:15 pm	Proposed Envelope Test Procedure, continued
3:15 – 3:30 pm	Break
3:30 – 4:30 pm	Proposed Refrigeration System Test Procedure
4:30 – 4:45 pm	Discussion of Small Business Impacts
4:45 – 5:00 pm	Other Issues; Questions & Comments; Closing Remarks
5:00 pm	Adjourn

Background & Approach >> Overview

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DOE is conducting this rulemaking as required by law.

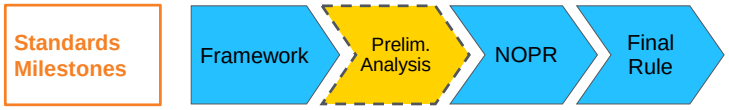
- The Energy Independence and Security Act of 2007 (**EISA 2007**) amended the Energy Policy and Conservation Act (**EPCA**) to add provisions for WICF.

EPCA Provision	Authority	Effective Date	Details
Prescriptive Standards	Congress	January 1, 2009	DOE does not have the authority to alter these prescriptive standards.
Test Procedures	DOE	30 Days After Test Procedure Final Rule Publication	This is the subject of today's rulemaking.
Energy Conservation Standards	DOE	3 Years After Standards Final Rule Publication	This is being addressed in a separate DOE rulemaking.

➢ **Test procedures and energy conservation standards set by DOE are separate from the prescriptive standards set by EPCA.**

The test procedure and standards rulemakings are currently at different stages.

The test procedure NOPR is the subject of this public meeting.



The energy conservation standards rulemaking is in the preliminary analysis stage. The standards preliminary analysis results will be presented in a separate public meeting.

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Major Milestones

- NOPR published: January 4, 2010 (75 FR 186).
- NOPR public meeting: March 24, 2010 (today).
- NOPR comments due: March 31, 2010 (one week from today).
  - Transcript records oral comments from today's public meeting.
  - Written comments.
- DOE reviews and considers all comments.

Overview >> Purpose of the Public Meeting

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Following publication of the notice of proposed rulemaking (NOPR), DOE is holding this public meeting:

- To present DOE's proposed test procedures for walk-in coolers and freezers (WICF or walk-ins).
- To clarify any questions about DOE's proposed approach.
- To seek comment from participants on the proposed test procedure.
- To describe the next steps for the rulemaking.

Overview >> Issues for Public Comment

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Major issues for public comment are detailed in this presentation and in Section V.E of the NOPR.

1. Background & Approach
   1. Separate Test Procedures for Envelope & Refrigeration System
   2. Testing Responsibilities*
   3. Definition of Envelope
   4. Definition of Refrigeration System
2. Basic Model
   1. Basic Model of Envelope
   2. Daily Energy Consumption Coefficients
   3. Basic Model of Refrigeration System
   4. Definition of Basic Model for Refrigeration System*
3. Proposed Test Procedure – Envelope
   1. Normalization Factor
   2. Proposed Test Method for Conditioning of Foam
   3. Impact of Water on Foam*
   4. Efficacy of Skins
   5. Floorless Cooler Heat Transfer
   6. Freezer Floor R-Values
   7. Insulated Floor Surface Temperature Assumptions
   8. Performance Data for Glass Products
   9. Glass Door Energy Calculation
   10. Steady-State Infiltration and Reduction Device Effectiveness
   11. Calculations for Door-Opening Events
   12. Infiltration Reduction Device Effectiveness
   13. Electrical Duty Cycle
   14. Nominal Energy Efficiency Ratio

*** Did not appear in Section V.E of the NOPR**

(Continued on Next Slide)

Overview >> Issues for Public Comment

Continued: Major issues for public comment

4. Refrigeration Test Procedure
    1. Proposed Test Procedure
    2. Calculation Methodology
    3. Reporting Requirements
5. Impacts on Small Businesses
    1. Number of Small Entities Regulated
    2. Differential Impacts on Small Manufacturers

Overview >> Issues for Public Comment

Issue Box: DOE welcomes comments, data, and information concerning this proposed test procedure on walk-in coolers and freezers. Throughout this presentation, issues are provided in boxes like this one for discussion in the public meeting. While these are specific issues that DOE identified for review, **comments are welcome on any part of DOE's proposed rule**.

Overview >> Opening Statements

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Interested parties who contacted DOE to request an opportunity to make an opening statement should speak now.

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EPCA specifies which equipment is covered by the test procedure.

Statutory Definition of Walk-in Coolers and Freezers:

- "The terms 'walk-in cooler' and 'walk-in freezer' mean an enclosed storage space refrigerated to temperatures, respectively, above, and at or below 32 degrees Fahrenheit that can be walked into, and has a total chilled storage area of less than 3,000 square feet." 42 U.S.C. 6311(20)(A)

Walk-in Type	Description of EPCA Requirement
All	Has a total chilled storage area of less than 3,000 square feet.
Coolers	Above 32°F
Freezers	At or below 32°F
Exceptions	The definition specifically excludes "products designed and marketed exclusively for medical, scientific, or research purposes." (42 U.S.C. 6311(20)(B))

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DOE initially considered a single test procedure but changed its approach after receiving input from interested parties.

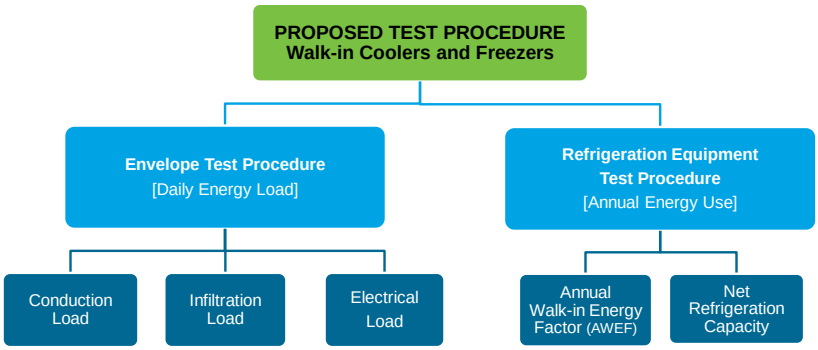
- There are TWO components of a walk-in cooler or walk-in freezer:
  - **Envelope** in which items are stored.
  - **Refrigeration system** that chills the space inside the envelope.

- **Feedback from Interested Parties (Standards Framework Public Meeting)** indicated that using a single test procedure was **not a viable approach** because:
  - Could be burdensome to perform the test.
  - Envelope & refrigeration system typically manufactured separately.
  - Assembler or installer could be required to demonstrate compliance – not DOE's typical approach.
  - Difficult to enforce testing requirements if the walk-in is assembled in the field.

➢ **DOE proposes to develop separate test procedures for the envelope & refrigeration system.**

Background & Approach >> Separate Test Procedures

Separated into its distinct systems – envelope and refrigeration system – the proposed WICF test procedure follows this structure.



- **The purpose of the proposed test procedure is to quantitatively capture energy use in WICF as fully and accurately as possible.**

Background & Approach >> Manufacturer Requirements

DOE proposes to assign testing responsibilities to the manufacturers of the envelope and refrigeration system.

- **Envelope manufacturer** would be responsible for testing the envelope according to the envelope test procedure.
- **Refrigeration system manufacturer** would be responsible for testing the refrigeration system according to the refrigeration system test procedure.
- Purpose of this provision:
  - Accurately reflect the structure of the walk-in market.
  - Assign testing responsibilities to the appropriate equipment manufacturers.

- **"Manufacturer" refers to either the envelope manufacturer or the refrigeration system manufacturer.**

Background & Approach

Issue 1-1: Separate Test Procedures for Envelope & Refrigeration System

DOE invites comments on its proposal for separate test procedures for the insulated envelopes and refrigeration systems of walk-in coolers and freezers. See Section III.C.1. for details.

Issue 1-2: Testing Responsibilities

DOE invites comments on its proposal to consider the envelope and refrigeration manufacturers responsible for the envelope and refrigeration system test, respectively.

Background & Approach >> Envelope

DOE proposes that the definition of "envelope" include the box, its components, and some electrical equipment.

- "**Envelope** means (1) the portion of a walk-in cooler or walk-in freezer that isolates the interior, refrigerated environment from the ambient, external environment; and (2) all energy-consuming components of the walk-in cooler or walk-in freezer that are not part of its refrigeration system."
- Examples:
  - (1) insulated panels, windows, gasketing, doors (passage & display), etc.
  - (2) lighting, anti-sweat door heaters, etc.

Issue 1-3: Definition of Envelope

DOE invites comments on its proposed definition for the envelope of walk-in coolers and freezers. See Section III.B.1. for details.

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In the NOPR, DOE proposed the following definition for "refrigeration system:"

"**Refrigeration system** means the mechanism used to create the refrigerated environment in the interior of a walk-in cooler or freezer, consisting of an integrated single package refrigeration unit, or a split system with separate unit cooler and condensing unit sections, or a unit cooler that is connected to a central rack system; and including all controls and other components integral to the operation of this mechanism."

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DOE is interested in commenter feedback regarding the proposed definition of "refrigeration system."

Revisions to the definition may include the following:

- Substituting "integrated single package refrigeration unit," with "*a packaged system where the unit cooler and condensing unit are integrated into a single piece of equipment*" in order to **clarify** the term.
- Substituting "central rack system," with "*multiplex condensing system*," because the latter is a more **inclusive** term and may be more **technically accurate**.

REVISED DEFINITION WOULD READ AS FOLLOWS: "Refrigeration system means the mechanism used to create the refrigerated environment in the interior of a walk-in cooler or freezer, consisting of ***a packaged system where the unit cooler and condensing unit are integrated into a single piece of equipment***, or a split system with separate unit cooler and condensing unit sections, or a unit cooler that is connected to ***a multiplex condensing system***; and including all controls and other components integral to the operation of this mechanism."

Background & Approach >> Refrigeration

Issue 1-4: Definition of "Refrigeration System"

DOE invites comments on the proposed definition for the refrigeration system of walk-in coolers and freezers, and the suggested modifications to the proposed definition. DOE seeks comment on other possible modifications to the definition to help improve its clarity. See Section III.C.1 for details.

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DOE is considering allowing manufacturers to group similar walk-in equipment under a single "Basic Model."

- Under this proposal, DOE is considering:
  - Allowing manufacturers to group equipment with essentially identical **characteristics** with regard to **energy consumption** under a single Basic Model.
  - For envelopes, this approach would include adopting a **calculation methodology** for determining the energy consumption of units within the Basic Model.
- **The purpose of using Basic Models is to reduce testing burden.** The proposed Basic Model approach enables manufacturers to group equipment with respect to energy consumption characteristics and test only one unit within a Basic Model.

➢ **In the NOPR, DOE proposed using this approach for both the envelope and the refrigeration system.**

Basic Model >> Concepts & Definitions

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The Basic Model concept provides a way for manufacturers to rate their equipment without testing every unit.

- Manufacturers must **rate** the energy consumption of **every unit** of walk-in equipment that they manufacture.
- Manufacturers are required to **test** at least **one** unit of each Basic Model to determine its energy consumption.
- **For envelopes**, the manufacturers may use a **calculation methodology** to rate every other unit in the Basic Model based on the test results from the tested unit.
  - DOE proposes a calculation methodology for rating envelopes within a Basic Model because every envelope a manufacturer makes could be unique.

➢ **DOE believes this approach ensures compliance with a future standard while reducing testing burden.**

The underlying rationale for the Basic Model is the Daily Energy Consumption Coefficient (DECC), a scaling factor that allows for the calculation of energy consumption for some components.

DECC Parameters
Wall surface area
Non-glass door surface area
Glass display door surface area
Glass wall and inset window surface area
Opening of doors (and effectiveness of infiltration reduction devices)
Electrical energy consumption due to devices including, but not limited to: lights, anti-sweat heaters, and motors to drive air mixing fans

➢ **DECCs provide a linear expression of the energy consumption of any envelope of the same Basic Model as the tested envelope.**

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DOE developed the DECC to replace a previously proposed approach that stakeholder feedback indicated was not appropriate.

- In the standards framework document, DOE proposed to allow manufacturers to develop Alternative Efficiency Determination Methods (AEDMs) for calculating energy consumption of units.
  - The AEDMs would be substantiated with test data and verified by DOE.
- **Interested Parties (Standards Framework Public Meeting)** objected to the idea of allowing manufacturers to develop AEDMs for these reasons:
  - Could be **expensive and time-consuming** for manufacturers to develop.
  - Could benefit some manufacturers **unfairly**.
  - **May not provide consistent information** to end users.
- Therefore, DOE created a single, consistent calculation methodology based on Daily Energy Consumption Coefficients (DECCs).

➢ **DECCs are a scaling methodology that manufacturers would use to rate their equipment.**

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Which changes necessitate a separate Basic Model?

Feature	Sample change	How addressed?	New Rating?	New Basic Model?
Temperature	**Cooler vs. Freezer**	Testing	Yes	Yes
Insulation Material	• Foam (e.g., urethane, styrene) • Blowing agent (e.g., HFC 245fa)			
Infiltration Devices	Strip or air curtains			
Assembly System	• Panel locking system (e.g., camlock) • Gasketing, door sweep • Material			
Doors	Materials			
	• Number of doors • Door type	Calculation	Yes	No
Dimensions of Envelope	Size of envelope			
Electrical Load	• Anti-sweat heaters • Lighting — interior, door			
Miscellaneous	• Paint color, type • Type of metal (e.g., galvanized) • Shelving	No action required	No	No

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These WICF belong to different Basic Models.

Polyurethane

Polystyrene

Different Basic Models?	Rationale
Yes	✓ **Different insulation material**

➢ **Different Basic Models would be required because a trigger parameter is met.**

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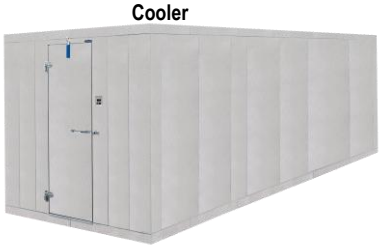
These WICF belong to the same Basic Model.

Cooler

Cooler



Different Basic Models?	Rationale
No	✓ Same temperature ✓ Same materials ✓ Same assembly systems

➢ **However, these models would be RATED differently using DECCs, owing to their dimensional differences.**

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Example calculation for this Basic Model: the two units differ only in their surface area.

DECC = Energy Load / Exterior Surface Area

Surface $\text{Area}_{\text{Basic Model Unit}}$ = **400 ft²**

Energy $\text{Load}_{\text{Basic Model Unit}}$ (**as tested**) = **5,126 Watt-hours (Wh) / day**

THEREFORE, the $\text{DECC}_{\text{Basic Model}}$ = 12.815 Wh / day-ft²

Example calculation for this Basic Model: the units differ only in their surface area.

$DECC_{Basic\ Model}$ = 12.815 Wh / day-ft^2 (from previous slide)

Exterior Surface Area $_{Calculated\ Unit}$ = **1,200 ft^2**

Energy $Load_{Calculated\ Unit}$ = $DECC_{Basic\ Model}$ X Exterior Surface $Area_{Calculated\ Unit}$

THEREFORE, the calculated Energy $Load_{Calculated\ Unit}$ = 15.4 kWh / day

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Taking these ideas into consideration, DOE proposes the following definition of Basic Model for envelopes:

"Basic Model means all units of a given type of walk-in equipment manufactured by a single manufacturer, and—with respect to envelopes, which do not have any differing construction methods, materials, components, or other characteristics that significantly affect the energy consumption characteristics."

Issue 2-1: Basic Model of Envelope

DOE invites comments on the approach of grouping walk-in envelopes into Basic Models and on the proposed definition of Basic Model for envelopes.

Issue 2-2: Daily Energy Consumption Coefficients

DOE invites comments on the approach of using DECCs to calculate energy consumption of units with a Basic Model.

Basic Model >> Refrigeration System

The Basic Model concept could also apply to refrigeration systems.

- Refrigeration systems may be virtually identical but may have different design characteristics, either electrical (e.g. voltage), or physical (e.g. exterior finish), that would change the energy consumption either very minimally or not at all.
- The purpose of using a Basic Model would be reducing the testing burden on manufacturers by allowing them to group similar models of refrigeration systems into a single Basic Model.

➢ **DOE is considering applying the Basic Model concept to refrigeration systems to reduce testing burden.**

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Basic Model >> Refrigeration System

DOE is considering the following options for testing refrigeration systems:

Option	Description	Implications
1	**Basic Model approach <u>proposed in the NOPR</u>**	• Manufacturers may group several models into a single Basic Model, consisting of units that may differ in energy consumption but **<u>not significantly</u>**. • It may be difficult to determine what constitutes a "significant" difference.
2	**Basic Model approach used for other equipment in the appliance standards program**	• Manufacturers may group several models into a single Basic Model, consisting of models that **<u>do not</u>** differ in energy consumption. • Purely cosmetic changes, e.g. those to the exterior finish, would not necessitate a new test.
3	**No provision for Basic Model**	• Manufacturers must test one of **<u>every model</u>** of refrigeration system they manufacture

➢ **DOE is considering an additional approach to the Basic Model definition and concept originally described in the NOPR.**

Basic Model >> Refrigeration System

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DOE is considering how best to define the term Basic Model for refrigeration systems, if a Basic Model were used for this equipment.

- As defined in the NOPR, refrigeration systems in one Basic Model **could include** design changes that **do affect energy consumption**, though minimally. (**Option 1** on the previous slide)

- Original definition proposed in NOPR that DOE is considering:

  "Basic Model means all units of a given type of walk-in equipment manufactured by a single manufacturer, and—With respect to refrigeration systems, which do not have any differing electrical, physical, or functional characteristics that significantly affect energy consumption."

➢ **In this approach, differences that impact energy consumption in a minimal way would not trigger a new Basic Model.**

Basic Model >> Refrigeration System

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DOE is considering how best to define the term Basic Model for refrigeration systems, if a Basic Model were used for this equipment.

- DOE is considering a **revised definition**: refrigeration systems in one Basic Model **could not** include design changes that affect energy consumption. (**Option 2**)

- Revised definition that DOE is considering:

  "Basic Model means all units of a given type of walk-in equipment manufactured by a single manufacturer, and—With respect to refrigeration systems, which have electrical characteristics that are essentially identical, and which do not have any differing electrical, physical, or functional characteristics that affect energy consumption."

➢ **In this approach, any difference that impacts energy consumption in any way would trigger a new Basic Model.**

DOE may decide to reject both Option 1 and Option 2, leaving the default of no provision for Basic Model (Option 3).

- DOE may decide that manufacturers cannot use either Basic Model approach.
- In this case, manufacturers would have to test **one of every model** of refrigeration system they manufacture.
- This would ensure that every model would be rated accurately and could be certified to comply with a future energy conservation standard.

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Issue 2-3: Basic Model of Refrigeration Systems

DOE invites comments on these options and whether a Basic Model approach is necessary or appropriate for refrigeration systems. DOE asks interested parties to suggest additional options that DOE should consider.

Issue 2-4: Definition of Basic Model for Refrigeration Systems

DOE invites comments on the definitions of Basic Model as proposed in the NOPR and as outlined in this presentation. For purposes of defining Basic Model, DOE also requests comment on what might constitute a “significant difference” in energy consumption that would make a new Basic Model necessary.

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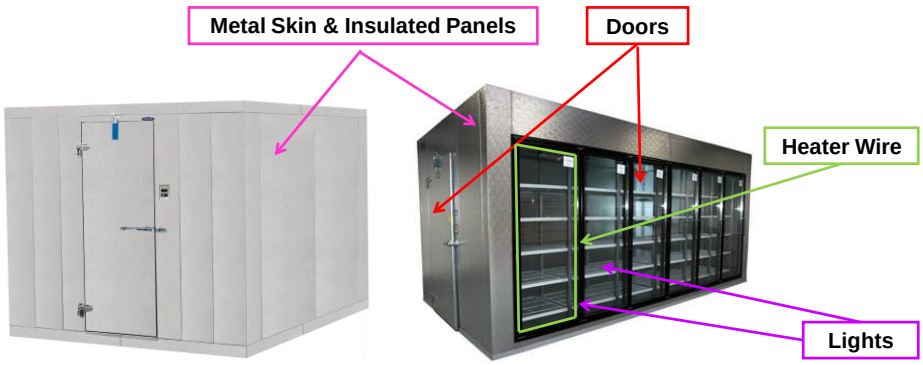
Envelope >> Overview

Envelope energy load depends on a variety of components.



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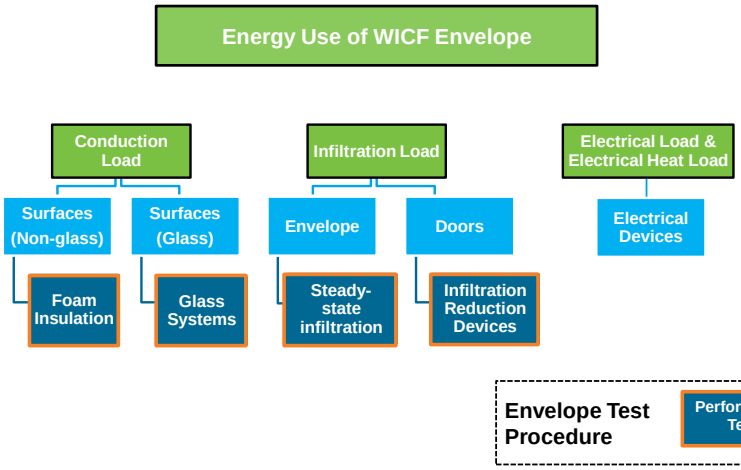
Conduction, infiltration, and electric use determine envelope energy load.



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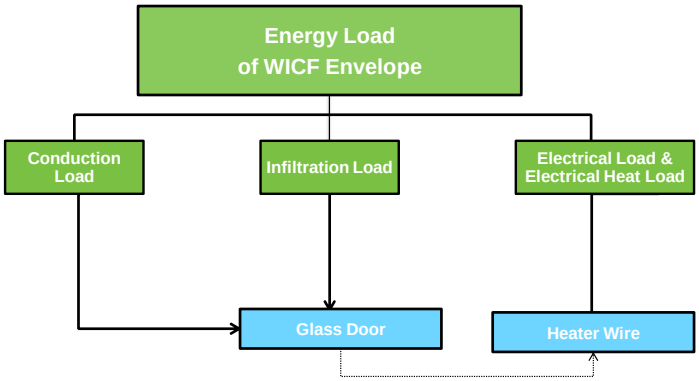
The purpose of the envelope test procedure is to accurately and fully capture the energy load of the envelope.



- **As in this example for glass doors, various components may impact energy load through more than one of the three primary mechanisms.**

Stakeholder comments suggested that WICF should be normalized by a parameter related to the size of the walk-in.

WICF Normalization Factor: External Area and Glass Area Ratio

- DOE believes that the external surface area of the envelope is an appropriate normalization factor
  - Surface area is the key geometric characteristic related to both conduction and infiltration
  - Glass surface area in particular has a major impact on energy use.
- Therefore, DOE proposes to normalize the energy use by an external surface area corrected by the ratio of glass to non-glass area of the WICF.

➢ **Energy associated with the envelope will be normalized by external surface area (ft^2)**

Envelope >> Overview > Normalization

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Equation 3-34 describes the energy normalization and correction by surface area and glass to non-glass ratio, respectively.

$$E_{tot,non-glass} = \frac{A_{non-glass,tot}}{A_{non-glass,tot} + A_{glass,tot}} \times \left[\frac{Q_{tot,EER}}{A_{non-glass,tot} + A_{glass,tot}} \right]$$

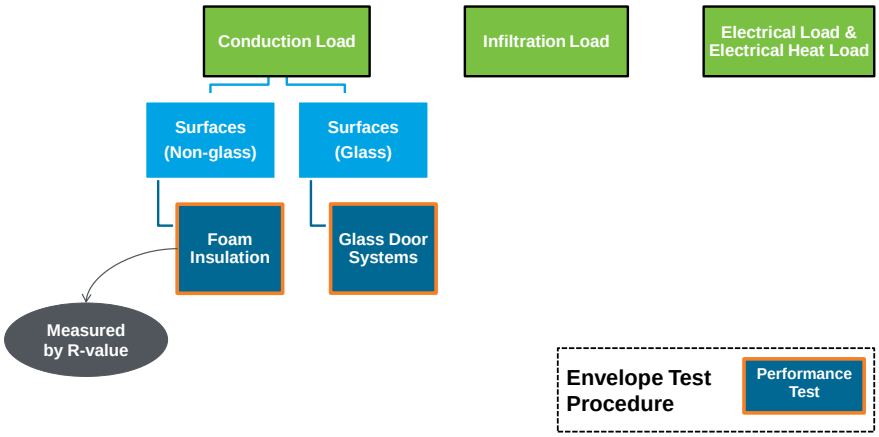
Eq. 3-34
E = Energy (kWh/day-ft^2)
A = Area (ft^2)
Q = Heat load (kWh/day)

Issue 3-1: Normalization Factor

DOE invites comments on its proposal to normalize the energy consumption using surface area. See Section III.B.3.e for details.

Envelope >> Conduction

Conduction refers to the transfer of heat through a material and is a key mechanism of heat gain.



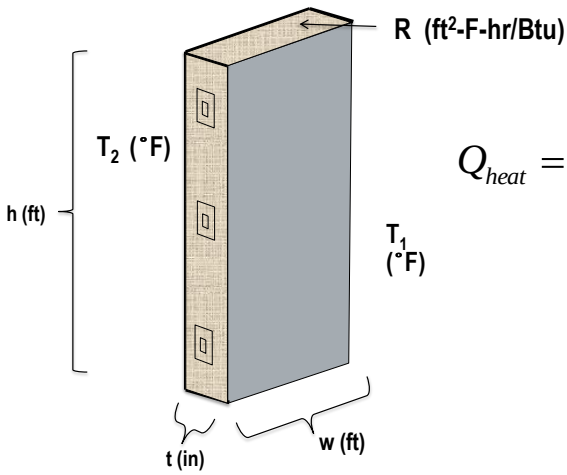
Envelope >> Conduction > Foam R-Value

"R-Value" is typically used to describe the performance of a thermally insulating material.

R-Value, ft^2-F-h/Btu	
• R-Value is a measure of **resistance to thermal conductivity**. • The greater the R-Value, the greater the thermal resistance. • Foam is the most common insulating material used in walk-in cooler and freezer construction.	
@ 4" thickness	• **Steel R-Value: 0.16 ft^2-F-h/Btu** • **Foam R-Value: 16.00-32.00 ft^2-F-h/Btu** • **Vacuum Insulated Panel R-value: 120-200 ft^2-F-h/Btu**

➢ **Foam R-Value has a major impact on WICF conduction losses.**

Heat transfer through insulation is easily calculated. The calculation requires known area, R-value, thickness, and ΔT.



$$A = h \times w$$

$$Q_{heat} = \frac{A \times (T_2 - T_1)}{R \times t} = \frac{Btu}{hr}$$

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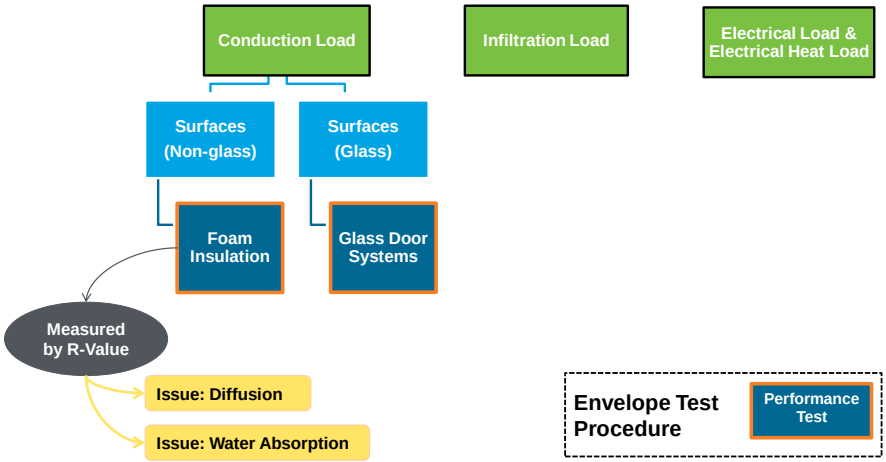
At the framework public meeting, DOE received numerous comments regarding the diminishing R-Value of insulating foams.

1. **Diffusion of gases**, which typically occurs within 2-3 years after manufacture.

2. **Moisture infiltration**, which may occur over time due to environmental conditions inherent in refrigerated boxes and WICF design, such as but not limited to differences in temperature and relative humidity.

➢ **There are two key mechanisms of R-value decline: the diffusion of gases and moisture infiltration.**

DOE found that diffusion and water absorption may affect the R-value of foam insulation.



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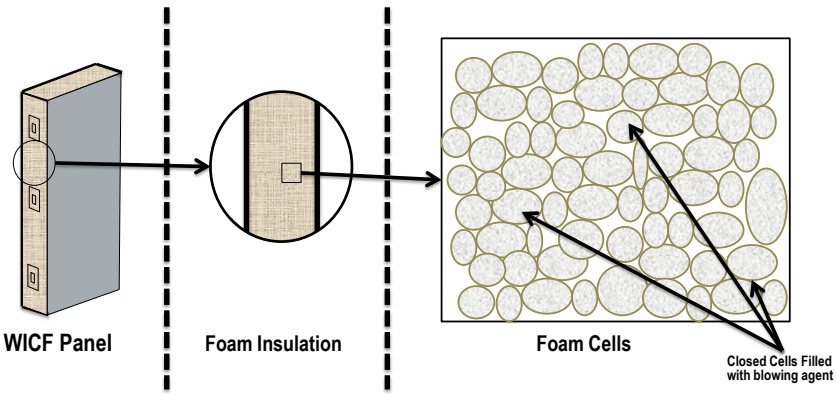
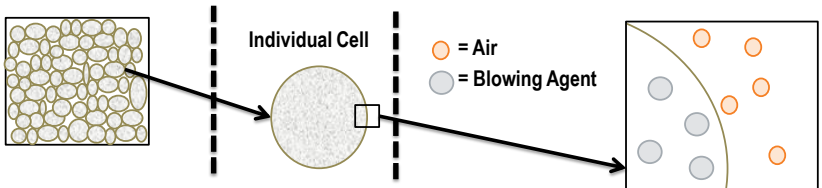
The insulating performance of foam depends both on the plastic polymer and on the gas trapped within its cells.



- **Although the cells are called "closed," they are permeable.**

Initially, foam cells are filled with high concentration of blowing agent. Over time, the concentration of blowing agent decreases.



Primary mechanism

1. Air (nitrogen and oxygen) diffuses into the cells.
2. The air reduces the concentration of blowing agent and therefore reduces the thermal resistivity of the foam.

Secondary mechanism

1. Blowing agent diffuses out of the foam into the atmosphere.
2. This further reduces the concentration of blowing agent and reduces thermal resistivity.

➢ **The rate of diffusion of gases decays exponentially.**

Envelope >> Conduction > Foam R-Value

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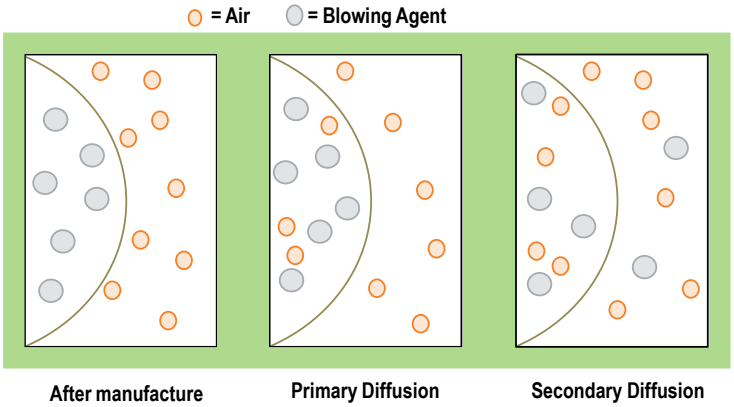
First, air diffuses into the foam cells, and then the blowing agent diffuses out of the foam.



➢ **The change in concentration of blowing agent over time reduces insulating performance.**

DOE believes that thin slicing is the best option for conditioning insulating foams.

Overview of ASTM C1303-08 test procedure

1. Slice the full thickness foam sample.
2. Allow time to pass (time determined based on slice thickness).
3. Measure the R-Value of the stack of slices using ASTM C518-04.

Benefits

- Results from thin slicing are used to predict an average R-value over a 15 year life.
- The U.S. building industry recognizes that initial R-values decline over time and therefore uses conditioned R-values on labeling of insulating foams.
- Since 2001, Canada has required industries using insulating foams to use a thin slicing method to accelerate conditioning.

Envelope >> Conduction > Foam R-Value

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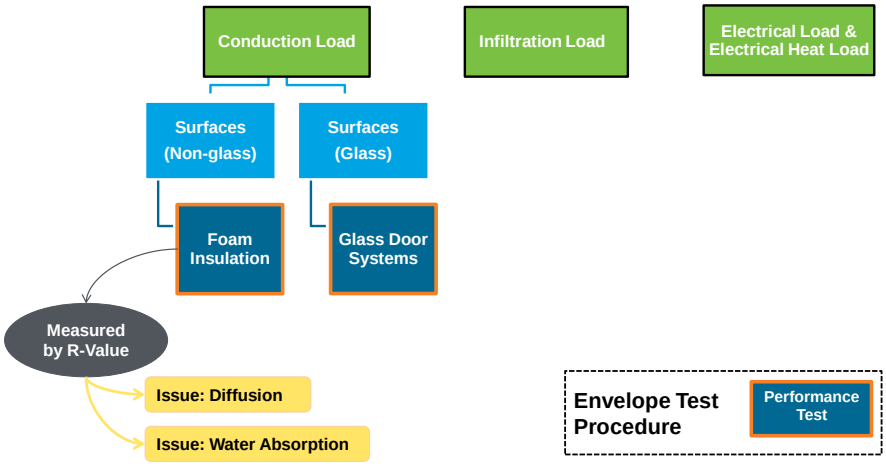
Issue 3-2: Proposed Test Method for Conditioning of Foam

DOE invites comment on the proposal to require the use of ASTM C1303-08, "Standard Test Method for Predicting Long-Term Thermal Resistance of Closed-Cell Foam Insulation," as a standard conditioning method for insulating foams used in walk-in coolers and freezers prior to testing these foams with ASTM C518-04 as required by EPCA. See Section III.B.2.a. for details.

Oral and written comments submitted by interested parties requested that DOE investigate the impact of water absorption on the R-Value of foams.



DOE believes that water impacts the R-Value of foam insulation. No test procedure is currently available and DOE has not developed one.

Summary of Water Issues

1. There are limited or nonexistent industry-accepted measurement procedures for this issue.
2. Limited research conducted by academic, government, or industry has focused on issues specific to the building industry rather than WICF.

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Issue 3-3: Impact of Water on Foam

DOE invites comments on this issue. See Section III.B.2.ii for details.

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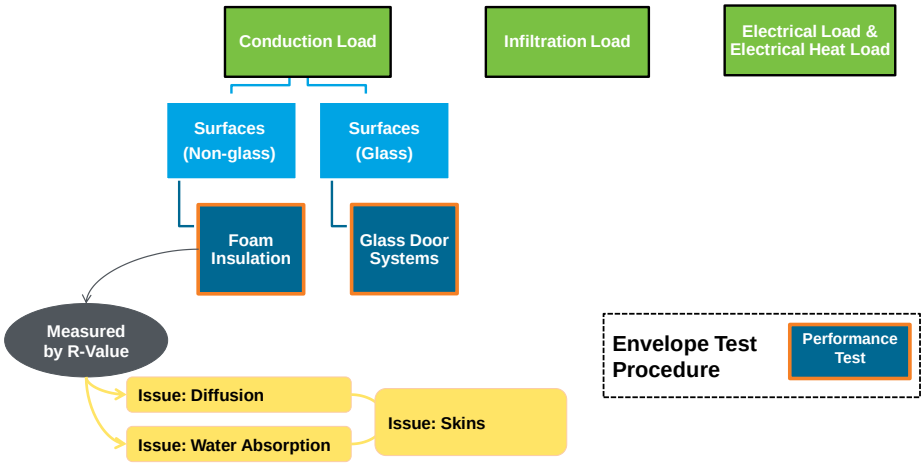
Oral and written comments submitted by interested parties regarding diffusion and water absorption referenced the topic of permeability of "skins".



Many manufacturers seek to prevent or delay diffusion and moisture infiltration.

DOE received conflicting comments on this issue

1. Whether WICF walls can be made fully impermeable using metal skins;

-OR-

2. Whether full impermeability cannot be achieved due to:
   - Lack of or imperfect sealing at panel joints;
   - Imperfect adherence of foam to metal skins during or after manufacture; and/or
   - Deliberate punctures for fixtures and shelving and/or inadvertent punctures that typically occur in the field.

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Issue 3-4: Efficacy of Skins

DOE invites comments on skins used to reduce moisture and air permeance through insulating materials. DOE invites the submission of test results regarding the impact of impermeable skins on long-term R-value, specifically peer-reviewed, published data pertaining to the efficacy of skins in preventing or delaying R-value decline. See Section III.B.2.a for details.

DOE is considering a correction to the method used to calculate heat transfer through floorless coolers.

Floorless Coolers: Correction to NOPR

- In the published NOPR, DOE proposed the use of a method for calculating heat transfer through **uninsulated cooler floors**.
- Subsequent modeling has demonstrated that the previously published approach could be improved.

➢ **The proposed correction is available on the following slide.**

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DOE is considering an improved approach to calculating the heat transfer ONLY through floorless coolers.

Floorless Coolers: Proposed Correction

- DOE performed computational simulations of walk-in coolers of various sizes.
- The result is an equation that is a function of floor area.
- A = floor area of the walk-in cooler [ft^2]
- q_{floor}= Average floor heat flux [Btu/h-ft^2]

If $A \leq 750\ ft^2$, $\mathbf{q_{floor} = 33.153 \times A^{-0.364}}$

If $A > 750\ ft^2$, $\mathbf{q_{floor} = 0.0002 \times A + 2.84}$

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Comparison of original and new equations from the published NOPR:

Original Eq. 3-10
(except floorless coolers)

$$Q_{\text{cond-non-glass}} = \sum_{1}^{i} \Delta T_i \times \frac{A_{\text{walls,i}}}{R_{\text{non-glass,wall,i}}} + \sum_{1}^{j} \Delta T_j \times \frac{A_{\text{floor, j}}}{R_{\text{non-glass,floor, j}}} + \sum_{1}^{k} \Delta T_k \times \frac{A_{\text{ceiling,k}}}{R_{\text{non-glass,ceil, k}}} + \sum_{1}^{l} \Delta T_l \times \frac{A_{\text{non-glass doors,l}}}{R_{\text{non-glass,door, l}}}$$

New Eq. 3-10a
(for floorless coolers only)

$$Q_{\text{cond-non-glass}} = \sum_{1}^{i} \Delta T_i \times \frac{A_{\text{walls,i}}}{R_{\text{non-glass,wall,i}}} + q_{floor} \times A_{\text{floor}} + \sum_{1}^{k} \Delta T_k \times \frac{A_{\text{ceiling,k}}}{R_{\text{non-glass,ceil, k}}} + \sum_{1}^{j} \Delta T_i \times \frac{A_{\text{non-glass,doors, j}}}{R_{\text{non-glass,wall, j}}}$$

Issue 3-5: Floorless Cooler Heat Transfer
DOE invites comment on its proposed correction for floorless coolers.

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DOE is considering conditional requirements for heat transfer calculations through insulated freezer floors.

Freezers: R-28 Floor Assumption

If the manufacturer <u>does not</u> provide <u>any additional insulating surface:</u>

- DOE will require the use of an R-value of 28 [ft^2-F-h/Btu] for freezers for the purposes of calculating the energy loss through walk-in freezer floors.
- This reflects the R-value minimum prescribed by EPCA for freezer floors.

Issue 3-6: Freezer Floor R-Values
DOE invites comment on freezer floor R-values. See Section III.B.3.b for details.

Envelope >> Conduction > Floor

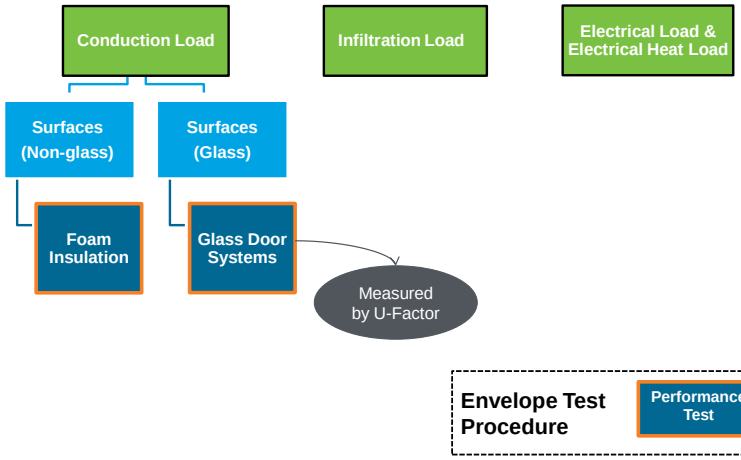
DOE proposes a correction to the floor temperature assumption for <u>insulated floors</u> in WICF.

Floor Surface Temperature Assumption
• In the NOPR, DOE specified that 55˚F be used in heat transfer calculations for both freezers and coolers. • DOE proposes replacing 55 ˚F with separate assumptions: **1. Freezers: 60˚F** **2. Coolers: 65˚F**

Issue 3-7: Insulated Floor Surface Temperature Assumptions
DOE invites comment on floor surface temperature assumptions.

Envelope >> Conduction > Glass U-Factor

Conduction refers to the transfer of heat through a material and is a key mechanism of heat gain.



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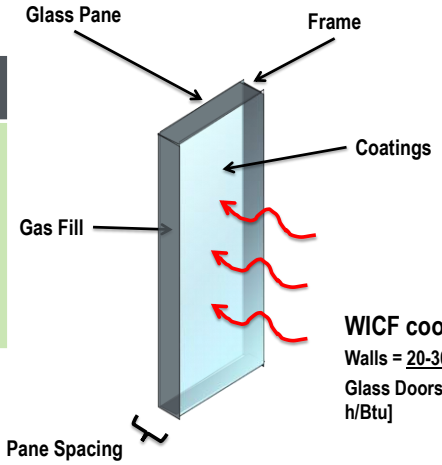
In addition to panes, the inert gas fill, emissivity coating, and pane separation distance have an impact on door performance.

Variables That Impact U-Factor Include:

- Number of glass panes
- Glass coatings
- Inert gas fill
- Inter-pane spacing
- Frame materials
- Gasket materials

U-Factor = 1 / R-Value



WICF cooler R-Value

Walls = 20-30 [ft^2-F-h/Btu]

Glass Doors = 2-3 [ft^2-F-h/Btu]

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DOE proposes that manufacturers account for the energy use of their glass components with the NFRC component label.

Primary Option: National Fenestration Rating Council (NFRC) Label

If WICF door suppliers participate in the NFRC rating program, the performance of the door shall be simply read from its label and used for calculations in this test procedure.

Alternative Option: Window 5.2 Calculation

If a glass door does not have an NFRC rating, then DOE proposes to require manufacturers to use Lawrence Berkeley National Laboratory's (LBNL) publicly available Window 5.2 software package to calculate glass door performance.

➢ **Manufacturers may use Window 5.2 method only if an NFRC label is not available.**

LBNL's Window 5.2 software (available for free online) has been thoroughly verified with years of use and empirical test data.

Use of Window 5.2 Software

- The WICF manufacturer must fully document the glass door model and **all** specifications/inputs used calculate the U-Factor in Window 5.2 such as the size of the door, number of panes of glass, gas fill between panes, pane spacing etc.
- This will help ensure that inputs used to calculate overall door performance are not being manipulated since any of the results should be reproducible and inputs can be directly compared to shipped products.

Issue 3-8: Performance Data of Glass Products

DOE seeks comment on the availability of performance data on glass products used in walk-in applications, glass component manufacturers' participation in third-party certification programs such as NFRC, and the proposed method for predicting the thermal performance of glass components using Window 5.2.

Envelope >> Conduction > Glass U-Factor

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NOPR Clarification: energy calculation for display-type WICF sold with and without glass doors

Display-Type Walk-in Sold Without Display Doors

For the purposes of calculating the energy use associated with display doors:

- **EPCA maximum whole door U-Factors: 0.43* and 0.3* [Btu/hr-ft^2-F] for coolers and freezers, respectively**

Display-Type Walk-in Sold With Display Doors

For the purposes of calculating the energy use associated with display doors:

- **The rating of the glass doors sold with the walk-in shall be used.**

*Calculated using Window 5.2: 2-pane argon gas fill and 3-pane argon gas fill for coolers and freezers (no low e-coatings).

Issue 3-9: Glass Door Energy Calculation

DOE seeks comment on the use of using EPCA maximum U-Factor for glass door energy calculations and their related assumed values.

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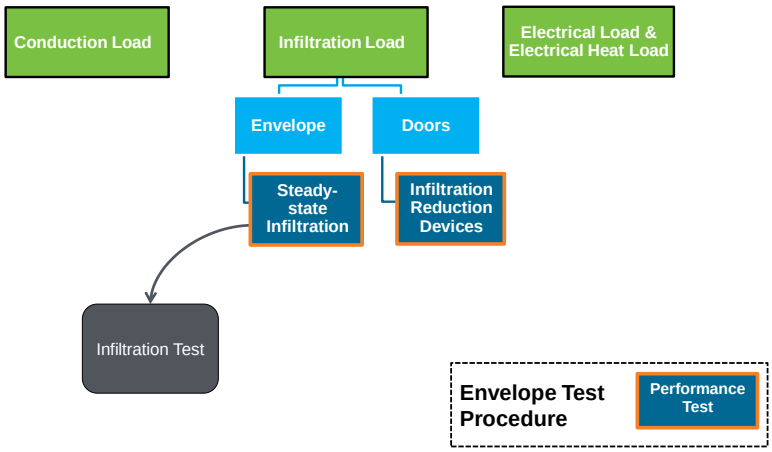
Infiltration refers to air leakage into WICF and is a key pathway for envelope energy losses.



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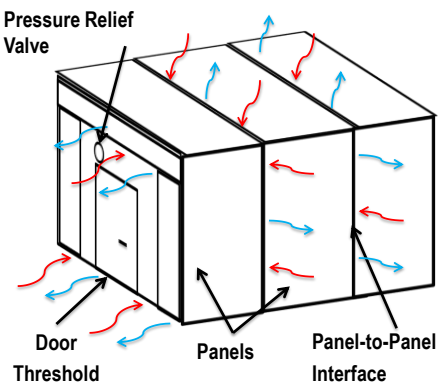
DOE proposes to account for steady-state air infiltration in the envelope test procedure.



Steady-state infiltration may occur through:

- Panels
- Panel-to-panel interfaces
- Door threshold
- Bi-directional pressure relief valves (freezers)

➢ **Air exchange accounts for a large portion of WICF energy use.**

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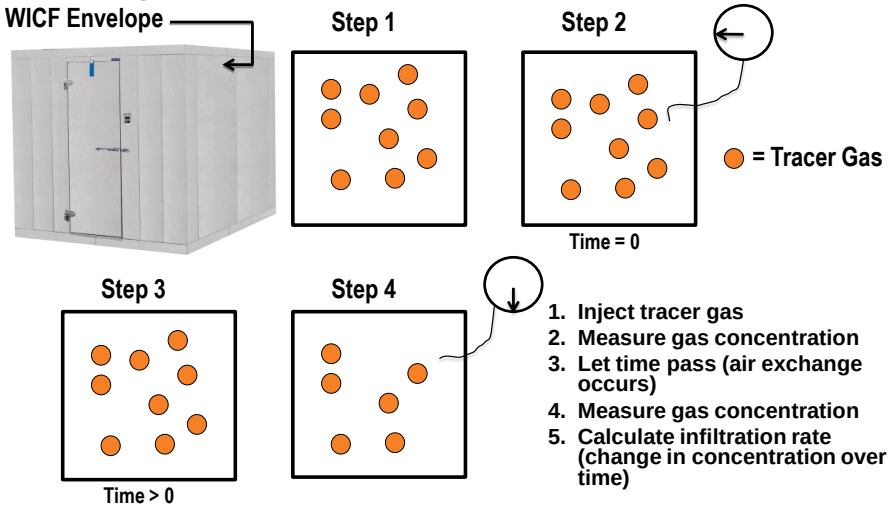
DOE identified the Gas Tracer Method as a good method for measuring air infiltration in WICF.



1. Inject tracer gas
2. Measure gas concentration
3. Let time pass (air exchange occurs)
4. Measure gas concentration
5. Calculate infiltration rate (change in concentration over time)

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DOE proposes the use of ASTM E741-06 to measure steady-state infiltration and the effectiveness of infiltration reduction devices.

- ASTM E741-06: "Standard Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution"
- Also referred to as the Gas Tracer Method
- The Gas Tracer Method is **NOT** used for calculation of air infiltration related to door-opening events. (An analytical approach is used instead to calculate air exchange due to door opening events).

Issue 3-10: Steady-State Infiltration Measurement

DOE invites comments on the proposed test method for measuring steady-state infiltration. See Section III.B.2.b for details on the proposed analytical methods.

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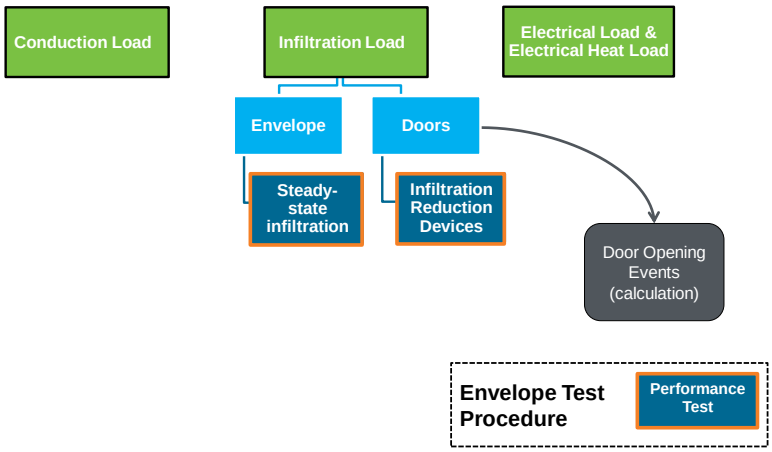
Infiltration refers to air leakage into WICF and is a key pathway for envelope energy losses.



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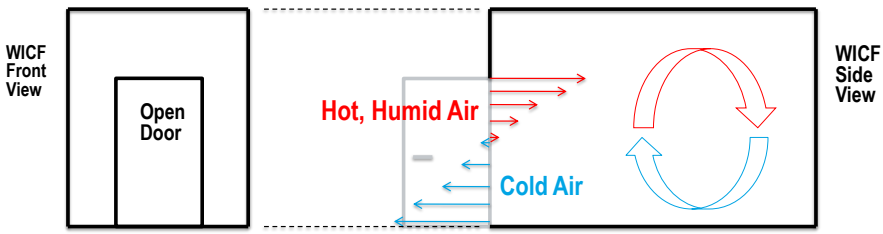
Hot air enters through the top of the passage as cold dense air flows through the bottom.



Factors that impact energy lost during air infiltration:

1. Door size
2. Air properties (relative humidity and temperature)
3. Door opening frequency
4. Door opening duration
5. Infiltration reduction device effectiveness

The energy associated with door infiltration **is calculated using ASHRAE defined equations** (as described in the NOPR).

➢ **Door opening air exchange accounts for a large portion of WICF energy use.**

DOE proposes the use of an analytical method to calculate infiltration due to door-opening events.

- The DOE approach uses equations described in ASHRAE Fundamentals as well as assumed door-opening frequency, duration, and the measured infiltration barrier effectiveness to calculate the air infiltration associated with each door.
- This method avoids the burden of individual infiltration measurements for each unique door.

Issue 3-11: Calculations for Door-Opening Events

DOE invites input and feedback on the calculations proposed for determining infiltration from door-opening events. See Section III.B.2.b for details on the proposed analytical methods.

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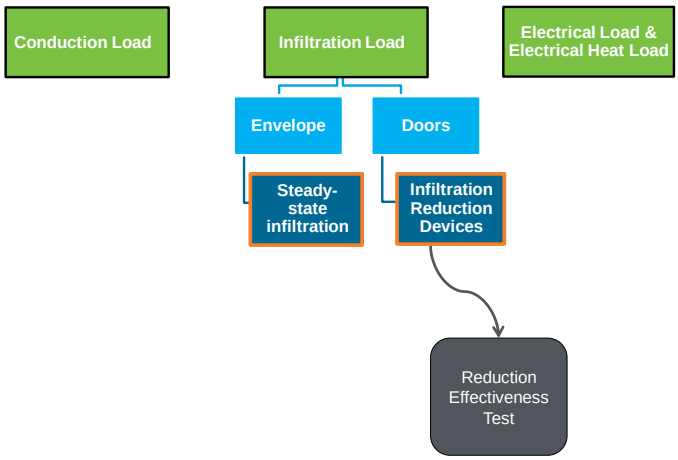
Infiltration refers to air leakage into WICF and is a key pathway for envelope energy losses.



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Infiltration Reduction Devices (IRD) can reduce air exchange associated with door opening events.

IRDs include:

- Strip Curtains
- Air Curtains
- Automated curtain doors

Source: DOE

➢ **IRD performance is measured in terms of device effectiveness.**

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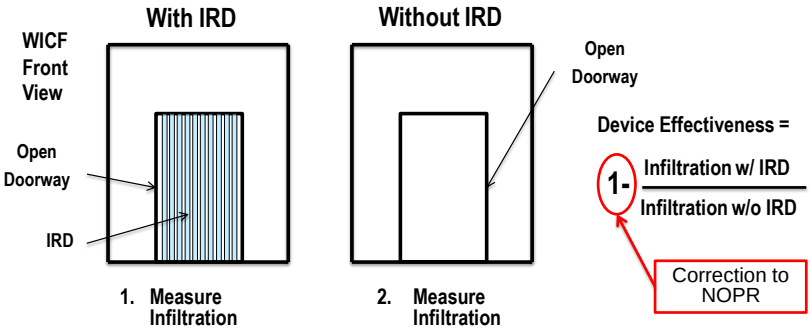
Infiltration Reduction Device effectiveness is measured using the gas tracer test.



$$\text{Device Effectiveness} = 1 - \frac{\text{Infiltration w/ IRD}}{\text{Infiltration w/o IRD}}$$

Correction to NOPR

Issue 3-12: Infiltration Reduction Device Effectiveness

DOE invites input and feedback on the IRD effectiveness test. See section III.B.2.b.iii for details.

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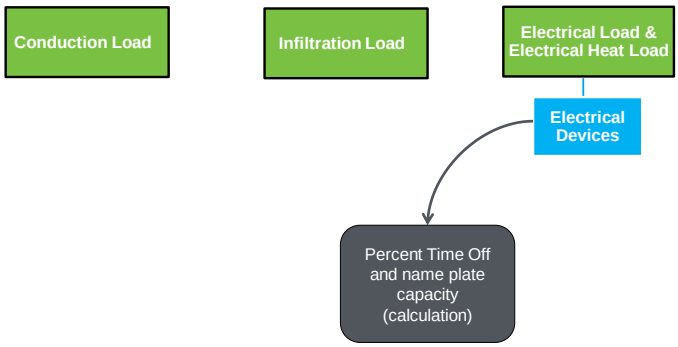
Electricity use is another form of energy consumption in the envelope. Electricity is used for devices like heater wires and lighting.



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DOE examined the energy use of electrical components sited within the envelope.

Electrical Device Calculations
• DOE recommends calculating the electricity consumption of lights, sensors, and other miscellaneous electrical devices not considered part of the refrigeration equipment **using name-plate rating and an assumed daily operation**.
• DOE incorporates assumed duty cycles of lights, anti-sweat heaters, and other devices based on **whether they are controlled by a preset control system**.

➢ **This will provide a uniform means of comparison.**

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DOE assumed certain values for the daily operation of electrical components.

Percent Time Off (PTO) Assumptions	
Lights	• PTO **value of 25%** for systems without timers or other auto shut-off systems. • PTO **value of 50%** for systems with timers or other auto shut-off systems installed.
Anti-sweat heaters	• PTO **value of 0%** for all systems without direct or indirect relative humidity sensing controls. • DOE further proposes that **75% be used for walk-in coolers and 50% for walk-in freezers** with these controls.

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DOE assumed certain values for the daily operation of electrical components.

Percent Time Off (PTO) Assumptions	
Powered infiltration reduction devices	• **For devices not actively controlled** based on door open or closed positions, DOE proposes a PTO **value of 25%.** • For devices actively controlled based on door open or closed position for **display doors**, DOE **proposes 99.33%.** • For devices actively controlled based on door open or closed position **for all other doors**, DOE **proposes 99.17%.**
All other devices	• DOE proposes a PTO **value of 0%**, unless the walk-in manufacturer can demonstrate that the device is controlled by a preset control system. • If this can be demonstrated, DOE **proposes 25%** for the device in question.

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Issue 3-13: Percent Time Off (PTO) Assumptions

DOE invites comments on the assumed PTO for the purposes of calculating electrical load of the envelope. See Section III.B.3.d for details.

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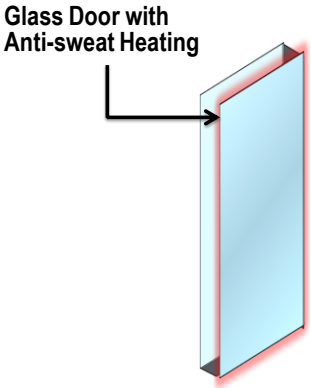
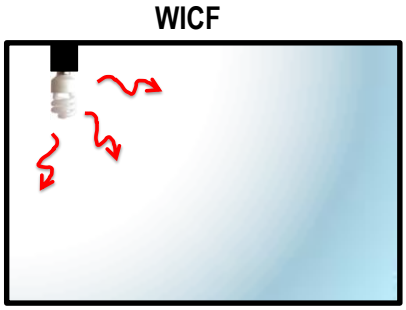
DOE examined the energy impact of door anti-sweat heaters and lights (power use and heat generation).





- **All electrical devices sited inside a WICF increase the amount of heat that must be removed by the refrigeration equipment.**

Evaluating the conduction, infiltration, and energy consumption of electrical devices yields values of heat gain.

Energy Consumption Associated with the Envelope

- A single metric, in units of **kWh/day, is preferred.**
- The heat gains related to the envelope are expressed in units of [Btu/h].
  - For these reasons, a method is needed to express these thermal gain values into heat removed by the refrigeration system [i.e. convert Btu/h to kWh/day]

➢ **A means for translating the thermal properties of the envelope into a quantifiable energy consumption value is needed.**

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DOE proposes the use of Energy Efficiency Ratios (EER) to "convert" the envelope-related thermal energy into kWh/day of electrical energy consumption.

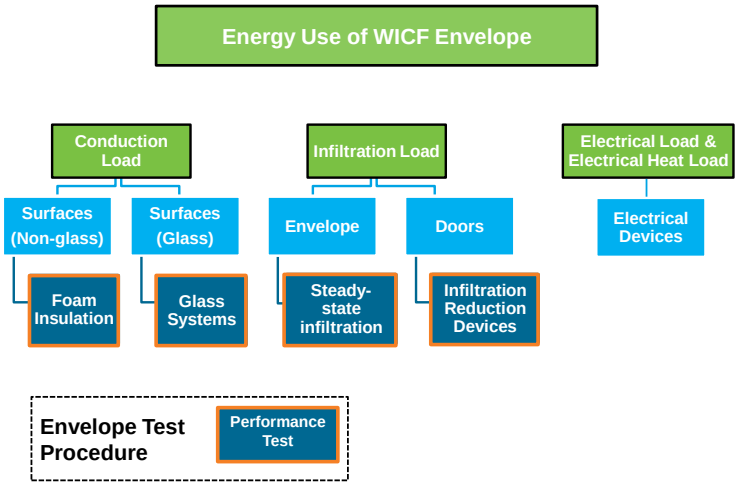
- EERs represent the relative system efficiencies of walk-in refrigeration equipment; i.e. a measure of how many units of heat are removed per unit electrical energy input into the refrigeration equipment.
- **Proposed nominal values**: DOE is considering the use of an EER of **12.4 and 6.3 (Btu/W-h)** for coolers and freezers, respectively (AHRI 1250-2009).

Issue 3-14: Nominal Energy Efficiency Ratio

DOE invites comments on the use of EERs for the refrigeration system to determine the energy consumption associated with heat gain through the envelope due to conduction, infiltration and electric devices. See Section III.B.3.a for details.

Envelope >> Overview

In summary, conduction, infiltration, and electric use determine envelope energy load.



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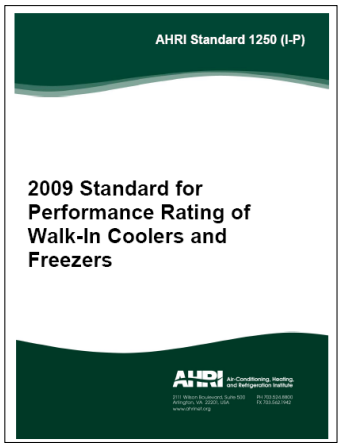
1 Overview of Public Meeting
2 Background & Approach
3 Basic Model
4 Proposed Test Procedure – Envelope
5 Proposed Test Procedure – Refrigeration System
6 Impacts on Small Businesses
7 Others Issues/Closing Discussion

DOE proposes to adopt Air-Conditioning, Heating and Refrigeration Institute (AHRI) Standard 1250, published in 2009.

- In 2009, AHRI developed a **new** rating method for refrigeration systems of walk-in coolers and freezers.
- DOE proposes to incorporate AHRI 1250 as the DOE test procedure for walk-in refrigeration systems.
  - This test procedure measures Annual Walk-in Energy Factor (AWEF), a measure of efficiency.
  - DOE proposes to add calculations to derive the energy consumption as required by EPCA.



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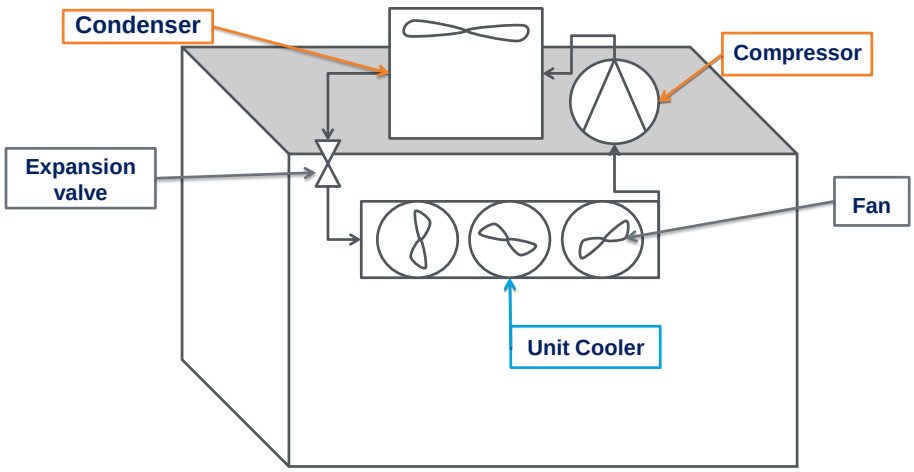
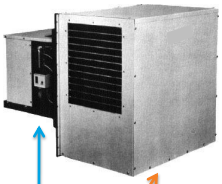
A refrigeration system consists primarily of a compressor, condenser, unit cooler and other miscellaneous components.



Refrigeration systems come in three general configurations:

1. Packaged System



Unit Cooler

Compressor & Condenser

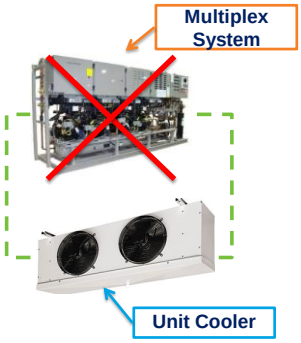
2. Split System

Unit Cooler

Compressor & Condenser

These systems **have a dedicated** compressor and condenser. The compressor and condenser are included in the test.

3. Unit Cooler Connected to a Multiplex System



This system **does not have a dedicated** compressor and condenser. The multiplex system is not included in the test.

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AHRI 1250 accounts for three different types of equipment systems.

1. **Matched system:** Unit cooler paired with a condensing unit and tested together as a complete system.
2. **Mix-match system:** Unit cooler and condensing unit are tested separately; their efficiency when they are paired together is calculated from the test results.
3. **Unit cooler paired with a multiplex system**: Unit cooler is tested alone. The efficiency is calculated using a nominal EER value for the multiplex system that depends on the suction dew point temperature.

➢ **The following slides summarize the tests for each system type.**

eere.energy.gov

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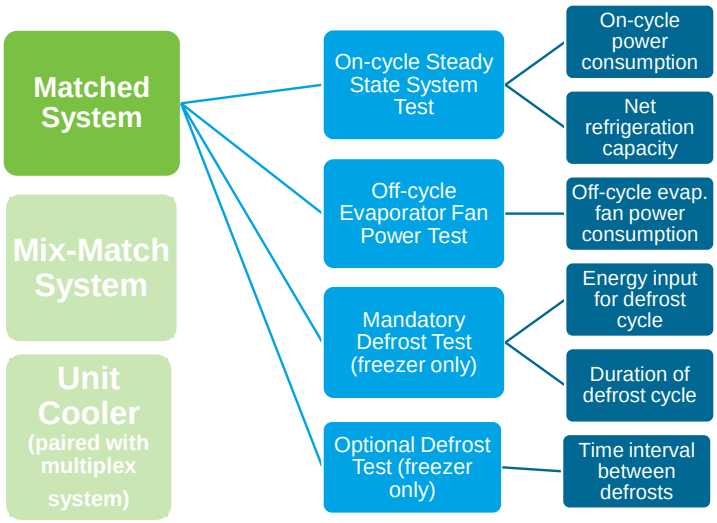
Summary of tests for a matched system.



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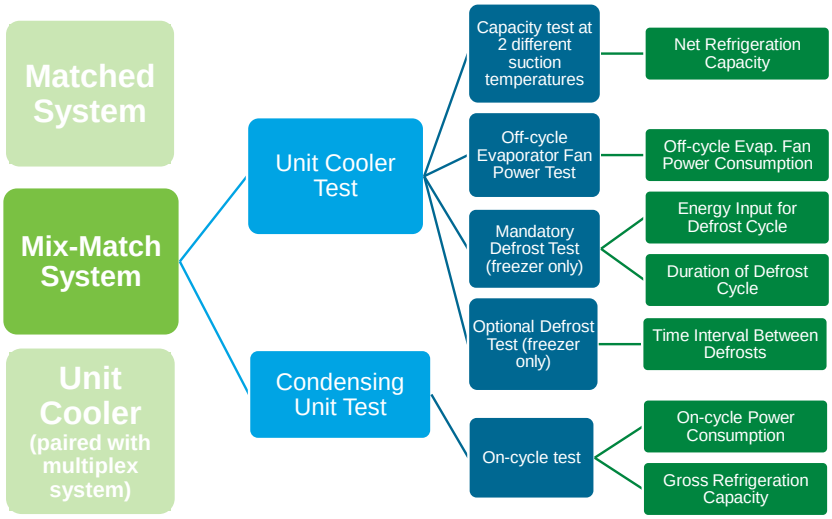
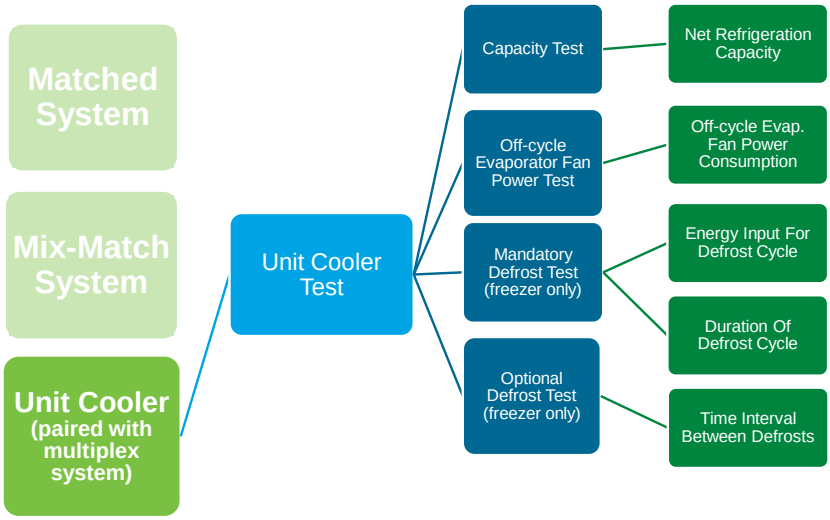
Summary of tests for a mix-match system.



Summary of tests for a unit cooler paired with a multiplex system.



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The test procedure specifies test conditions for various parameters to give credit for energy-saving technologies.

Category	Parameter	Conditions
Interior WICF Temperature	Cooler	At 35 F
	Freezer	At -10 F
Condenser Location	Indoors	At one ambient temperature (90 F)
	Outdoors	At three ambient temperatures (35 F, 59 F, and 95 F)
Compressor Type	Fixed-capacity	At single capacity
	Two-capacity	At both capacities
	Variable-capacity	At minimum, maximum, and an intermediate capacity

DOE examined AHRI 1250 and believes that the methods are well-suited to test WICF refrigeration systems.

- Based on test methods already used in the industry and shown to be **accurate and repeatable**.
- Developed and **approved by industry** and published by the industry trade association.
- **Applicable to the covered equipment** because it accounts for the unique operating conditions, configurations, and use patterns of WICF refrigeration.
- **Gives credit for energy saving technologies** such as variable-speed evaporator fans and defrost control strategies.

Issue 4-1: Proposed Test Procedure

DOE invites comment on whether AHRI 1250-2009 is an appropriate test procedure for refrigeration systems used in walk-ins. See Section III.C.1 for details.

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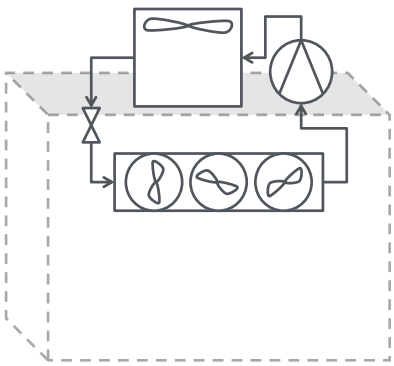
After the test data are gathered, the AWEF is calculated.



- The AWEF is a measure of the efficiency of the system.
- The refrigeration system is analytically paired with a theoretical envelope.
- The test procedure calculates the energy the refrigeration system would use to reject the heat load associated with the envelope.

$$\text{AWEF} = \frac{\text{net heat removed from the walk-in (Btu)*}}{\text{total energy consumption of the refrigeration system (Wh)}}$$

* Does not include heat generated by the refrigeration system.

The test procedure calculates the AWEF under assumed ambient conditions.

Assumptions Regarding Ambient Conditions:	The Ambient Conditions Affect:
1. For indoor units, the ambient temperature is assumed to be constant at 90 °F. 2. For outdoor units, the ambient temperature varies according to an **assumed temperature profile**.	1. The conduction load on the theoretical envelope, which contributes to the total heat load removed from the walk-in. 2. The energy consumption of the condensing unit.

➢ **The assumed ambient conditions are consistent across all WICF refrigeration systems.**

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DOE adapted the AHRI test procedure to fulfill the statutory requirement of EPCA.

- The AHRI test procedure calculates the AWEF of a refrigeration system, a measure of **efficiency**.

$$\text{AWEF} = \frac{\text{net heat removed from the walk-in [Btu]*}}{\text{total energy consumption of the refrigeration system [Wh]}}$$

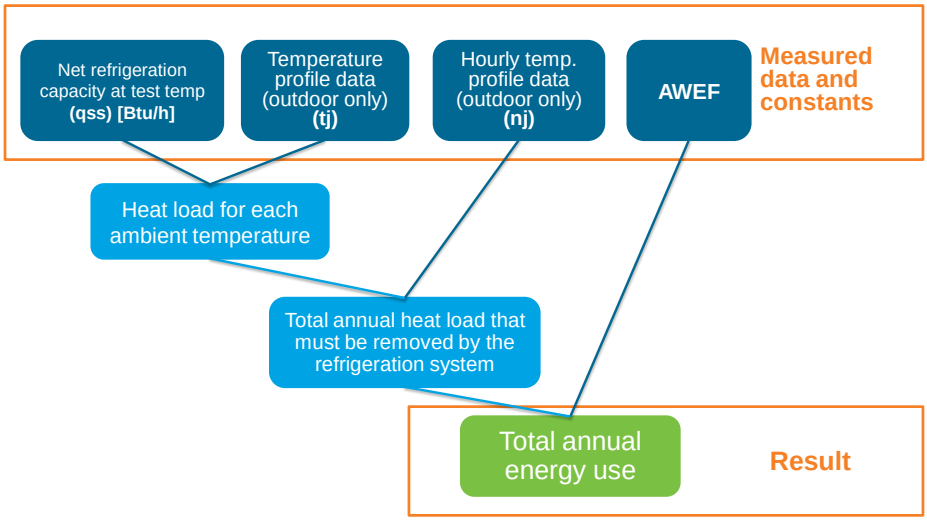
* Does not include heat generated by the refrigeration system.

- The DOE test procedure derives **annual energy use** from the AWEF, consistent with the EPCA mandate that the test procedure measure "energy use."

$$\text{Annual Energy Use [Wh]} = \frac{\text{net heat removed from the walk-in [Btu]*}}{\text{AWEF [Btu/Wh]}}$$

* Does not include heat generated by the refrigeration system.

DOE derived energy use from measured data and constants.



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DOE proposes the following equations in the rule language:

Net heat removed

Indoor units

Coolers:

$$\text{Annual Energy Use} = \frac{0.30 \times q_{ss}(90\ ^{o}\text{F}) \times 8760\ \text{hrs/year}}{\text{AWEF}}$$

Freezers:

$$\text{Annual Energy Use} = \frac{0.53 \times q_{ss}(90\ ^{o}\text{F}) \times 8760\ \text{hrs/year}}{\text{AWEF}}$$

Legend:
q_{ss} = net capacity
AWEF = annual walk-in energy factor
t_j = temperature j
n_j = number of hours at temperature j

Net heat removed

Outdoor units

Coolers:

$$\text{Annual Energy Use} = \frac{\sum_{j=1}^{\#bins}\left[\left(0.24 \times q_{ss}(95\ ^{o}\text{F}) + 0.06 \times \frac{q_{ss}(95\ ^{o}\text{F}) \times (t_j - 35)}{60}\right) \times n_j\right]}{\text{AWEF}}$$

Freezers:

$$\text{Annual Energy Use} = \frac{\sum_{j=1}^{\#bins}\left[\left(0.28 \times q_{ss}(95\ ^{o}\text{F}) + 0.25 \times \frac{q_{ss}(95\ ^{o}\text{F}) \times (t_j + 10)}{105}\right) \times n_j\right]}{\text{AWEF}}$$

Refrigeration >> Calculation

The method DOE used to derive these equations appears in the NOPR.

Issue 4-2: Calculation Methodology
DOE invites comments on its proposed method for deriving annual energy consumption from the AWEF. See Section III.C.4 for details.

Refrigeration >> Reporting Requirements

DOE anticipates that manufacturers would measure and report both the annual energy consumption and the AWEF.

- DOE does not specify certification and reporting requirements in this test procedure.
- DOE will develop future certification requirements in another rulemaking.
- DOE expects that the test procedure will be used to measure compliance with a future energy conservation standard.
- Either AWEF or energy consumption could be more useful in developing an energy conservation standard.

Issue 4-3: Reporting Requirements
DOE requests comments on the approach of reporting both energy consumption and AWEF. See Section III.C.4 for details.

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Small Business Impacts

DOE must consider impacts on small businesses.

- SBA size standard for the commercial and industrial refrigeration manufacturing industry: **< 750 employees**.
- Sources that list businesses in the WICF industry include:
  - Regulatory databases
  - AHRI's listing of commercial refrigeration manufacturer members
  - National Sanitation Foundation (NSF) Section 7 database
- DOE found **37 small manufacturers of WICF envelopes** and **5 small manufacturers of WICF refrigeration systems**.
- There could be other small manufacturers than are publicly listed.

Issue 5-1: Number of Small Entities Regulated

DOE invites comments on the number of small entities that may be affected by the proposed rule. See Section IV.B.3 for details.

Small Business Impacts

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DOE identified potential impacts and burden-reducing measures for walk-in equipment.

- Impacts are associated with the **cost of testing** and **length of time** it takes to perform the tests.
- Measures that may reduce burdens include:
  - Allowing low-cost testing options; e.g., for ASTM E741-06, DOE specifies CO_2 as the tracer gas, the lowest-cost option.
  - Reducing the number of tests manufacturers need to perform by allowing them to group similar models into one Basic Model.
- These apply to all manufacturers but may have a greater impact on small business manufacturers.

Issue 5-2: Impacts on Small Manufacturers

DOE invites comments on the expected impact of the rule on small entities and whether that impact is expected to be significant. DOE also asks whether small manufacturers would be differentially impacted by the proposed test procedures. DOE requests comments on any alternatives to the proposed rule and their impacts on small manufacturers. See Section IV.B for details.

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Closing Remarks

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Interested parties who wish to make a closing statement should speak now.

Closing Remarks >> Comments

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How to submit comments:

Public Meeting – Oral comments will be captured in the transcript and become part of the public record.

Written Comments –Reference **Docket EERE-2008-TP-0014** and/or **RIN 1904-AB85**.

Email: WICF-tp-2008-0014@ee.doe.gov
Include **EERE-2008-BT-TP-0014** and/or **RIN 1904-AB85** in the subject line of your message.

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950 L'Enfant Plaza, 6th Floor
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Telephone: 202-586-2945

Please include one signed original paper copy.

- **Comment period is open until March 31, 2010**