DEPARTMENT OF ENERGY

10 CFR Parts 429 and 431

[EERE–2017–BT–TP–0010]

RIN 1904–AD78

Energy Conservation Program: Test Procedures for Walk-In Coolers and Walk-In Freezers

AGENCY: Office of Energy Efficiency and Renewable Energy, Department of Energy.

ACTION: Final rule.

SUMMARY: The U.S. Department of Energy (DOE) is amending the test procedures for walk-in coolers and walk-in freezers to harmonize with updated industry standards, revise certain definitions, revise the test methods to more accurately represent field energy use, and to accommodate a wider range of walk-in cooler and walk-in freezer component equipment designs.

DATES: The effective date of this rule is June 5, 2023. The amendments will be mandatory for product testing starting October 31, 2023. Manufacturers will be required to use the amended test procedures until the compliance date of any final rule establishing amended energy conservation standards based on the newly established test procedures. At such time, manufacturers will be required to begin using the newly established test procedures.

The incorporation by reference of certain materials listed in the rule is approved by the Director of the Federal Register on June 5, 2023. The incorporation by reference of certain other material listed in the rule was approved by the Director of the Federal Register on January 27, 2017.

ADDRESSES: The docket, which includes **Federal Register** notices, public meeting attendee lists and transcripts, comments, and other supporting documents/materials, is available for review at *www.regulations.gov.* All documents in the docket are listed in the *www.regulations.gov* index. However, not all documents listed in the index may be publicly available, such as those containing information that is exempt from public disclosure.

A link to the docket web page can be found at *www.regulations.gov/docket/EERE-2017-BT-TP-0010.* The docket web page contains instructions on how to access all documents, including public comments, in the docket.

For further information on how to review the docket contact the Appliance and Equipment Standards Program staff at (202) 287–1445 or by email: *ApplianceStandardsQuestions@ee.doe.gov.*

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SUPPLEMENTARY INFORMATION: DOE maintains a previously approved incorporation by reference and incorporates by reference the following industry standards into part 431:

AHRI Standard 1250–2020, ''2020 Standard for Performance Rating of Walk-in Coolers and Freezers.''

Copies of AHRI 1250–2020 can be obtained from the Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Blvd., Suite 400, Arlington, VA 22201 or at *www.ahrinet.org.*

ANSI/ASHRAE 16–2016, ''Method of Testing for Rating Room Air Conditioners, Packaged Terminal Air Conditioners, and Packaged Terminal Heat Pumps for Cooling and Heating Capacity''.

ANSI/ASHRAE 23.1–2010, ''Methods of Testing for Rating the Performance of Positive Displacement Refrigerant Compressors and Condensing Units that Operate at Subcritical Temperatures of the Refrigerant''.

ANSI/ASHRAE 37–2009, ''Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat-Pump Equipment''.

ANSI/ASHRAE 41.1–2013, ''Standard Method for Temperature Measurement''.

ANSI/ASHRAE 41.3–2014, ''Standard Methods for Pressure Measurement''.

ANSI/ASHRAE 41.6–2014, ''Standard Method for Humidity Measurement''.

ANSI/ASHRAE 41.10–2013, ''Standard Methods for Refrigerant Mass Flow Measurement Using Flowmeters''.

Copies of ANSI/ASHRAE 16–2016, ANSI/ASHRAE 23.1–2010, ANSI/ASHRAE 37–2009, ANSI/ASHRAE 41.1–2013, ANSI/ASHRAE 41.3–2014, ANSI/ASHRAE 41.6–2014, and ANSI/ASHRAE 41.10–2013, can be obtained from the American Society of Heating, Refrigerating and Air-Conditioning Engineers, 180 Technology Parkway NW, Peachtree Corners, GA 30092, or at *www.ashrae.org.*

ASTM C518–17, ''Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus''.

ASTM C1199–14, ''Standard Test Method for Measuring the Steady-State Thermal Transmittance of Fenestration Systems Using Hot Box Methods.''

Copies of ASTM C518–17 and ASTM C1199–14 can be obtained from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428–2959, or at *www.astm.org.*

NFRC 102–2020 [E0A0], ''Procedure for Measuring the Steady-State Thermal Transmittance of Fenestration Systems''

Copies of NFRC 102–2020 can be obtained from the National Fenestration Rating Council, 6305 Ivy Lane, Suite 140, Greenbelt, MD 20770, or at *www.nfrc.org.*

See section IV.N of this document for a further discussion of these standards.

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I. Authority and Background

Walk-in coolers and walk-in freezers (collectively "WICFs" or "walk-ins") are included in the list of "covered equipment" for which the U.S. Department of Energy (DOE) is authorized to establish and amend energy conservation standards and test procedures. (42 U.S.C. 6311(1)(G)) DOE's energy conservation standards and test procedures for WICFs are currently prescribed at subpart R of part 431 of title 10 of the Code of Federal Regulations (CFR). The following sections discuss DOE's authority to establish test procedures for WICFs and relevant background information regarding DOE's consideration of test procedures for this equipment.

A. Authority

The Energy Policy and Conservation Act, Public Law 94–163, as amended ("EPCA"),[1] authorizes DOE to regulate the energy efficiency of a number of consumer products and certain industrial equipment. (42 U.S.C. 6291–6317) Title III, Part C of EPCA[2] established the Energy Conservation Program for Certain Industrial Equipment, which sets forth a variety of provisions designed to improve energy efficiency. This equipment includes WICFs, the subject of this document. (42 U.S.C. 6311(1)(G))

The energy conservation program under EPCA consists essentially of four parts: (1) testing, (2) labeling, (3) Federal energy conservation standards, and (4) certification and enforcement procedures. Relevant provisions of EPCA include definitions (42 U.S.C. 6311), test procedures (42 U.S.C. 6314), labeling provisions (42 U.S.C. 6315), energy conservation standards (42 U.S.C. 6313), and the authority to require information and reports from manufacturers (42 U.S.C. 6316).

The Federal testing requirements consist of test procedures that manufacturers of covered equipment must use as the basis for: (1) certifying to DOE that their equipment complies with the applicable energy conservation standards adopted pursuant to EPCA (42 U.S.C. 6316(a); 42 U.S.C. 6295(s)), and (2) making other representations about the efficiency of that equipment (42 U.S.C. 6314(d)). Similarly, DOE must use these test procedures to determine whether the equipment complies with relevant standards promulgated under EPCA. (42 U.S.C. 6316(a); 42 U.S.C. 6295(s))

Federal energy efficiency requirements for covered equipment established under EPCA generally supersede State laws and regulations concerning energy conservation testing, labeling, and standards. (42 U.S.C. 6316(a) and 42 U.S.C. 6316(b); 42 U.S.C. 6297) DOE may, however, grant waivers of Federal preemption for particular State laws or regulations, in accordance with the procedures and other provisions of EPCA. (42 U.S.C. 6316(b)(2)(D))

Under 42 U.S.C. 6314, EPCA sets forth the criteria and procedures DOE must follow when prescribing or amending test procedures for covered equipment. EPCA requires that any test procedures prescribed or amended under this section must be reasonably designed to produce test results that reflect energy efficiency, energy use, or estimated annual operating cost of a given type of covered equipment during a representative average use cycle (as determined by the Secretary) and requires that test procedures not be unduly burdensome to conduct. (42 U.S.C. 6314(a)(2))

EPCA also requires that, at least once every 7 years, DOE evaluate test procedures for each type of covered equipment, including WICFs, to determine whether amended test procedures would more accurately or fully comply with the requirements for the test procedures to not be unduly burdensome to conduct and be reasonably designed to produce test results that reflect energy efficiency, energy use, and estimated operating costs during a representative average use cycle. (42 U.S.C. 6314(a)(1)) DOE considers this rulemaking to be in satisfaction of the 7-year review requirement specified in EPCA.

In addition, if the Secretary determines that a test procedure amendment is warranted, the Secretary must publish proposed test procedures in the **Federal Register**, and afford interested persons an opportunity (of not less than 45 days duration) to present oral and written data, views, and arguments on the proposed test procedures. (42 U.S.C. 6314(b)) If DOE determines that test procedure revisions are not appropriate, DOE must publish its determination not to amend the test procedures. (42 U.S.C. 6314(a)(1)(A)(ii))

B. Background

For measuring walk-in energy use, DOE has established separate test procedures for the principal components that may comprise a walk-in (*i.e.,* doors, panels, and refrigeration systems), with separate test metrics for each component. (10 CFR 431.304(b)) For walk-in doors and display panels, the efficiency metric is daily energy consumption, measured in kilowatt-hours per day (kWh/day), which accounts for the thermal conduction through the door or display panel and the direct and indirect electricity use of any electrical components associated with the door. *See* 10 CFR 431.304(b)(1)–(2) and 10 CFR part 431, subpart R, appendix A, "Uniform Test Method for the Measurement of Energy Consumption of the Components of Envelopes of Walk-in Coolers and Walk-in Freezers" (appendix A). The thermal transmittance through the door, which inputs into the calculation of thermal

[1] All references to EPCA in this document refer to the statute as amended through the Energy Act of 2020, Public Law 116–260 (Dec. 27, 2020), which reflect the last statutory amendments that impact Parts A and A–1 of EPCA.

[2] For editorial reasons, upon codification in the U.S. Code, Part C was redesignated Part A–1.

conduction, is determined using National Fenestration Rating Council (NFRC) 100–2010, ''Procedure for Determining Fenestration U-factors'' (NFRC 100–2010), which is incorporated by reference at 10 CFR 431.303.

For walk-in non-display panels and non-display doors, in the final rule published on April 15, 2011, DOE codified in the CFR the standards established in EPCA based on the R-value metric,[3] expressed in units of (h-ft^2-°F/Btu),[4] which is calculated as the thickness of the panel in inches (in.) divided by the K-factor.[5] *See* 10 CFR 431.304(b)(3) and 10 CFR part 431, subpart R, appendix B, ''Uniform Test Method for the Measurement of R-Value for Envelope Components of Walk-in Coolers and Walk-in Freezers'' (appendix B). (*See also* 42 U.S.C. 6314(a)(9)(A)) The K-factor is calculated based on ASTM International (ASTM) C518, ''Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus'' (ASTM C518), which is incorporated by reference at 10 CFR 431.303. *Id.*

For walk-in refrigeration systems, the efficiency metric is the annual walk-in energy factor (''AWEF''), which is the ratio of the total heat, not including the heat generated by the operation of refrigeration systems, removed, in Btu, from a walk-in box during a one-year period of usage for refrigeration to the total energy input of refrigeration systems, in watt-hours, during the same period. AWEF is determined by conducting the test procedure set forth in American National Standards Institute (ANSI)/Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 1250 (I–P), ''2009 Standard for Performance Rating of Walk-in Coolers and Freezers'' (AHRI 1250–2009), which is incorporated by reference in 10 CFR 431.303 with certain adjustments specified in the CFR. *See* 10 CFR 431.304(b)(4) and 10 CFR part 431, subpart R, appendix C, ''Uniform Test Method for the Measurement of Net Capacity and AWEF of Walk-in Cooler and Walk-in Freezer Refrigeration Systems'' (appendix C). A manufacturer may also determine AWEF using an alternative efficiency determination method (AEDM). 10 CFR 429.53(a)(2)(iii). An AEDM enables a manufacturer to utilize computer-based or mathematical models for purposes of determining an equipment's energy use or energy efficiency performance in lieu of testing, provided certain prerequisites have been met. 10 CFR 429.70(f).

On August 5, 2015, DOE published its intention to establish a working group under the Appliance Standards and Rulemaking Federal Advisory Committee (ASRAC) to negotiate energy conservation standards to replace the standards established in the final rule published on June 3, 2014 (79 FR 32050, ''June 2014 ECS Final Rule''). 80 FR 46521. The established working group (ASRAC Working Group) assembled its recommendations into a term sheet[6] (Docket No. EERE–2015–BT–STD–0016, No. 56) that was presented to and approved by ASRAC on December 18, 2015 (ASRAC Term Sheet).

The ASRAC Term Sheet provided recommendations for energy conservation standards to replace standards vacated by the United States Court of Appeals for the Fifth Circuit in a controlling order issued August 10, 2015. It also included recommendations regarding definitions for a number of terms related to the WICF regulations, as well as recommendations to amend the test procedure that the ASRAC Working Group viewed as necessary to properly implement the energy conservation standards recommendations. Consequently, in 2016 DOE initiated both an energy conservation standards rulemaking and a test procedure rulemaking to implement these recommendations. The ASRAC Term Sheet also included recommendations for future amendments to the test procedures intended to make DOE's test procedures more fully representative of walk-in energy use.

On December 28, 2016, DOE published a final rule amending the WICF test procedures (''December 2016 Final Rule''), consistent with the ASRAC Term Sheet recommendations and including provisions to facilitate implementation of energy conservation standards for walk-in components. 81 FR 95758.

In 2020, AHRI published an updated industry test standard for walk-in refrigeration systems, ''2020 Standard for Performance Rating of Walk-in Coolers and Freezers,'' (AHRI 1250–2020) updating the existing AHRI standard ''AHRI 1250P (I–P)-2009.'' This new test procedure included updated calculations for the determination of default values for equipment with electric defrost and hot gas defrost. DOE published a final rule for hot gas defrost unit coolers on March 26, 2021 (March 2021 Final Rule), that amended the test procedure to rate hot gas defrost unit coolers using the modified default values for energy use and heat load contributions in AHRI 1250–2020. These amendments ensure that ratings for hot gas defrost unit coolers are consistent with those of electric defrost unit coolers. 86 FR 16027.

Under 10 CFR 431.401, any interested person may submit a petition for waiver from DOE's test procedure requirements. DOE will grant a waiver from the test procedure requirements if DOE determines either the basic model for which the waiver was requested contains a design characteristic that prevents testing of the basic model according to the prescribed test procedures, or the prescribed test procedures evaluate the basic model in a manner so unrepresentative of its true energy consumption characteristics as to provide materially inaccurate comparative data. 10 CFR 431.401(f)(2). DOE may grant the waiver subject to conditions, including adherence to alternate test procedures specified by DOE. *Id.* DOE has granted interim waivers and/or waivers to the manufacturers listed in Table I.1.

TABLE I.1—MANUFACTURERS WHO RECEIVED A TEST PROCEDURE WAIVER/INTERIM WAIVER FROM DOE

Manufacturer	Subject	Case No.	Waiver from appendix
Jamison Door Company	Percent Time Off (PTO) for Door Motors	2017–009	A
HH Technologies	PTO for Door Motors	2018–001	A

[3] The R-value is the thermal resistance, or the capacity of an insulated material to resist heat flow. *See* section 3.3.3 of ASTM C518. *See* 42 U.S.C. 6313(f)(1)(C) for the EPCA R-value requirements for non-display panels and doors.

[4] These symbols represent the following units of measurement—h: hour; ft^2: square foot; °F: degrees Fahrenheit; Btu: British thermal unit.

[5] The K-factor represents the thermal conductivity of a material, or its ability to conduct heat, in units of Btu-in/(h-ft^2-°F). *See* section 3.3.1 of ASTM C518.

[6] Appliance Standards and Rulemaking Federal Advisory Committee Refrigeration Systems Walk-in Coolers and Freezers Term Sheet, available at *www.regulations.gov/document/EERE-2015-BT-STD-0016-0056.*

TABLE I.1—MANUFACTURERS WHO RECEIVED A TEST PROCEDURE WAIVER/INTERIM WAIVER FROM DOE—Continued

Manufacturer	Subject	Case No.	Waiver from appendix
Senneca Holdings	PTO for Door Motors	2020–002	A
Hercules	PTO for Door Motors	2020–013	A
Heat Transfer Products Group, LLC (HTPG)	CO_2 Unit Coolers	2020–009	C
Hussmann Corporation (Hussmann)	CO_2 Unit Coolers	2020–010	C
KeepRite Refrigeration, Inc. (KeepRite)	CO_2 Unit Coolers	2020–014	C
RefPlus, Inc.	CO_2 Unit Coolers	2021–006	C
Refrigerated Solutions Group (RSG)	Multi-Circuit Single-Package Dedicated Systems	2022–004	C
Store It Cold	Single-Packaged Dedicated Systems	2018–002	C
CellarPro	Wine Cellar Refrigeration Systems	2019–009	C
Air Innovations	Wine Cellar Refrigeration Systems	2019–010	C
Vinotheque	Wine Cellar Refrigeration Systems	2019–011	C
Vinotemp	Wine Cellar Refrigeration Systems	2020–005	C
LRC Coil Company (LRC Coil)	Wine Cellar Refrigeration Systems	2020–024	C

On June 17, 2021, DOE published a request for information (RFI) to initiate a test procedure rulemaking for walk-ins (June 2021 RFI). 86 FR 32332. DOE published a notice of proposed rulemaking (NOPR) on April 21, 2022 (April 2022 NOPR), responding to comments received in response to the June 2021 RFI and presenting DOE's proposals to amend the WICFs test procedure—including amendments to eliminate the need for existing test procedure waivers—and establish a new test procedure at 10 CFR part 431, subpart R, appendix C1 (appendix C1), that would establish a new energy efficiency metric, AWEF2. 87 FR 23920. DOE held a public meeting related to the April 2022 NOPR on May 9, 2022.

DOE received comments in response to the April 2022 NOPR from the interested parties listed in Table I.2.

TABLE I.2—LIST OF COMMENTERS WITH WRITTEN SUBMISSIONS IN RESPONSE TO THE APRIL 2022 NOPR

Commenter(s)	Reference in this Final Rule	Comment No. in the docket	Commenter type
Air-Conditioning, Heating, & Refrigeration Institute	AHRI [7]	30	Trade Association.
Air-Conditioning, Heating, & Refrigeration Institute	AHRI-Wine [8]	30	Trade Association.
Anthony International	Anthony	31	Manufacturer.
Appliance Standards Awareness Project, American Council for an Energy-Efficient Economy, Natural Resources Defense Council, Northwest Energy Efficiency Alliance.	Efficiency Advocates	37	Efficiency Organizations.
Bally Refrigerated Boxes, Inc	Bally	40	Manufacturer.
Heat Transfer Products Group, LLC	HTPG	32	Manufacturer.
Hussmann Corporation	Hussmann	34, 38	Manufacturer.
KeepRite Refrigeration, Inc	KeepRite	36	Manufacturer.
Lennox International Inc	Lennox	35	Manufacturer.
National Refrigeration & Air Conditioning Canada Corp	National Refrigeration	39	Manufacturer.
North American Association of Food Equipment	NAFEM	33	Trade Association.
Pacific Gas and Electric Company, San Diego Gas & Electric, and Southern California Edison; collectively, the California Investor-Owned Utilities.	CA IOUs	42	Utility Association.
Refrigerated Solutions Group	RSG	41	Manufacturer.
Senneca Holdings	Senneca	26	Manufacturer.

Aparenthetical reference at the end of a comment quotation or paraphrase provides the location of the item in the public record.[9] To the extent that interested parties have provided written comments that are substantively consistent with any oral comments provided during the May 2022 public meeting, DOE cites the written comments throughout this final rule.

In response to the April 2022 NOPR, NAFEM commented that while the April 2022 NOPR was not inconsistent with DOE's Process Rule,[10] NAFEM supports the U.S. Small Business Administration Office of Advocacy request [11] that DOE reopen public comment on the 2021 Process Rule and

[7] AHRI submitted two comment documents to the docket. The first document in the docket includes AHRI's comments for traditional walk-in manufacturers (*i.e.,* medium- and low-temperature walk-in components). The associated file name in the docket is: AHRI Comments WICF NOPR EERE–2017–BT–TP–0010. These comments are referenced in this document as ''AHRI'' comments.

[8] AHRI submitted two comment documents to the docket. The second document in the docket includes AHRI's comments supporting wine cellar manufacturers (*i.e.,* high-temperature walk-in refrigeration systems). The associated file name in the docket is: Comments WICF NOPR EERE–2017–BT–TP–0010 Wine. These comments are referenced in this document as ''AHRI-Wine'' comments.

[9] The parenthetical reference provides a reference for information located in the docket of DOE's rulemaking to develop test procedures for walk-ins (Docket No. EERE–2017–BT–TP–0010, maintained at *www.regulations.gov*). The references are arranged as follows: (commenter name, comment docket ID number, page of that document).

[10] The term ''Process Rule'' refers to DOE's *Procedures, Interpretations, and Policies for Consideration of New or Revised Energy Conservation Standards and Test Procedures for Consumer Products and Certain Commercial/Industrial Equipment* at 10 CFR part 430, subpart C, appendix A.

[11] The U.S. Small Business Administration Office of Advocacy request is available at *cdn.advocacy.sba.gov/wp-content/uploads/2022/05/13104422/Comment-Letter-DOE-Process-Rule-Letter_5-13-22.pdf.*

concurrent proposed rulemaking.[12] (NAFEM, No. 33 at p. 2) The request referenced by NAFEM specifically refers to a National Academies of Sciences (''NAS'') report entitled ''Review of Methods Used by the U.S. Department of Energy in Setting Appliance and Equipment Standards.'' Given that the recommendations in the NAS report pertain to the processes by which DOE analyzes energy conservation standards, DOE will consider this comment in a separate rulemaking that includes all product categories.

II. Synopsis of the Final Rule

In this final rule, DOE is expanding the scope of its walk-in coolers and freezers test procedure to include carbon dioxide (CO_2) unit coolers, multi-circuit single-packaged dedicated systems, and ducted fan coil units. DOE has also determined that liquid-cooled refrigeration systems are within the scope of DOE coverage authority for walk-ins but is not adding an applicable test procedure at this time.

In this final rule, DOE is amending the definitions of walk-in cooler and walk-in freezer, door, door surface area, and single-packaged dedicated systems. DOE is also adding new definitions for door leaf, hinged vertical door, non-display door, roll-up door, sliding door, high-temperature refrigeration systems, ducted fan coil units, multi-circuit single-packaged dedicated systems, ducted multi-circuit single-packaged dedicated systems, attached split systems, detachable single-packaged dedicated systems, and CO_2 unit coolers.

In this final rule, DOE is revising appendix A as follows: (1) incorporate by reference NFRC 102–2020 as the applicable test procedure to determine door ''U-factor'' in place of NFRC 100–2010; [13] (2) provide further detail on and distinguish the area to be used for calculating a thermal load from U-factor and determining compliance with standards; (3) establish a percent time off (''PTO'') specific to door motors; and (4) reorganize appendix A so it is easier to follow.

Additionally, DOE is modifying appendix B to improve test representativeness and repeatability. Specifically, DOE is revising appendix B as follows: (1) reference the updated industry standard ASTM C518–17; (2) include more detailed provisions for determining measuring insulation thickness and test specimen thickness; (3) provide additional specifications for determining parallelism and flatness of a test specimen; and (4) reorganize appendix B as a step-by-step procedure to improve readability.

DOE is also including walk-in doors and walk-in panels in the list of covered equipment in the same sampling plan for enforcement testing that is used for walk-in refrigeration systems. (*See* 10 CFR 429.110(e)(2))

In this final rule, DOE is making two sets of changes to the refrigeration system test procedure. One set of changes is grouped into revisions to appendix C, and the other set of changes is included in a new appendix C1. DOE has determined that the changes to appendix C will not affect AWEF ratings and therefore will not require any retesting or recertification. These changes will be required starting 180 days after the test procedure final rule is published. DOE is also establishing a new metric, AWEF2, in the new appendix C1, which will require retesting and recertification. Use of appendix C1 will not be required until the compliance date of amended energy conservation standards for WICFs that DOE may ultimately adopt as part of a separate rulemaking.

DOE is revising appendix C, as follows:

(1) Specify refrigeration test room conditions.

(2) Provide for a temperature probe exception for small diameter refrigerant lines.

(3) Incorporate a test setup hierarchy of installation instructions for laboratories to follow when setting up a unit for test.

(4) Allow active cooling of the liquid line in order to achieve the required 3 °F subcooling at a refrigerant mass flow meter.

(5) Modify instrument accuracy and test tolerances.

(6) Address current test procedure waivers for CO_2 unit coolers tested alone and high-temperature unit coolers tested alone by incorporating amendments appropriate for this equipment.

The new appendix C1 includes these changes to appendix C, as well as the following additional changes:

(1) Adopt AHRI 1250–2020.

(2) Provide for testing single-packaged dedicated systems, detachable single-packaged dedicated systems; attached split systems; CO_2, variable-, two-, and multiple-capacity dedicated condensing units; indoor variable-, two-, and multiple-capacity matched pairs; matched refrigeration systems for high-temperature applications; and multi-circuit single-packaged dedicated systems.

(3) Add a single-packaged dedicated system refrigerant enthalpy test procedure.

(4) Add a new energy efficiency metric, AWEF2, to reflect the changes in the test procedure that would result in a significant change to energy use values compared to the AWEF metric in appendix C.

Table II.1 summarizes the current DOE test procedure, DOE's changes to the test procedure, the attribution for each proposed change, and the relevant test procedure appendix.

TABLE II.1—SUMMARY OF CHANGES IN TEST PROCEDURE RELATIVE TO CURRENT TEST PROCEDURE

WICF component(s)	DOE test procedure prior to amendment	Amended test procedure	Attribution	Relevant appendix
Doors and Display Panels.	Incorporates by reference NFRC 100–2010 for determining U-factor as part of determining energy consumption.	Incorporates by reference NFRC 102–2020 for determining U-factor and allows AEDMs to be used for determining energy consumption.	Reduce test burden	A
Doors and Display Panels.	Uses surface area of the door or display panel external to the walk-in to convert U-factor into a conduction load.	Requires that area of the aperture or surface area used to determine U-factor be used to convert U-factor into a conduction load.	Improve representative values	A

[12] DOE published a NOPR and request for comment on July 7, 2021, proposing changes to the Process Rule. 86 FR 35668.

[13] As discussed further in section III.C.1.b of this final rule, DOE is also adopting AEDM provisions for doors in 10 CFR 429.53 to allow calculation of door energy use representations.

TABLE II.1—SUMMARY OF CHANGES IN TEST PROCEDURE RELATIVE TO CURRENT TEST PROCEDURE—Continued

WICF component(s)	DOE test procedure prior to amendment	Amended test procedure	Attribution	Relevant appendix
Doors	Uses a PTO value of 25 percent for door motors (as they are considered "other electricity-consuming devices").	Establishes a PTO value of 97 percent specific to door motors.	Improve representative values and address inconsistent values across waivers granted.	A
Non-display Doors and Panels.	Incorporates by reference ASTM C518–04.	Incorporates by reference ASTM C518–17.	Update applicable industry test procedures.	B
Non-display Doors and Panels.	Does not include detailed provisions for determining and measuring total insulation thickness and test specimen thickness.	Includes detailed provisions for determining and measuring total insulation thickness and test specimen thickness.	Ensure test repeatability	B
Non-display Doors and Panels.	Requires that the test specimen meet a parallelism and flatness tolerance of ±0.03 inches but provides no guidance on measurement.	Provides specifications for determining parallelism and flatness of the test specimen.	Ensure test repeatability	B
Refrigeration Systems	Does not include guidance on test room conditioning.	Includes guidance on test room conditioning.	Ensure test repeatability	C
Refrigeration Systems	Does not include an allowance for measuring refrigerant temperatures with surface-mounted measuring instruments.	Includes an allowance for measuring refrigerant temperatures with surface-mounted measuring instruments for small diameter tubes.	Reduce test burden	C
Refrigeration Systems	Does not include guidance for unit charging or a setup condition hierarchy.	Includes guidance for unit charging and a setup condition hierarchy.	Ensure test repeatability	C
Refrigeration Systems	Does not include provisions for testing CO_2 unit coolers.	Includes provisions for testing CO_2 unit coolers.	Improve representative values	C
Refrigeration Systems	Does not include provisions for testing high-temperature unit coolers alone.	Includes provisions for testing high-temperature unit coolers alone.	Improve representative values	C
Refrigeration Systems	Incorporates by reference AHRI 1250–2009, ASHRAE 23.1–2010, and AHRI 420–2008.	Incorporates by reference AHRI 1250–2020, ASHRAE 37–2009, and ASHRAE 16–2016.	Update applicable industry test procedures.	C1
Refrigeration Systems	Tests single-packaged dedicated systems using the refrigerant enthalpy method for matched pairs.	Includes multiple methods for testing single-packaged dedicated systems.	Improve representative values	C1
Refrigeration Systems	Does not include provisions for testing attached split systems or detachable single-packaged dedicated systems.	Includes provisions for testing attached split systems or detachable single-packaged dedicated systems.	Improve representative values	C1
Refrigeration Systems	Does not include provisions for testing multi-circuit single-packaged dedicated systems.	Includes provisions for testing multi-circuit single-packaged dedicated systems.	Improve representative values	C1
Refrigeration Systems	Does not include provisions for testing ducted fan coil units.	Includes provisions for testing ducted fan coil units.	Improve representative values	C1
Refrigeration Systems	Does not include provisions for testing high-temperature matched-pair and single-packaged dedicated systems.	Includes provisions for testing high-temperature matched-pair and single-packaged dedicated systems.	Improve representative values	C1
Refrigeration Systems	Does not include provisions for testing of variable- and multiple-capacity dedicated condensing units nor variable- and multiple-capacity outdoor matched pairs.	Includes provisions for testing of variable, two-, and multiple-capacity dedicated condensing units and variable, two-, and multiple-capacity outdoor matched pairs.	Improve representative values	C1

DOE has determined that the amendments described in section III.C and III.E of this final rule would not alter the measured energy consumption of walk-in doors without motors or the R-value of walk-in non-display doors and non-display panels. Therefore, retesting or recertification would not be required solely as a result of DOE's adoption of the amendments to the test procedures. Additionally, DOE has determined that the amendments would not increase the cost of testing.

For walk-in doors with motors, DOE has determined that the amendments described in section III of this final rule would either not change the measured energy consumption or would result in a lower measured energy consumption and therefore, would not require retesting or recertification as a result of DOE's adoption of the amendments to the test procedures. New testing is only required if the manufacturer wishes to make claims using the new, more efficient rating. Additionally, DOE has determined the amendments would not increase the cost of testing for doors with motors.

DOE has also determined that the amendments to appendix C, described in section III.F of this final rule would not alter the measured efficiency of walk-in refrigeration systems and would not require retesting or recertification as a result of DOE's adoption of the amendments to the test procedures. Additionally, DOE has determined that the amendments would not increase the cost of testing.

Finally, DOE has determined that the provisions of the new appendix C1 described in section III.G of this final rule would alter the measured efficiency of walk-in refrigeration systems, in part because the amended test procedure adopts a different energy efficiency metric than in the current test procedure. However, the use of appendix C1 is not required for use until the compliance date of any amended energy conservation standards based on the test procedure in appendix C1. Additionally, DOE has determined that the provisions in appendix C1 will increase the cost of testing. DOE's estimation of costs is discussed in section III.K of this document.

The effective date for the amended test procedures adopted in this final rule is 30 days after publication of this document in the **Federal Register**. Representations of energy use or energy efficiency must be based on testing in accordance with the amended appendices A, B, and C test procedures beginning 180 days after the publication of this final rule. Manufacturers will be required to certify compliance using the new appendix C1 test procedures beginning on the compliance date of any final rule establishing amended energy conservation standards for walk-in refrigeration systems that are published after the effective date of this final rule.

III. Discussion

A. Scope and Definitions

This final rule applies to the test procedures for ''walk-in coolers and walk-in freezers.'' The following sections discuss DOE's consideration of the scope of the test procedures and relevant definitions.

1. Scope

The following sections discuss considerations and adopted changes regarding the scope of equipment covered by DOE's test procedures for walk-ins.

a. Liquid-Cooled Refrigeration Systems

A liquid-cooled refrigeration system rejects heat during the condensing process to a liquid, and the liquid transports the heat to a remote location. This contrasts with an air-cooled system, which rejects heat to ambient air during the condensing process. The current DOE test procedure for walk-in refrigeration systems, which incorporates by reference AHRI 1250–2009, does not address how to test liquid-cooled systems. Additionally, liquid-cooled dedicated condensing units are outside the scope of AHRI 1250–2020, being specifically excluded in Section 2.2.4. In the April 2022 NOPR, DOE tentatively determined that liquid-cooled refrigeration systems represent a small portion of the walk-in market, and thus DOE did not propose to amend its test procedures to include liquid-cooled refrigeration systems. 87 FR 23920, 23927.

In response to the April 2022 NOPR, the Efficiency Advocates and CA IOUs encouraged DOE to develop a test procedure for liquid-cooled refrigeration systems. (Efficiency Advocates, No. 37 at p. 3; CA IOUs, No. 42 at p. 5)

DOE recognizes the potential benefit of a test procedure for liquid-cooled walk-ins and the value that a reliable test procedure can provide to facilitate comparable representations of energy use for consumers. However, DOE maintains that liquid-cooled refrigeration systems represent a small portion of the walk-in market, and the potential for energy savings that could be realized through the development of a test procedure and corresponding energy conservation standards is likely limited at this time. Additionally, DOE is not aware of an industry test standard for liquid cooled walk-in refrigeration systems. Therefore, although liquid-cooled refrigeration systems are covered within the scope of the walk-in coolers and walk-in freezers definition, DOE is not adopting provisions specific to liquid-cooled refrigeration systems in its test procedure at this time.

b. Carbon Dioxide Systems

Currently, the DOE test procedure for walk-in refrigeration systems does not explicitly define scope based on refrigerant. *See* 10 CFR 431.301 and 431.304 and appendix C. DOE understands that the current test procedure, which is based on AHRI 1250–2009 (incorporated by reference, 10 CFR 431.303(b)), specifies test conditions that may not be consistent with the design and operation of carbon dioxide (''CO_2'') refrigeration systems (*i.e.,* although AHRI 1250–2009 does not specifically exclude CO_2 systems, the test method is not designed to accommodate such systems).[14]

As a result, DOE has granted waivers or interim waivers to manufacturers from appendix C, for specific basic models of CO_2 unit coolers.[15] The alternate test procedure granted in these waivers and DOE's amendments with respect to refrigeration systems utilizing CO_2 as a refrigerant are further discussed in section III.F.6 of this document.

In the April 2022 NOPR, DOE tentatively determined that walk-in refrigeration equipment utilizing CO_2 as a refrigerant meets the definition of a walk-in refrigeration system. In the April 2022 NOPR, DOE proposed test procedure provisions specific to (1) single-packaged dedicated systems and (2) unit cooler variants of CO_2 refrigeration systems. DOE did not propose test procedure provisions specific to CO_2-dedicated condensing units.[16]

In response to the April 2022 NOPR, the CA IOUs and HTPG stated that CO_2-dedicated condensing units are available on the market in the United States. (CA IOUs, No. 42 at p. 4; HTPG, No. 32 at p. 2) The CA IOUs, HTPG, and the Efficiency Advocates encouraged DOE to develop a test procedure for CO_2-dedicated condensing units. (CA IOUs, No. 42 at p. 4; HTPG, No. 32 at p. 2; Efficiency Advocates, No. 37 at p. 2)

DOE has conducted additional market research and determined that while CO_2 dedicated condensing units are currently available in the United States the market is small. In addition, due to COVID supply constraints, DOE has not been able to procure a CO_2 dedicated condensing unit to evaluate for testing. Therefore, DOE is not adopting a test procedure for CO_2 dedicated condensing units at this time. The test procedures for CO_2 unit coolers and single-packaged dedicated systems that use CO_2 as a refrigerant are discussed in

[14] The DOE test procedure for unit coolers requires testing with a liquid inlet saturation temperature of 105 °F and a liquid inlet subcooling temperature of 9 °F, as specified by Tables 15 and 16 of AHRI 1250–2009. However, CO_2 has a critical temperature of 87.8 °F; therefore, it does not coexist as saturated liquid and gas above this temperature. The liquid inlet saturation temperature of 105 °F and the liquid inlet subcooling temperature of 9 °F specified in appendix C, are not achievable by CO_2 unit coolers.

[15] HTPG Decision and Order, 86 FR 14887 (Mar. 19, 2021); Hussmann Decision and Order, 86 FR 24606 (May 7, 2021); KeepRite Decision and Order, 86 FR 24603 (May 7, 2021); RefPlus Interim Waiver, 86 FR 43633 (Aug. 10, 2021).

[16] As discussed in the April 2022 NOPR, DOE preliminarily found that, in the North American market, CO_2 is primarily used in large rack systems, and there do not appear to be any CO_2 dedicated condensing units available. Hence, DOE tentatively found that adopting a test procedure for CO_2 dedicated condensing units is currently not warranted. 87 FR 23920, 23928.

more detail in sections III.F.6 and III.G.2.g of this document, respectively.

c. Multi-Circuit Single-Packaged Dedicated Systems

DOE published an interim test procedure waiver for Refrigerated Solutions Group (RSG) on July 22, 2022. 87 FR 43808. In its petition for waiver and interim waiver, RSG stated that the current walk-in test procedure does not address multiple refrigeration circuits enclosed in a single unit. DOE has determined that refrigeration systems with multiple refrigeration circuits that share a single evaporator and a single condenser and that are used in walk-in applications meet the definition of ''walk-in cooler and walk-in freezer.'' Thus, DOE is adding a definition for ''multi-circuit single-packaged dedicated system,'' as discussed in section III.A.2.e of this document, and adopting a test procedure for such systems, as discussed in section III.G.2.f of this document.

d. Ducted Units

As discussed in the April 2022 NOPR, DOE is aware that some walk-in evaporators and/or dedicated condensing units are sold with provisions to be installed with ducting to circulate air between the walk-in and the refrigeration system; however, unit cooler and single-packaged systems sold for ducted installation are not addressed by either the definition for ''single-packaged dedicated system'' or ''unit cooler.'' 87 FR 23920, 23928. The current definition of ''single-packaged dedicated system'' specifies that such systems do not have ''any element external to the system imposing resistance to flow of the refrigerated air,'' and the definition of ''unit cooler'' specifies that such equipment does not have ''any element external to the cooler imposing air resistance.'' 10 CFR 431.302. As such, unit coolers and single-packaged dedicated systems sold for ducted installation are not addressed by either definition. In addition, the current test procedure does not include provisions for the setup of ductwork. While the definition of ''condensing unit'' does not exclude systems intended for ducted installation, the current test procedure also does not include provisions for setup of ductwork for these components.

DOE has granted waivers from the test procedure in appendix C, to CellarPro, Air Innovations, Vinotheque, and Vinotemp, and an interim waiver to LRC Coil, for walk-ins marketed for use as wine cellar refrigeration systems.[17] Relevant to the present discussion of scope, the specific basic models for which waivers have been granted include equipment sold as ducted units.

In this final rule, DOE is revising the single-packaged dedicated system definition to clarify that such systems may have provisions for ducted installation. DOE is adding a definition for ''ducted fan coil unit,'' the ducted equivalent of a unit cooler, as discussed in section III.A.2.d of this document. In doing so, DOE preserves the industry standard definition of a unit cooler while expanding the scope of the test procedure to ducted units. DOE is also adding provisions in the test procedures to address setup of ductwork and the external static pressure that it imposes on refrigeration system fans—all to improve the representativeness of the test procedure for ducted units. These test procedure revisions are addressed in section III.G.6 of this document.

2. Definitions

a. Walk-In Cooler and Walk-In Freezer

DOE currently defines the term ''walk-in cooler and walk-in freezer'' as 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; however, the term does not include products designed and marketed exclusively for medical, scientific, or research purposes. 10 CFR 431.302. (*See also* 42 U.S.C. 6311(20))

To align the definition of walk-in cooler and walk-in freezer with the regulatory scheme adopted by DOE—which establishes separate test procedures and energy conservation standards for the principal components that make up a walk-in: panels, doors, and refrigeration systems—in the April 2022 NOPR, DOE proposed to amend the definition to specify that a walk-in may comprise these principal components. DOE requested comment on this proposed change. 87 FR 23920, 23928.

AHRI, Anthony, RSG, HTPG, KeepRite, Lennox, and National Refrigeration agreed with DOE's proposed changes to the definition of walk-in cooler and walk-in freezer. (AHRI, No. 30 at p. 2; Anthony, No. 31 at p. 1; RSG, No. 41 at p. 1; HTPG, No. 32 at p. 2; KeepRite, No. 36 at p. 1; Lennox, No. 35 at p. 2; National Refrigeration, No. 39 at p. 1) For the reasons discussed in the previous paragraph and the April 2022 NOPR, DOE is adopting the definition proposed in the April 2022 NOPR that ''walk-in cooler and walk-in freezer'' means an enclosed storage space, including but not limited to panels, doors, and refrigeration systems, 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; however, the terms do not include products designed and marketed exclusively for medical, scientific, or research purposes.

The Efficiency Advocates commented that refrigerated shipping containers should be within the scope of the walk-in test procedures. (Efficiency Advocates, No. 37 at p. 4) DOE notes that based on its initial research, neither the previous definition of walk-in cooler and walk-in freezer nor the amended definition adopted in this final rule would specifically exclude refrigerated shipping containers. However, DOE has not evaluated refrigerated shipping containers to determine if current walk-in test procedures would produce test results that reflect energy efficiency, energy use, or estimated operating costs during a representative average use cycle, without being unduly burdensome to conduct. Therefore, DOE has determined that refrigerated shipping containers are not currently subject to the DOE test procedure or energy conservation standards for WICFs. DOE may consider whether test procedures and energy conservation standards should be applied to refrigerated shipping containers in future rulemakings.

b. Doors

With respect to walk-ins, DOE defines a ''door'' as an assembly installed in an opening on an interior or exterior wall that is used to allow access or close off the opening and that is movable in a sliding, pivoting, hinged, or revolving manner of movement. For walk-in coolers and walk-in freezers, a door includes the door panel, glass, framing materials, door plug, mullions, and any other elements that form the door or part of its connection to the wall. 10 CFR 431.302.

(1) Door, Door Leaf, and Door Plug

In the April 2022 NOPR, DOE discussed that the current definition of ''door'' does not explicitly address that walk-in door assemblies may contain multiple door openings within one frame. 87 FR 23920, 23929. DOE also

[17] CellarPro Decision and Order, 86 FR 26496 (May 14, 2021); Air Innovations Decision and Order, 86 FR 23702 (May 4, 2021); Vinotheque Decision and Order, 86 FR 26504 (May 14, 2021); Vinotemp Decision and Order, 86 FR 36732 (July 13, 2021); LRC Coil Interim Waiver, 86 FR 47631 (Aug. 26, 2021).

noted that NFRC 100–2010 includes several defined terms relating to door components (*e.g.,* door leaf), which differ from the terms used in DOE's definition of ''door.'' *Id.* Additionally, certain stakeholders commented that they are unfamiliar with the term ''door plug,'' whereas others used it to describe different components of the door assembly. *Id.*[18]

In the April 2022 NOPR, DOE proposed to amend the definition of ''door'' to address doors with multiple openings within one frame, to include terminology that generally aligns with that used by the industry, and to remove use of the term ''door plug.'' *Id.* Specifically, DOE proposed to define ''door'' as an assembly installed in an opening on an interior or exterior wall that is used to allow access or close off the opening and that is movable in a sliding, pivoting, hinged, or revolving manner of movement. For walk-in coolers and walk-in freezers, a door includes the frame (including mullions), the door leaf or multiple door leaves (including glass) within the frame, and any other elements that form the assembly or part of its connection to the wall. DOE also proposed to define the term ''door leaf'' to mean the pivoting, rolling, sliding, or swinging portion of a door. *Id.*

Regarding the proposed definition of ''door,'' Senneca considered the proposed definition of ''door'' to refer to the door system (*i.e.,* includes the door leaf, frame, casings, header, tracks, and all necessary components and hardware). (Senneca, No. 26 at p. 1) AHRI commented that its members find DOE's current definition unclear and recommended that DOE not use what AHRI referred to as the ''single door'' interpretation. (AHRI, No. 30 at p. 2) DOE interprets AHRI's comment to mean that a door with multiple openings within a single frame should not be treated as a single basic model. DOE notes that the proposed definition of ''door'' is consistent with Senneca's understanding. Additionally, DOE notes that the proposed definition intends to clarify the definition of ''door'', particularly, that a ''door'' consists of a single frame and includes all parts of the door assembly attached to the single frame, including multiple door openings where applicable.

Anthony stated that the definition of ''door'' does not accurately reflect the use of the term ''door'' in the 2014 final rule engineering analysis spreadsheet.[19] (Anthony, No. 31 at pp. 1–3) Specifically, Anthony commented that when applying the same formula to a single door with multiple openings, there is a 20 to 30 percent reduction in energy allowance per door. *Id.* DOE notes that this comment refers to the representative units used to evaluate and adopt energy conservation standards in a final rule published on June 3, 2014 (79 FR 32050). DOE has determined that the representative units used in 2014 met the definition of ''door'' at the time of the analysis and would continue to meet the definition of ''door'' as amended by this final rule.—The amended definition of ''door'' adopted in this final rule provides additional clarity that a door contains a single frame with one or multiple door openings. Regarding the energy impacts of doors with multiple openings, DOE recommends that stakeholders provide feedback on the representative unit characteristics in response to the ongoing energy conservation standards rulemaking which is the appropriate venue to address such concerns (see docket EERE–2017–BT–STD–0009).

For the reasons discussed in the preceding paragraphs and the April 2022 NOPR, this final rule adopts the revised definition of ''door'' as proposed.

Bally agreed with the term ''door leaf'' and stated that the term as defined would be easily understood. (Bally, No. 40 at p. 1) AHRI stated that DOE's proposed definition of ''door leaf'' is clear. (AHRI, No. 30 at p. 2) Senneca commented that it considers ''door leaf'' to be a movable, insulated portion of the assembly. (Senneca, No. 26 at p. 10) DOE has concluded that Senneca's comment is consistent with the proposed definition of ''door leaf.'' This final rule adopts the definition of ''door leaf'' as proposed in the April 2022 NOPR. 87 FR 23920, 23929.

DOE did not receive any comments regarding its proposal to remove use of the term ''door plug.'' For the reasons discussed in the April 2022 NOPR, this final rule removes the term ''door plug'' as proposed. *Id.*

(2) Non-Display Door

DOE also proposed to define the term ''non-display door'' in the April 2022 NOPR. 87 FR 23920, 23930. Although the test procedures outlined in 10 CFR 431.304 and appendices A and B use the term ''non-display door,'' it is not currently defined. DOE proposed to define a ''non-display door'' as a door that is not a display door.[20]

In response to the April 2022 NOPR discussion of non-display doors, Hussmann stated that although its Heavy Duty Door products and ABC Beer Cave sliding door products are made largely of glass, it does not believe these doors meet the display door definition because they are designed to be used as passage doors (*i.e.,* passage of people). (Hussmann, No. 34 at p. 2) In response, DOE notes that the display door definition references the physical characteristics of the door (*i.e.,* the portion of surface area composed of glass or another transparent material), and is not contingent on door application. Any door(s) that meets this criteria is considered a display door, even those not necessarily designed for product display.

In this final rule, DOE is adopting the definition of ''non-display door'' as proposed in the April 2022 NOPR.

(3) Hinged Vertical Door, Roll-Up Door, and Sliding Door

In the April 2022 NOPR, DOE tentatively determined that differentiating walk-in doors based on opening characteristics would better align with industry terminology and proposed to define three terms to further differentiate all walk-in doors (including both display and non-display doors): ''hinged vertical door,'' ''roll-up door,'' and ''sliding door.'' 87 FR 23920, 23930.

DOE proposed to define ''hinged vertical door'' as a door with a door leaf (or leaves) with a hinge (or hinges) connecting one vertical edge of the door leaf (or leaves) to a frame or mullion of the door. This includes doors that swing open in one direction (*i.e.,* into or out of the walk-in) and free-swinging doors that open both into and out of the walk-in. 87 FR 23920, 23991.

DOE proposed to define ''roll-up door'' as a door that bi-directionally rolls open and closed in a vertical and horizontal manner and may include vertical jamb tracks. *Id.*

DOE proposed to define ''sliding door'' as a door having one or more manually operated or motorized door leaves within a common frame that slide horizontally or vertically. *Id.*

[18] In response to the June 2021 RFI, Anthony and AHRI stated that they were unfamiliar with the term ''door plug.'' (Anthony, No. 8 at pp. 1–2; AHRI, No. 11 at pp. 2–3) In response to the June 2021 RFI, Imperial Brown and Hussmann commented that they used the term ''door plug'' to describe different components of the door assembly. (Imperial Brown, No. 15 at p. 1; Hussmann, No. 18 at p. 3)

[19] Anthony is referring to the engineering analysis for display doors as part of the June 2014 ECS Final Rule, which can be found at *regulations.gov* under docket number EERE–2008–BT–STD–0015–0084.

[20] DOE defines ''display door'' as a door that (1) is designed for product display; or (2) has 75 percent or more of its surface area composed of glass or another transparent material. 10 CFR 431.302.

In the April 2022 NOPR, DOE requested feedback on the proposed definitions for ''hinged vertical door,'' ''roll-up door,'' and ''sliding door.'' *Id.* Senneca and AHRI agreed with DOE's proposed definitions. (Senneca, No. 26 at p. 1; AHRI, No. 30 at p. 2)

DOE recognizes that these definitions are not used in the adopted test procedure amendments. In the preliminary analysis for the walk-in standards energy conservation rulemaking, DOE stated that it was interested in differentiating its analysis by door opening characteristics. *See* page ES–36 of the preliminary analysis technical support document (EERE–2017–BT–STD–0009–0024). DOE is not adopting definitions for the terms ''hinged vertical door,'' ''roll-up door,'' and ''sliding door'' and will consider the potential adoption of these terms in the ongoing energy conservation standards rulemaking for WICFs.

As discussed in the April 2022 NOPR, DOE currently differentiates non-display doors by whether they are passage doors or freight doors. 87 FR 23920, 23929. A ''freight door'' is a door that is not a display door and is equal to or larger than 4 feet wide and 8 feet tall. 10 CFR 431.302. A ''passage door'' is a door that is not a freight or display door. *Id.* After reviewing comments submitted in response to the June 2021 RFI, DOE did not propose to amend the definition of freight door or passage door. DOE again received comments, however, on the definitions of freight and passage doors. 87 FR 23920, 23930.

Bally commented that specifying the way a door leaf is moved would not aid in defining a door nor clarify whether a non-display door is a passage or a freight door. (Bally, No. 40 at p. 1) Additionally, Bally disagreed with the current distinction of freight doors by size, stating that it manufactures doors with a width greater than or equal to 4 feet that are often the only door in the WICF; therefore, it considers these doors to be passage doors rather than freight doors. *Id.* Senneca stated that it views opening size as a determinant to whether a non-display door is designated as a passage or freight door and reiterated that a freight door has a width-in clear [21] (''WIC'') greater than or equal to 4 feet and a height-in-clear [22] (''HIC'') greater than or equal to 8 feet. (Senneca, No. 26 at p. 1)

DOE acknowledges that stakeholder comments demonstrate that factors other than size may be used to differentiate between a passage and freight door. However, DOE concludes that size is currently the most suitable way to differentiate between a passage door and a freight door. Therefore, DOE is not amending these definitions.

c. High-Temperature Refrigeration System

As mentioned previously, DOE has granted several manufacturers waivers and interim waivers from the current test procedure in appendix C for basic models of refrigeration systems marketed as wine cellar refrigeration systems (*see* section III.A.1.d of this document). These manufacturers stated that walk-ins used for wine storage are intended to operate at a temperature range of 45 to 65 °F and 50 to 70 percent relative humidity, rather than the 35 °F and less than 50 percent relative humidity test conditions prescribed in appendix C.

In the April 2022 NOPR, DOE proposed to define ''high-temperature refrigeration system'' as a walk-in refrigeration system that is not designed to operate below 45 °F. 87 FR 23920, 23930. DOE did not receive any feedback from stakeholders on the proposed definition; however, the CA IOUs commented that they support DOE including a test method for high-temperature unit coolers (CA IOUs, No. 42 at p. 6). DOE is adopting the definition for ''high-temperature refrigeration system'' as proposed in the April 2022 NOPR. Section III.G.6 provides further details of the corresponding test procedure provisions.

d. Ducted Fan Coil Unit and Ducted Single-Packaged Dedicated System

As discussed in the April 2022 NOPR, the definitions for single-packaged dedicated systems and unit coolers currently exclude ducted units. 87 FR 23920, 23931. As a part of the high-temperature refrigeration system waivers discussed in section III.A.2.c, DOE has granted waivers to Air Innovations, Vinotheque, CellarPro, and Vinotemp, and an interim waiver to LRC Coil, for walk-ins that are marketed as wine cellar refrigeration systems that are designed and marketed as ducted units.

To clarify that refrigeration systems with provision for ducted installation are included in the DOE test procedure, DOE proposed to adopt the new term ''ducted fan-coil unit,'' defined as an assembly including means for forced air circulation capable of moving air against both internal and non-zero external flow resistance and elements by which heat is transferred from air to refrigerant to cool the air, with provision for ducted installation. 87 FR 23920, 23931. DOE also proposed to revise the current ''single-packaged dedicated system'' definition to mean a refrigeration system (as defined in 10 CFR 431.302) that is a single-packaged assembly that includes one or more compressors, a condenser, a means for forced circulation of refrigerated air, and elements by which heat is transferred from air to refrigerant. *Id.*

In the April 2022 NOPR, DOE requested comment on its proposed definition for ''ducted fan coil unit'' and on the proposed modification to the definition of ''single-packaged dedicated system.'' *Id.* RSG agreed with the proposed definitions. (RSG, No. 41 at p. 1) AHRI and HTPG suggested separate definitions for ducted and non-ducted single-packaged dedicated systems. (AHRI, No. 30 at pp. 2–3; HTPG, No. 32 at p. 2)

After consideration of stakeholder comments, and to maintain consistency with industry terminology, DOE is adopting a separate definition for ''ducted single-packaged dedicated system'' that means a refrigeration system (as defined in 10 CFR 431.302) that is a single-packaged assembly designed for use with ducts, that includes one or more compressors, a condenser, a means for forced circulation of refrigerated air, and elements by which heat is transferred from air to refrigerant. As such, DOE is maintaining its current definition of a ''single-packaged dedicated system,'' and clarifying that it describes non-ducted units.

DOE received no feedback from stakeholders on the proposed definition for the new term ''ducted fan coil unit.'' DOE is adopting the definition for ''ducted fan coil unit'' as proposed in the April 2022 NOPR.

e. Multi-Circuit Single-Packaged Dedicated System

In the April 2022 NOPR, DOE proposed to define a ''multi-circuit single-packaged dedicated system'' as a single-packaged dedicated system (as defined in 10 CFR 431.302) that contains two or more refrigeration circuits that refrigerate a single stream of circulated air. DOE requested comment on this proposed definition. 87 FR 23920, 23931.

RSG agreed with the proposed definition. (RSG, No. 41 at p. 1) AHRI and HTPG suggested that the proposed definition is too specific and should be

[21] In their comment in response to the June 2021 RFI, Imperial Brown defined WIC as the clear opening width, typically from left frame jamb to right frame jamb. *See* EERE–2017–BT–TP–0010–0015 at p. 1.

[22] In their comment in response to the June 2021 RFI, Imperial Brown defined HIC as the clear opening height, typically from door sill to frame header. *See* EERE–2017–BT–TP–0010–0015 at p. 1.

broader. (AHRI, No. 30 at p. 3; HTPG, No. 32 at p. 3) However, AHRI and HTPG did not provide alternative definitions or other additional information that might support broadening the definition.

In this final rule, DOE is adopting the definition for ''multi-circuit single-packaged dedicated refrigeration system'' as proposed in the April 2022 NOPR.

As discussed in section III.A.2.d, DOE proposed to adopt the new term ''ducted fan-coil unit'' to clarify that refrigeration systems with provision for ducted installation are included in the DOE test procedure. 87 FR 23920, 23931. In response to the April 2022 NOPR, several stakeholders suggested creating separate definitions for ducted and non-ducted single-packaged dedicated systems. (AHRI, No. 30 at pp. 2–3; HTPG, No. 32 at p. 2) DOE's current definition for a ''single-packaged dedicated system'' applies only to non-ducted units. As discussed in section III.A.2.d, after consideration of stakeholder comments, and to maintain consistency with industry terminology, DOE is adopting a definition for ducted single-packaged dedicated systems Since ducted multi-circuit single-packaged dedicated systems are a derivative of ducted single-packaged dedicated systems, DOE is also defining ''ducted multi-circuit single-packaged dedicated systems'' to mean a ducted single-packaged dedicated system that contains two or more refrigeration circuits that refrigerate a single stream of circulated air. DOE believes these amendments are consistent with the intent of proposed changes in the April 2022 NOPR while being responsive to stakeholder feedback.

f. Attached Split System

As discussed in the April 2022 NOPR, DOE is aware of some refrigeration systems that are sold as matched pairs in which the dedicated condensing unit and unit cooler are permanently attached to each other with structural beams. 87 FR 23920, 23931. The DOE test procedure does not currently define such systems, nor does it provide any unique test provisions for them, thereby affecting the ability of manufacturers to provide test results reflecting the energy efficiency of this equipment during a representative average use cycle. DOE proposed to define ''attached split system'' as a matched-pair refrigeration system designed to be installed with the evaporator entirely inside the walk-in enclosure and the condenser entirely outside the walk-in enclosure, and the evaporator and condenser are permanently connected with structural members extending through the walk-in wall. *Id.*

In the April 2022 NOPR, DOE requested comment on the proposed definition for ''attached split system.'' *Id.* AHRI, HTPG, Hussmann, and Lennox agreed with the proposed definition. (AHRI, No. 30 at p. 3; HTPG, No. 32 at p. 3; Hussmann, No. 38 at p. 2; Lennox, No. 35 at p. 2)

In this final rule, DOE is adopting the proposed definition for ''attached split system.'' The provisions for testing such units are discussed in section III.G.4 of this document.

g. Detachable Single-Packaged System

As discussed in the April 2022 NOPR, DOE had tentatively determined that detachable single-packaged systems are a type of single-packaged dedicated system, and proposed to define ''detachable single-packaged system'' as a system consisting of a dedicated condensing unit and an insulated evaporator section in which the evaporator section is designed to be installed external to the walk-in enclosure and circulating air through the enclosure wall, and the condensing unit is designed to be installed either attached to the evaporator section or mounted remotely with a set of refrigerant lines connecting the two components. 87 FR 23920, 23931. The current DOE test procedure does not define such systems or provide testing provisions specific to this configuration.

In the April 2022 NOPR, DOE requested comment on the proposed definition for ''detachable single-packaged dedicated system.'' *Id.* AHRI, HTPG, Lennox, and RSG agreed with the proposed definition. (AHRI, No. 30 at p. 3; HTPG, No. 32 at p. 3; Lennox, No. 35 at p. 2; RSG, No. 41 at p. 1)

In this final rule, DOE is adopting the definition for ''detachable single-packaged dedicated system'' as proposed in the April 2022 NOPR.

h. CO_2 Unit Cooler

In the April 2022 NOPR, DOE proposed a test procedure for CO_2 unit coolers. 87 FR 23920, 23952. To clarify the scope of the proposed CO_2 unit cooler test procedure, DOE proposed to define a ''CO_2 unit cooler'' as one that includes a nameplate listing only CO_2 as an approved refrigerant. 87 FR 23920, 23932.

In the April 2022 NOPR, DOE requested comment on the proposed definition of CO_2 unit coolers. *Id.* AHRI, HTPG, Hussmann, Lennox, National Refrigeration, and RSG agreed with the proposed definition. (AHRI, No. 30 at p. 3; HTPG, No. 32 at p. 3; Hussmann, No. 38 at p. 2; Lennox, No. 35 at p. 2; National Refrigeration, No. 39 at p. 1; RSG, No. 41 at p. 1)

DOE also requested comment on whether any distinguishing features of CO_2 unit coolers exist that could reliably be used as an alternative approach to differentiate them from those unit coolers intended for use with conventional refrigerants. 87 FR 23920, 23932.

AHRI, HTPG, Lennox, and National Refrigeration all stated that they were not aware of any features that distinguish CO_2 unit coolers from those that use traditional refrigerants. (AHRI, No. 30 at p. 3; HTPG, No. 32 at p. 3; Lennox, No. 35 at p. 2; National Refrigeration, No. 39 at p. 1)

Given that stakeholders are not aware of any features that distinguish CO_2 unit coolers from those that use traditional refrigerants, this information must be provided on the unit in some way. Therefore, DOE is adopting the ''CO_2 unit cooler'' definition proposed in the April 2022 NOPR which requires a nameplate listing only CO_2 as an approved refrigerant for this equipment.

i. Hot Gas Defrost

In the April 2022 NOPR, DOE proposed that manufacturers of equipment with hot gas defrost installed at the factory may make market representations of performance with hot gas defrost activated, in addition to the current required calculation-based approach using default electric defrost parameters, and proposed a definition for ''hot gas defrost'' to clarify the scope of the voluntary representation. 87 FR 23920, 23932.

AHRI, HTPG, KeepRite, Lennox, National Refrigeration, and RSG all recommended changes to the definition as proposed. (AHRI, No. 30 at p. 3; HTPG, No. 32 at p. 3; KeepRite, No. 36 at p. 1; Lennox, No. 35 at p. 2; National Refrigeration, No. 39 at p. 1; RSG, No. 41 at p. 4) In particular, AHRI, HTPG, and Lennox stated that not all hot gas defrost systems are factory installed. (AHRI, No. 30 at pp. 3–4; HTPG, No. 32 at p. 3; Lennox, No. 35 at p. 2)

DOE intended for the voluntary hot gas defrost representation provisions proposed in the April 2022 NOPR to apply only to factory-installed hot gas defrost systems. 87 FR 23920, 23970. Considering the comments received, DOE recognizes that the proposed provisions would not apply to many hot gas defrost applications, thus negating the purpose and intent of DOE's proposal. Therefore, DOE has determined not to adopt provisions allowing representations of performance with hot gas defrost activated at this time and consequently is not adopting a definition for ''hot gas defrost.''

B. Updates to Industry Standards

The current DOE test procedures for walk-in coolers and freezers incorporate the following industry test standards: NFRC 100–2010 into appendix A; ASTM C518–04 into appendix B; and AHRI 1250–2009, AHRI 420–2008,[23] and ASHRAE 23.1–2010[24] into appendix C. The following sections discuss the industry standards DOE is incorporating by reference in this final rule and the relevant provisions of those industry standards that DOE is adopting.

1. Industry Standards for Determining Thermal Transmittance (U-Factor)

As discussed in the April 2022 NOPR, appendix A to subpart R of part 431 references NFRC 100–2010 as the method for determining the U-factor of doors and display panels, which references NFRC 102–2010. 87 FR 23920, 23932. NFRC has published updates to NFRC 102–2010, the most recent being NFRC 102–2020, which contains the following substantive changes from NFRC 102–2010:

1. Added a list of required calibrations for primary measurement equipment;

2. Added metering box wall transducer and surround panel flanking loss characterization and annual verification procedure;

3. Incorporated a calibration transfer standard continuous characterization procedure; and

4. Revised the provisions regarding air velocity distribution to be more specific to the type of fans used.

DOE proposed to adopt by reference in appendix A the following sections of NFRC 102–2020 in place of NFRC 100–2010 for determining U-factor:

- 2. Referenced Documents
- 3. Terminology
- 5. Apparatus
- 6. Calibration
- 7. Experimental Procedure (excluding 7.3. Test Conditions)
- 8. Calculation of Thermal Transmittance
- 9. Calculation of Standardized Thermal Transmittance
- Annex A1. Calibration Transfer Standard Design
- Annex A2. Radiation Heat Transfer Calculation Procedure
- Annex A4. Garage Panel and Rolling Door Installation

87 FR 23920, 23932.

DOE also proposed to incorporate by reference ASTM C1199–14, as it is referenced in NFRC 102–2020. Specifically, in the appendix A test procedure, DOE proposed to reference the following sections of ASTM C1199–14 as referenced through NFRC 102–2020: sections 2, 3, 5, 6, 7 (excluding 7.3), 8, 9, and annexes A1 and A2. DOE did not propose to reference any other sections of NFRC 102–2020 or ASTM C1199–14, as either they do not apply or they are in direct conflict with other test procedure provisions included in appendix A.

In this final rule, DOE is incorporating by reference NFRC 102–2020 and ASTM C1199–14 in appendix A as proposed in the April 2020 NOPR. DOE further discusses the reference to NFRC 102–2020 in place of NFRC 100–2010 and addresses stakeholder comments in section III.C.1 of this document.

2. Industry Standard for Determining R-Value

As discussed in the April 2022 NOPR, section 4.2 of appendix B to subpart R of part 431 references ASTM C518–04[25] to determine the thermal conductivity, or K-factor, of panel insulation. 87 FR 23920, 23932. ASTM published a revision of ASTM C518 in July 2017 (''ASTM C518–17''). *Id.*

In the April 2022 NOPR, DOE tentatively determined that the updates in ASTM C518–17 do not substantively change the test method and do not impact test burden compared to ASTM C518–04. Therefore, DOE proposed to amend its test procedure for determining insulation R-value for non-display doors and panels by incorporating by reference ASTM C518–17. Specifically, in the test procedure in appendix B, DOE proposed to reference the following sections of ASTM C518–17:

- 2. Referenced Documents
- 3. Terminology
- 5. Apparatus
- 6. Calibration
- 7. Test Procedures (excluding 7.3. Specimen Conditioning)
- 8. Calculation
- Annex A1. Equipment Design

87 FR 23920, 23933.

DOE did not propose to reference any other sections of ASTM C518–17, as either they do not apply or they are in direct conflict with other test procedure provisions included in appendix B. Because ASTM C518–17 is an updated version of ASTM C518–04, DOE stated in the April 2022 NOPR that the test procedure for determining the K-factor would effectively remain based on ASTM C518–04 as specified by EPCA (42 U.S.C. 6314(a)(9)(A)(ii)).

In response to the April 2022 NOPR, Anthony supported the proposal to reference the latest version of the industry test procedure, ASTM C518–17. (Anthony, No. 31 at p. 3)

In this final rule, DOE is incorporating by reference the sections of ASTM C518–17 as proposed in the April 2022 NOPR.

3. Industry Standards for Determining AWEF

DOE's current test procedure for WICF refrigeration systems is codified in appendix C to subpart R of part 431 and incorporates by reference AHRI 1250–2009, AHRI 420–2008, and ASHRAE 23.1–2010. AHRI 1250–2009 is the industry test standard for walk-in cooler and freezer refrigeration systems, including unit coolers and dedicated condensing units sold separately, as well as matched pairs. 81 FR 95758, 95798.[26] The procedure describes the method for measuring the refrigeration capacity and the electrical energy consumption for a condensing unit and a unit cooler, including off-cycle fan and defrost subsystem contributions. Using the refrigeration capacity and electrical energy consumption, AHRI 1250–2009 provides a calculation methodology to compute AWEF, the applicable energy performance metric for refrigeration systems.

The DOE test procedure for walk-in refrigeration systems incorporates by reference the test procedure in AHRI 1250–2009 (excluding Tables 15 and 16), with certain enumerated modifications. *See* appendix C to subpart R of part 431.

In April 2020, AHRI published AHRI 1250–2020, which incorporates many of the modifications and additions to AHRI 1250–2009 that DOE currently prescribes in its test procedure at appendix C. It also includes test methods for unit coolers and dedicated condensing units tested alone, rather than incorporating by reference updated versions of AHRI 420–2008 and/or ASHRAE 23.1–2010. AHRI 1250–2020 also includes test methods for single-packaged dedicated systems.

The following sections discuss the amendments being adopted in appendix

[23] AHRI 420–2008, ''Performance Rating of Forced-Circulation Free-Delivery Unit Coolers for Refrigeration'' (''AHRI 420–2008'').

[24] ANSI/ASHRAE 23.1–2010, ''Methods of Testing for Rating the Performance of Positive Displacement Refrigerant Compressors and Condensing Units that Operate at Subcritical Temperatures of the Refrigerant'' (''ASHRAE 23.1–2010'').

[25] ASTM C518–04 is the version of the industry test procedure specified by EPCA as the basis for calculating the K-factor.

[26] Available at *www.ahrinet.org.*

C and appendix C1 with respect to the aforementioned industry test methods.

a. Appendix C

In the April 2022 NOPR, DOE proposed minor modifications to appendix C that improve test procedure accuracy and repeatability, while maintaining equivalent measurements of AWEF. 87 FR 23920, 23933. As discussed further in the section that follows, DOE also proposed to establish a new appendix C1 to subpart R that would incorporate substantive changes that would result in different measured values of efficiency, AWEF2, compared to appendix C. DOE proposed that the use of appendix C with the proposed amendments would be required 180 days after this test procedure final rule is published and would remain required for use until the compliance date of any future amended energy conservation standards based on appendix C1.

Within appendix C, DOE proposed to maintain reference to AHRI 1250–2009. DOE proposed to adopt certain instrument accuracy and test tolerances from AHRI 1250–2020 that would not change the measured AWEF value, as discussed further in section III.F.5 of this document.

DOE received no comments on its proposal to maintain appendix C, with modification, until the compliance date of any future amended energy conservation standards based on appendix C1.

In this final rule, DOE maintains the required use of appendix C, as amended by this final rule, including the incorporation by reference of AHRI 1250–2009, until the compliance date of any future amended energy conservation standards based on appendix C1.

b. Appendix C1

As discussed, in the April 2022 NOPR, DOE proposed to establish a new appendix C1 to subpart R that incorporates by reference AHRI 1250–2020. 87 FR 23920, 23933. DOE tentatively determined that the changes proposed in appendix C1 through the incorporation of AHRI 1250–2020 would increase the representativeness of the DOE test procedure for walk-ins. DOE also tentatively determined that several of the changes in AHRI 1250–2020 would change the measured AWEF value. These changes can be grouped into five categories: off-cycle tests, single-packaged dedicated systems, defrost calculations, variable capacity, and default unit cooler parameters. These changes and the comments received on these proposed changes are discussed in detail in section III.G. Since these changes would result in a change to measured AWEF, DOE proposed to establish a new metric called ''AWEF2.''

In the April 2022 NOPR, DOE proposed to incorporate AHRI 1250–2020 for use in appendix C1, with the following exclusions:

- Section 1 Purpose
- Section 2 Scope
- Section 9 Minimum Data Requirements for Published Ratings
- Section 10 Marking and Nameplate Data
- Section 11 Conformance Conditions
- Section C10.2.1.1 Test Room Conditioning Equipment under section C10—Defrost Calculation and Test Methods

87 FR 23920, 23933.

DOE proposed to exclude these sections of AHRI 1250–2020 because they either do not apply or conflict with other test procedure provisions included in appendix C1.

Further, DOE proposed to reference ASHRAE 16–2016 in appendix C1, as it is referenced in AHRI 1250–2020, with the following exclusions:

- Section 1 Purpose
- Section 2 Scope
- Section 4 Classifications
- Normative Appendices E–M
- Informative Appendices N–R

87 FR 23920, 23934.

DOE did not propose to reference these sections of ASHRAE 16–2016, as either they do not apply or they conflict with other test procedure provisions that are included as part of appendix C1.

Similarly, DOE proposed to reference ASHRAE 37–2009 in appendix C1, as it is referenced in AHRI 1250–2020, with the following exclusions:

- Section 1 Purpose
- Section 2 Scope
- Section 4 Classifications
- Informative Appendix A Classifications of Unitary Air-conditioners and Heat Pumps

Id.

DOE did not propose to reference these sections of ASHRAE 37–2009, as either they do not apply, or they conflict with other test procedure provisions that are included as part of appendix C1.

As discussed in the April 2022 NOPR, AHRI 1250–2020 incorporates many of the modifications and additions to AHRI 1250–2009 that DOE currently prescribes in its appendix C test procedure. *Id.* Since DOE proposed to adopt AHRI 1250–2020, DOE did not propose to carry over the sections listed in Table III.1 from appendix C to appendix C1.

TABLE III.1—LIST OF SECTIONS IN APPENDIX C NOT PROPOSED TO BE INCLUDED IN APPENDIX C1

Appendix C	Summary
Section 3.1.1	Modifies Table 1 (Instrumentation Accuracy) in AHRI 1250–2009.
Section 3.1.2	Provides guidance on electrical power frequency tolerances.
Section 3.1.3	States that in Table 2 of AHRI 1250–2009, the test operating tolerances and test condition tolerances for air leaving temperatures shall be deleted.
Section 3.1.4	States that in Tables 2 through 14 in AHRI 1250–2009, the test condition outdoor wet-bulb temperature requirement and its associated tolerance apply only to units with evaporative cooling.
Section 3.1.5	Provides tables to use in place of AHRI 1250–2009 Tables 15 and 16, which are excluded from the reference in 10 CFR 431.303.
Section 3.2.1	Provides specific guidance on how to measure refrigerant temperature.
Section 3.2.2	Removes the requirement to perform a refrigerant composition and oil concentration analysis.
Section 3.2.5	Provides insulation and configuration requirements for liquid and suction lines used for testing.
Section 3.3.1	Gives direction for how to test and rate unit coolers tested alone.
Section 3.3.2	Clarifies that the 2008 version of AHRI Standard 420 should be used for unit coolers tested alone.
Section 3.3.3	Modifies the allowable reduction in fan speed for off-cycle evaporator testing.
Section 3.4.1	Specifies that the 2010 version of ASHRAE 23.1 should be used and that ''suction A'' condition test points should be used when testing dedicated condensing units.
Section 3.4.2	Provides instruction on how to calculate AWEF and net capacity for dedicated condensing units.
Section 3.5	Provides guidance on how to rate refrigeration systems with hot gas defrost.

AHRI 1250–2020 does not incorporate all the modifications and additions to AHRI 1250–2009 that DOE currently prescribes in its test procedure. Therefore, DOE proposed that the modifications in sections 3.2.3, 3.3.4, 3.3.5, and 3.3.7 of appendix C be incorporated into appendix C1.

In response to the April 2022 NOPR, DOE received several general comments about the incorporation of AHRI 1250–2020 for use in appendix C1. AHRI and National Refrigeration commented that they disagreed with DOE aligning appendix C1 with AHRI 1250–2020 and requested further clarification on the proposal. (AHRI, No. 30 at p. 7; National Refrigeration, No. 39 at p. 2) Neither AHRI nor National Refrigeration provided detail about what specifically they disagreed with, or which aspects of DOE's proposal required further clarification.

In response to the April 2022 NOPR, HTPG requested details on the changes in the new appendix C1 that may impact the determination of AWEF for unit coolers and variable-capacity systems. (HTPG, No. 32 at p. 2) These topics are discussed in detail in sections III.G.7 and III.G.11 of this document, respectively.

As discussed in this section and in more detail in section III.G, DOE has concluded that the changes in AHRI 1250–2020 improve the representativeness of the walk-in refrigeration systems test procedure. Therefore, DOE is incorporating AHRI 1250–2020, ASHRAE 37–2009, ASHRAE 16–2016 for use in appendix C1 as proposed in the April 2022 NOPR.

c. Additional Amendments

AHRI 1250–2020 includes additional amendments that are inconsistent with AHRI 1250–2009 but are either not referenced in the DOE test procedure or serve to make aspects of the test procedure more explicit or clear. None of these changes impact measured AWEF. These additional amendments are discussed in the paragraphs below.

AHRI 1250–2020 added exclusions for liquid-cooled condensing systems in section 2.2.4 and excludes systems that use carbon dioxide, glycol, or ammonia as refrigerants in section 2.2.5. As mentioned previously, DOE is not incorporating section 2 of AHRI 1250–2020 into appendix C1.

AHRI 1250–2020 includes an updated list of references and the applicable versions of certain test standards in appendix A, ''References—Normative.'' DOE does not expect these changes to impact measured AWEF apart from ways discussed in section III.G. AHRI 1250–2020 added specifications for refrigerant temperature measurement locations for unit coolers tested alone, matched pairs, and dedicated condensing systems tested alone in sections C3.1.3.1, C3.1.3.2, and C3.1.3.3. DOE has determined that these specifications will not affect measured AWEF.

AHRI 1250–2020 revised section C7.5.1 to provide more detailed instructions for calculating system capacity beginning with measured temperatures and pressures instead of calculated enthalpies, which is what was done in AHRI 1250–2009. Section C7.5.1 also includes the determination of capacity from enthalpy calculation results. The addition of these sections provides clarity and further instruction but does not affect measured AWEF.

AHRI 1250–2009 included section C12, ''Method of Testing Condensing Units for Walk-in Cooler and Freezer Systems for Use in Mix-Match System Ratings,'' which referenced ASHRAE 23.1–2010. AHRI 1250–2020 now provides specific methods for testing dedicated condensing units tested alone. DOE has determined that the test procedure incorporated into AHRI 1250–2020 is the same as that in ASHRAE 23.1–2010 and therefore does not impact measured AWEF.

Section C13 of AHRI 1250–2009, ''Method of Testing Unit Coolers for Walk-in Cooler and Freezer Systems for Use in Mix-Match System Ratings,'' referenced AHRI 420–2008. AHRI 1250–2020 no longer references AHRI 420–2008 and instead outlines a method for unit coolers tested alone. DOE has determined that the test procedure incorporated into AHRI 1250–2020 is the same as that in ASHRAE AHRI 420–2008 and therefore does not impact measured AWEF. As a result, DOE is not incorporating by reference AHRI 420–2008 in new appendix C1.

C. Amendments to Appendix A for Doors

Appendix A provides test procedures for measuring walk-in envelope component energy consumption. Specifically, appendix A provides the test procedures to determine the U-factor, conduction load, and energy use of walk-in display panels and to determine the energy use of walk-in display doors and non-display doors (*see* section III.D for discussion of display panels).

In the April 2022 NOPR, DOE proposed several changes to appendix A specific to display doors and non-display doors. 87 FR 23920, 23936–23943. DOE determined that these changes would improve test representativeness and repeatability. DOE stated in the April 2022 NOPR that it did not expect the changes it proposed to have a substantive impact on measured energy consumption calculations for display doors or non-display doors, except in the case of testing doors with motors.

The following sections describe the modifications that DOE proposed to appendix A with respect to walk-in display and non-display doors.

1. Reference to NFRC 102–2020 in Place of NFRC 100–2010 and Alternative Efficiency Determination Methods for Doors

a. NFRC 102–2020 in Place of NFRC 100–2010

Appendix A references NFRC 100–2010 as the method for determining the U-factor of doors and display panels. NFRC 100–2010 allows for computational determination of U-factor by simulating U-factor using Lawrence Berkeley National Lab's (LBNL) WINDOW and THERM software, provided that the simulated value for the baseline product in a product line is validated with a physical test of that baseline product and the simulated value is within the accepted agreement with the physical test value as specified in section 4.7.1 of NFRC 100–2010.[27]

As discussed in the April 2022 NOPR, DOE is aware there has been limited success using the computational method in NFRC 100–2010 to simulate U-factors of non-display doors. 87 FR 23920, 23936–23937. Thus, DOE proposed to remove reference to NFRC 100–2010 (*i.e.,* the computational method) and instead reference NFRC 102–2020 (*i.e.,* the physical test method) for determining U-factor. *Id.* Consistent with that proposal, and with stakeholder concerns regarding test burden given the highly customizable nature of the walk-in door market, DOE also proposed to allow use of alternative efficiency determination methods (AEDMs) to determine the represented value of energy consumption of walk-in doors at 10 CFR 429.53(a)(3). 87 FR 23920, 23972.

In response, Bally stated that it looks forward to using AEDMs to rate its walk-in doors. (Bally, No. 40 at p. 5) RSG also agreed with the proposal to allow for AEDMs. (RSG, No. 41 at p. 2)

[27] Section 4.7.1 of NFRC 100–2010 requires that the accepted difference between the tested U-factor and the simulated U-factor be (a) 0.03 Btu/(h-ft^2-°F) for simulated U-factors that are 0.3 Btu/(h-ft^2-°F) or less, or (b) 10 percent of the simulated U-factor for simulated U-factors greater than 0.3 Btu/(h-ft^2-°F). This agreement must match for the baseline product in a product line. Per NFRC 100, the baseline product is the individual product selected for validation; it is not synonymous with ''basic model'' as defined in 10 CFR 431.302.

Hussmann noted that, although it is ''not pleased'' with the current NFRC 100–2010 test method, it does not support use of an AEDM because it believes rating with an AEDM creates an opportunity for ''approved non-compliance.'' (Hussmann, No. 34 at pp. 3–4)

DOE acknowledges Hussmann's concern but notes that rating a basic model with an AEDM does not excuse a manufacturer from complying with the relevant energy conservation standards. DOE has several requirements pertaining to AEDM records retention; the ability to provide analyses, conduct simulations, or conduct certification testing of basic models rated with the AEDM at DOE's request; and verification testing of an AEDM by DOE. These requirements can be found in 10 CFR 429.70(f)(3) through (5). DOE enforces all these requirements.

DOE notes that despite the limited success historically with using the computational method in NFRC 100–2010, to the extent that manufacturers have successfully used the simulation method in NFRC 100–2010 to produce accurate results, such results would be acceptable as an AEDM. AEDMs and the specific provisions DOE is adopting pertaining to AEDMs for doors are explained and discussed in the following section.

b. Alternative Efficiency Determination Methods for Doors

Pursuant to the requirements of 10 CFR 429.70, DOE may permit use of an AEDM in lieu of testing equipment for which testing burden may be considerable and for which that equipment's energy efficiency performance may be well predicted by such alternative methods. Although specific requirements vary by product or equipment, use of an AEDM entails development of a mathematical model that estimates energy efficiency or energy consumption characteristics of the basic model, as would be measured by the applicable DOE test procedure. The AEDM must be based on engineering or statistical analysis, computer simulation or modeling, or other analytic evaluation of performance data. A manufacturer must perform validation of an AEDM by demonstrating that the performance, as predicted by the AEDM, agrees with the performance as measured by actual testing in accordance with the applicable DOE test procedure. The validation procedure and requirements, including the statistical tolerance, number of basic models, and number of units tested vary by product or equipment.

Once developed and validated, an AEDM may be used to rate and certify the performance of untested basic models in lieu of physical testing. Use of an AEDM for any basic model is always at the option of the manufacturer. One potential advantage of AEDM use is that it may free a manufacturer from the burden of physical testing. One potential risk is that the AEDM may not perfectly predict performance, and the manufacturer could be found responsible for having an invalid rating for the equipment in question or for having distributed a noncompliant basic model. The manufacturer, by using an AEDM, bears the responsibility and risk of the validity of the ratings.

For walk-ins, DOE currently permits the use of AEDMs for refrigeration systems only. 10 CFR 429.70(f). As discussed previously, DOE proposed to allow the use of AEDMs for rating walk-in doors in the April 2022 NOPR. 87 FR 23920, 23972. Concurrent with this proposal, DOE proposed a number of provisions specific to the validation and use of an AEDM. First, DOE proposed to include walk-in door validation classes at 10 CFR 429.70(f)(2)(iv) and to require that two basic models per validation class be tested using the proposed test procedure in appendix A, which is consistent with the number of basic models required to be tested per validation class for walk-in refrigeration systems. *Id.*

Second, DOE proposed to include a 5 percent individual model tolerance, which aligns with the individual model tolerance applicable to walk-in refrigeration systems, to validate the measured energy consumption result of an AEDM with the appendix A test result at 10 CFR 429.70(f)(2)(ii). *Id.* The individual model tolerance is used to validate the AEDM. This means that when validating the AEDM for use, the predicted daily energy consumption for each model calculated by applying the AEDM may not be more than 5 percent less than the daily energy consumption determined from the corresponding test of the model.

DOE also proposed that an AEDM for doors can only simulate or model characteristics of the door that are required to be tested by the DOE test procedure—*i.e.,* for the doors test procedure, the AEDM would be used to simulate or model the U-factor, which is the only part of the appendix A test procedure that is not a calculation. The AEDM cannot be used to simulate or model the energy consumption due to conduction thermal load, or the direct and indirect electrical energy consumption of electricity-consuming devices sited on the door—those must be calculated using the appendix A test procedure. However, when validating the AEDM, the comparison between a door that has been physically tested versus a door that has been modeled or simulated must be done using the complete metric (*i.e.,* total daily energy consumption). In other words, the AEDM can only be used to determine the U-factor, but the total daily energy consumption using an AEDM must be carried out using the calculations in appendix A for the energy consumption due to conduction thermal load, and the direct and indirect electrical energy consumption. Then, the validation of an AEDM would compare the energy consumption calculated using a simulated U-factor with the energy consumption calculated using a tested U-factor.

Lastly, DOE proposed to include a 5 percent tolerance applicable to the maximum daily energy consumption metric for AEDM verification testing conducted by DOE at 10 CFR 429.70(f)(5)(vi), which aligns with the tolerance applicable to AWEF of walk-in refrigeration systems. *Id.* DOE may randomly select and test a single unit of a basic model to assess whether a basic model is in compliance with the applicable energy conservation standards pursuant to 10 CFR 429.104, which extends to all DOE covered products and equipment, including those certified using an AEDM. As part of the AEDM requirements, DOE may use the test data from an assessment test for a given model to verify the certified rating determined by an AEDM. This is called verification testing. *See* 10 CFR 429.70(f)(5). For doors using an energy consumption metric, the result from a DOE verification test must be less than or equal to the certified rating multiplied by (1 plus the applicable tolerance); *i.e.,* the DOE verification test result must be less than or equal to 105 percent of the certified rating.

In the April 2022 NOPR, DOE requested comment on the specific proposals pertaining to the validation and use of AEDMs for doors. *Id.* RSG agreed with the proposals. (RSG, No. 41 at p. 2)

Anthony disagreed with DOE removing the reference to NFRC 100–2010 for NFRC 102–2020 and allowing AEDMs because it believes an AEDM would require more testing and result in an increased financial and physical burden on manufacturers without achieving an additional energy benefit. (Anthony, No. 31 at pp. 3, 8–9) Additionally, Anthony stated that if NFRC 100–2010 is able to be used as an AEDM, the application of the 5 percent tolerance on the energy consumption metric, E_{dd}, would conflict with the NFRC 100–2010 standard without achieving an additional energy benefit. *Id.* AHRI commented that the AEDM strategy with respect to U-factor is unclear and requested clarification of what the proposed 5 percent model tolerance applies to. (AHRI, No. 30 at p. 11)

DOE is clarifying that to use an AEDM, the manufacturer must first validate the AEDM. To validate the AEDM, the manufacturer must select at least the minimum number of basic models for each validation class (specified in table 1 to 10 CFR 429.70(f)(2)(iv)(A)) and physically test a single unit of each basic model. Thus, for a single validation class, where DOE proposed two basic models be tested per validation class, only two physical tests would be required, although more testing may be conducted at the manufacturer's discretion. The manufacturer would be required to conduct the physical U-factor tests according to NFRC 102–2020 referenced by appendix A and carry out the energy consumption calculations as done in appendix A. For the AEDM, the manufacturer would model or simulate the U-factor using a method of their choice, and then carry out the energy consumption calculations as done for the physical test, only deviating by using the simulated U-factor in the calculations. All other parts of the energy consumption calculations shall be done according to appendix A and may not be modeled. To validate the AEDM, the energy consumption output using the physical test must be compared with the energy consumption output using the AEDM for each basic model used for validation. If the output using the AEDM is lower than the physical test output by more than the individual model tolerance (*i.e.,* 5 percent), then the AEDM is not valid. If the output using the AEDM is greater than or equal to 95 percent of the output using physical testing and meets the standard for at least two basic models, then the AEDM has been validated for that validation class.

To illustrate the minimum number of physical tests required, consider an example of a display door manufacturer that produces models in two validation classes: medium-temperature and low-temperature. This manufacturer would need to, at a minimum, physically test the U-factor and calculate the energy consumption of two basic models per validation class, thus requiring a total of four physical tests: two for the medium-temperature display door validation class and two for the low-temperature display door validation class. The manufacturer would use the U-factor test results to calculate the total daily energy consumption each door. Then, the manufacturer would use their AEDM to model or simulate the U-factor of each door and calculate each door's total daily energy consumption. Each basic model's simulated and tested total daily energy consumption results would be compared using the tolerance of 5 percent in order to validate the AEDM. DOE stresses that this 5 percent tolerance used to validate the AEDM would only apply to the comparison of tested and simulated energy consumption for the minimum number of models physically tested for validation of the AEDM. If the AEDM is validated, the manufacturer could then use the AEDM to rate the remainder of the basic models it manufacturers in those validation classes. The 5 percent tolerance would not be used for any models simulated without a physical test because the AEDM was validated and thus no physical test would be further required.

DOE emphasizes that allowing use of an AEDM would provide manufacturers with the flexibility to use an alternative method (*i.e.,* besides NFRC 100–2010) that yields the best agreement with a physical test for their doors. Additionally, DOE notes that the change in test burden associated with the use of an AEDM is dependent on a manufacturer's product offerings. If a manufacturer does not have success with NFRC 100–2010 and is currently required to physically test all basic models, the AEDM option may reduce the test burden by requiring only two basic models per validation class to be tested. DOE is aware there has been limited success using the computational method in NFRC 100–2010 to simulate U-factors of non-display doors. Therefore, DOE expects a reduction of test burden across the industry since allowing AEDMs generally provides manufacturers, particularly those that manufacture non-display doors, the flexibility to use an alternate method that works best for them and meets the AEDM criteria established by DOE. However, if a manufacturer currently has success using NFRC 100–2010, there could be an increase in test burden, but only if the manufacturer currently validates the use of the simulation method with less than two basic models per validation class. Test burden and costs are discussed further in section III.K.1 of this document. The inclusion of AEDM provisions would enable manufacturers to continue using NFRC 100–2010, provided that manufacturers meet the AEDM requirements in 10 CFR 429.53 and 429.70(f). Therefore, DOE is removing reference to NFRC 100–2010 from its test procedure and is instead referencing NFRC 102–2020 and adopting provisions that allow manufacturers to use an AEDM, as proposed in the April 2022 NOPR.

c. Exceptions to the Industry Test Method for Determining U-Factor

Section 5.3 of appendix A references NFRC 100–2010 for determining U-factor, and section 5.3(a) of appendix A specifies four exceptions to that industry standard. The first exception implements a tolerance on the surface heat transfer coefficients (no such tolerance is specified in NFRC 100–2010); specifically, that the average surface heat transfer coefficients during a test must be within ± 5 percent of the values specified through NFRC 100–2010 in ASTM C1199. The second and third exceptions modify the cold and warm-side conditions from the standard conditions prescribed in NFRC 100–2010. The fourth exception specifies the direct solar irradiance be 0 Btu/(h-ft^2).

Sections 6.2.3 and 6.2.4 of ASTM C1199 specify the standardized heat transfer coefficients and their tolerances as part of the procedure to set the surface heat transfer conditions of the test facility using the Calibration Transfer Standard (''CTS'') test. The warm-side surface heat transfer coefficient must be within ± 5 percent of the standardized warm-side value of 1.36 Btu/(h-ft^2-°F), and the cold-side surface heat transfer coefficient must be within ± 10 percent of the standardized cold-side value of 5.3 Btu/(h-ft^2-°F) during the CTS test (ASTM C1199, sections 6.2.3 and 6.2.4). ASTM C1199 does not require that the measured surface heat transfer coefficients match or be within a certain tolerance of standardized values during the official sample test—although test facility operational (*e.g.,* cold-side fan settings) conditions would remain identical to those set during the CTS test. ASTM C1199 also does not require measurement of the warm-side surface temperature of the door. Rather, this value is calculated based on the radiative and convective heat flows from the test specimen's surface to the surroundings, which are driven by values determined from the calibration of the hot box using the CTS test (*e.g.,* the convection coefficient). *See* ASTM C1199, section 9.2.1.

As discussed in the April 2022 NOPR, DOE has found that obtaining the standardized heat transfer values within the ± 5 percent tolerance specified in section 5.3(a)(1) of appendix A on the warm side and cold side may not be achievable depending on the thermal transmittance through the door. 87 FR 23920, 23937. In the April 2022 NOPR, DOE proposed to remove the exceptions specified in section 5.3(a)(1) of appendix A regarding the surface heat transfer coefficients and the tolerances on them during testing.

DOE did not receive any comments on its proposal to remove the exceptions specified in section 5.3(a)(1) of appendix A.

For the reasons discussed in the preceding paragraphs and the April 2022 NOPR, DOE is removing the exceptions listed in section 5.3(a)(1) of appendix A regarding the surface heat transfer coefficients and the tolerances on them during testing. 87 FR 23920, 23937–23938. By removing these exceptions, the requirements pertaining to the surface heat transfer coefficients would apply as they are specified in the referenced industry standards.

Relatedly, Anthony commented on the specific values used to define the surface heat transfer coefficients. Specifically, Anthony commented that it disagrees with the current surface heat transfer coefficient applied to the cold side during testing and simulation of U-factors for display doors. (Anthony, No. 31 at pp. 4–5) Anthony presented data from field testing at several different public locations showing that the actual measured wind speed is on average 84 percent less than specified in NFRC 102–2020 and NFRC 100–2010, as well as a measured wind speed from their test cell showing an average of 1.1 miles per hour (''mph''). Anthony recommended that DOE adopt a cold-side heat transfer coefficient corresponding to a conservative wind speed value of 5 mph. *Id.*

DOE notes that deviating from the existing surface heat transfer coefficients would require test labs to change their test chamber calibration procedures and would require manufacturers to retest and rerate all envelope components subject to the energy consumption test procedure in appendix A. DOE has evaluated the data and information provided by Anthony but is unable to establish at this time whether such changes to the heat transfer coefficient would be nationally representative, nor the extent to which any such improvement in representativeness of the test result would outweigh the test burden associated with changing the heat transfer coefficient value. DOE has therefore determined it is not appropriate to amend the heat transfer coefficients in this final rule.

Additionally, section 5.3(a)(1) of appendix A currently specifies a direct solar irradiance [28] of 0 Btu/h-ft^2. Consistent with DOE's removal of its reference to NFRC 100–2010, DOE is removing the requirement of direct solar irradiance of 0 Btu/h-ft^2 in section 5.3(a)(4) of appendix A. DOE received no comment on solar irradiance in response to the April 2022 NOPR and notes that the removal of this requirement would not affect measured values. 87 FR 23920, 23938.

2. Additional Definitions

a. Surface Area for Determining Compliance With Standards

Surface area of a door is used in two ways in the regulations at subpart R of 10 CFR431: (1) to convert the tested U-factor of the door into a conduction load as part of the energy consumption test procedure, and (2) to determine compliance with the maximum energy consumption standards. As currently defined in section 3.4 of appendix A, 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. The definition does not provide detail on how to determine the boundaries of the walk-in door from which height and width are determined to calculate surface area. Additionally, the definition does not specify if these measurements are to be strictly in-plane with the surface of the wall or panel that the walk-in door would be affixed to, or if troughs and other design features on the exterior surface of the walk-in door should be included in the measured surface area.

In the April 2022 NOPR, DOE proposed that the surface area bounds of both display doors and non-display doors be the outer edge of the frame. 87 FR 23920, 23939. DOE proposed to change the term from ''surface area'' to ''door surface area,'' and to define the term as meaning the product of the height and width of a walk-in door measured external to the walk-in. *Id.* Under this definition, the height and width dimensions would be perpendicular to each other and parallel to the wall or panel of the walk-in to which the door is affixed, the height and width measurements would extend to the edge of the frame and frame flange (as applicable) to which the door leaf is affixed, and the surface area of a display door and non-display door would be represented as A_{dd} and A_{nd}, respectively.

[28] Solar irradiance is the power per unit area received from the sun in the form of electromagnetic radiation.

In addition, DOE proposed to move the defined term from the test procedure in appendix A to the definition section in 10 CFR 431.302 with the other definitions that are broadly applicable to subpart R. *Id.* DOE proposed this move because, as revised and in light of the following section III.C.2.b of this document, this term would no longer be used to convert the tested U-factor of the door into a conduction load as part of the energy consumption test procedure and is only relevant for determining compliance with the energy conservation standards. *Id.*

Anthony agreed with the proposed revision of using the external frame dimensions, which includes the flange, for determining A_{dd} and for determining the maximum energy consumption standard. (Anthony, No. 31 at p. 5)

Bally suggested that the surface area definition should include electrical conduit and pressure relief vents, not pieces of the door with low conductivity. (Bally, No. 40 at pp. 1–2) Bally also commented that it disagrees with DOE's discussion in the April 2022 NOPR that if the surface area of a door is measured without the frame, then it should be considered a panel. (*Id.*) Senneca stated that the outside dimensions of the frame should not be included in the surface area measurement because the frame mounts directly to the insulated panel and, therefore, the backside of the frame is not exposed directly to the cold-side temperature. (Senneca, No. 26 at p. 2) Additionally, Senneca described that a door with a longer track would require a longer frame and therefore would have a larger surface area; however, it stated that the larger frame would have no bearing on the energy consumption because, as mentioned, the backside of the frame is not exposed directly to the cold-side temperature. (*Id.*)

Senneca also stated that with the proposal for the door frame to be included in the surface area, it believes there is ambiguity in measuring sliding doors that have a track extending past the door frame. (*Id.*) DOE has considered Senneca's comment specific to sliding doors and acknowledges that the track of a horizontal sliding door may extend significantly beyond the width of the door leaf and door frame or casings and attach to the panels adjacent to the door, which would result in a significant increase in ''door surface area'' if the track width were to be included in the area measurement. Therefore, DOE has concluded that the portion of the track that extends beyond the external width (for a horizontal sliding door) or external height (for a vertical sliding door) of the door leaf or leaves and its frame or casings should be excluded from the surface area measurement used to determine compliance with the standards. DOE notes that given the equipment it is aware of on the market, this additional instruction will likely only impact the bounds of sliding non-display doors. DOE notes that sliding display doors typically have tracks that are integrated completely into the frame of the entire door system, thus the entire track is expected to be included in the determination of surface area.

DOE has considered stakeholder opposition to including the frame in the door surface area measurement but has determined that the definition of ''door'' includes the frame for consistent comparison across door products offered. DOE recognizes that non-display doors may have variations in the frames used, where some look similar to panels but tend to have electrical components wired through them, while others look more like casings used in replacement installations. DOE also recognizes that non-display doors may have variations in the installation of doors, where parts of the door frame may or may not be in direct contact with the cold side of the walk-in. However, DOE intends to consistently evaluate different products and sees a need to have consistent instructions on determining the bounds of surface area for all walk-in doors. DOE has determined that all parts of the door that impact the operation of the door shall be included in the determination of the surface area, with the exception of extended track area for sliding doors as discussed previously. Therefore, the bounds of the ''door surface area'' dimensions also include the frame.

As proposed in the April 2022 NOPR, in this final rule, DOE is defining ''door surface area'' as the product of the height and width of a walk-in door measured external to the walk-in. The height and width dimensions shall be perpendicular to each other and parallel to the wall or panel of the walk-in to which the door is affixed. The height and width measurements shall extend to the edge of the frame and frame flange (as applicable) to which the door is affixed. For sliding doors, the height and width measurements shall include the track; however, the width (for horizontal sliding doors) or the height (for vertical sliding doors) shall be truncated to the external width or height of the door leaf or leaves and its frame or casings. The surface area of a display door is represented as A_{dd}, and the surface area of a non-display door is represented as A_{nd}.

b. Surface Area for Determining U-Factor

As stated previously, appendix A currently references NFRC 100–2010, which in turn references NFRC 102 for the determination of U-factor through a physical test. When conducting physical testing, the U-factor (U_s) is calculated using projected surface area (A_s) and then converted to the final standardized U-factor (U_{ST}). *See* ASTM C1199, sections 8.1.3 and 9.2.7, as referenced through NFRC 102. Projected surface area (A_s) is defined as ''the projected area of test specimen (same as test specimen aperture in surround panel).'' *See* ASTM C1199, section 3.3, as referenced through NFRC 102.

Currently, equations 4–19 and 4–28 of appendix A specify that surface area of display doors (A_{dd}) and non-display doors (A_{nd}), respectively, are used to convert a door's U-factor into a conduction load. This conduction load represents the amount of heat that is transferred from the exterior to the interior of the walk-in.

As discussed in section III.C.2.a, DOE is amending the definitions of A_{nd} and A_{dd} to be specific to the exterior dimensions of the door, including the frame and frame flange as appropriate. Defining the bounds of the door through this definition is inconsistent with the defined area (A_s) used to calculate U-factor in NFRC 102–2020.

In the April 2022 NOPR, DOE proposed to specify that the projected area of the test specimen, A_s, as defined in ASTM C1199, or the area used to determine U-factor is the area used for converting the standardized tested U-factor, U_{ST}, into a conduction load in appendix A. 87 FR 23920, 23940. DOE recognizes that this may not change ratings for some doors, where A_s is equivalent to A_{nd} or A_{dd}, but it may result in slightly lower ratings of energy consumption for other doors, where A_s is less than A_{nd} or A_{dd}. DOE expects that since this proposed detail would either result in a reduced measured energy consumption or have no impact, there will likely be no need for manufacturers to retest or rerate. Additional details on how this detail impacts retesting and rerating are further discussed in section III.K.1 of this document.

Anthony commented that it agrees with the proposed revision to use the area of the test specimen, A_s, to calculate the conduction load. (Anthony, No. 31 at p. 6) Bally reiterated comments from AHRI, Hussmann, and Imperial Brown in response to the June 2021 RFI which suggested they did not see a distinction that warranted changing the definition. (Bally, No. 40 at p. 1) *See* summary of these comments at 87 FR 23920, 23939.

DOE reiterates that the door surface area defined in section III.C.2.a differs from the surface area used to calculate U-factor in NFRC 102–2020. Thus, despite stakeholder comments, DOE sees a need to resolve this discrepancy. Otherwise, the conduction load determined from the physical U-factor test may inflate the actual conduction load.

In the April 2022 NOPR, DOE also proposed to specify in appendix A that the physical U-factor test should include all components of the door that aid in the operation of the door, including the frame, rather than just the door leaf, to improve consistency in application of the test procedure across all walk-in doors. 87 FR 23920, 23940. Bally commented that it does not believe the frame of the door should be included in the U-factor test and suggested that including the frame in the U-factor test was minimal in comparison to the electrical components. (Bally, No. 40 at pp. 2–3) As stated in the April 2022 NOPR, DOE's testing of non-display doors has demonstrated that including the frame in the U-factor test has a measurable impact on the thermal performance of the door assembly relative to the increase in the total area, and so DOE is adopting the specification that the physical U-factor test should include the door frame.

3. Electrical Door Components

Sections 4.4.2 and 4.5.2 of appendix A currently include provisions for calculating the direct energy consumption of electrical components of display doors and non-display doors, respectively. Electrical components associated with doors could include, for example, heater wire (for anti-sweat or anti-freeze applications), lights (including display door lighting systems), control system units, or sensors. For each electricity consuming component, the calculation of energy consumption is based on the component's ''rated power'' rather than a measurement of its power draw. Section 3.5 of appendix A defines ''rated power'' as the electricity consuming device's power as specified (1) on the device's nameplate or (2) on the device's product data sheet if the device does not have a nameplate or such nameplate does not list the device's power.

As discussed in the April 2022 NOPR, DOE has observed issues that make calculating a door's total energy consumption a challenge. 87 FR 23920, 23940. These issues include using a single nameplate for all door electrical components rather than individual nameplates for all electricity-consuming devices, specification of voltage and amperage rather than wattage on the nameplate, and no specification of whether the nameplate represents the maximum or steady-state operating conditions. DOE is aware that measuring direct power consumption of each electrical component could alleviate some of these issues. In response to the April 2022 NOPR, the Efficiency Advocates stated that they support an option for direct measurement of door component electrical power in the test procedure (Efficiency Advocates, No. 37 at p. 4). DOE acknowledges the comment but has concluded that additional investigation is needed to develop a test procedure for such measurements. Therefore, DOE is not adopting provisions requiring measurement of power consumption of each electrical door component in appendix A.

Furthermore, DOE has observed that some manufacturers may be certifying door motor power as the output power rating of the motor, rather than the input power of the motor. Thus, DOE proposed in the April 2022 NOPR to specify in appendix A that the rated power of each electrical component, $P_{rated,u,t}$, would be the rated input power of each component because the input power represents power consumption. The Efficiency Advocates also supported the clarification that the certified door motor power should be the input power. *Id.*

Additionally, DOE has observed through testing that the measured power of some walk-in door electrical components exceeds either the certified or nameplate power values of these electrical components. In the April 2022 NOPR, DOE proposed that for the purposes of enforcement testing, in 10 CFR 429.134(q), DOE may validate the certified or nameplate power values of an electrical component by measuring the power when the device is energized using a power supply that provides power within the allowable voltage range listed on the nameplate. If the measured input power is more than 10 percent higher than the power listed on the nameplate or the rated input power in a manufacturer's certification, then the measured input power would be used in the energy consumption calculation. For electrical components with controls, the maximum input wattage observed while energizing the device and activating the control would be considered the measured input power. Anthony agreed with the proposal to use nameplate values for determining energy consumption unless physical testing results in a power value that exceeds what is depicted on the nameplate. (Anthony, No. 31 at p. 6) Bally stated that adjusting nameplate values based on measurement results requires door manufacturers to be responsible for the quality assurance of their vendors. (Bally, No. 40 at p. 3) In response, DOE notes that the door manufacturer is ultimately responsible for certifying that the walk-in door, when outfitted with all necessary components, meets the applicable DOE energy conservation standards.

Given DOE's observations during testing, DOE sees a need to provide a way to calculate energy consumption using a measured value of electrical component power. DOE recognizes that there may be minor variations in measured power as compared to the rated power and has determined that a tolerance of 10 percent accounts for such variation. DOE is adopting this provision at 10 CFR 429.134(q)(4) only for the purposes of enforcement testing to aid the Department in determining non-compliance with energy conservation standards.

4. Percent Time Off Values

The current test procedure assigns percent time off (''PTO'') values to various walk-in door components to reflect the hours in a day that an electricity-consuming device operates at its full rated or certified power. PTO values are not incorporated in the rated or certified power of an electricity-consuming device. Table III.2 lists the PTO values in the current DOE test procedure for walk-in door components.

TABLE III.2—ASSIGNED PTO VALUES FOR WALK-IN DOOR COMPONENTS

Component type	Percent time Off (PTO) (%)
Lights without timers, control system, or other demand-based control	25
Lights with timers, control system, or other demand-based control	50
Anti-sweat heaters without timers, control system, or other demand-based control	0
Anti-sweat heaters on walk-in cooler doors with timers, control system, or other demand-based control	75
Anti-sweat heaters on walk-in freezer doors with timers, control system, or other demand-based control	50
All other electricity-consuming devices without timers, control system, or other auto-shut-off system	0
All other electricity-consuming devices for which it can be demonstrated that the device is controlled by a preinstalled timer, control system, or auto-shut-off system	25

As mentioned in the April 2022 NOPR, DOE has granted waivers to several door manufacturers with motorized door openers, allowing the use of a different PTO for motors.[29] 87 FR 23920, 23941. DOE proposed a single PTO for use with door motors to create consistency in the test procedure among doors with motors. 87 FR 23920, 23941–23942. DOE calculated an average PTO value based on the information in the waivers to determine a single representative PTO value. Considering the waivers and its calculations, DOE proposed to adopt a door motor PTO value of 97 percent for all walk-in doors with motors. *Id.* Senneca and the Efficiency Advocates agreed with the proposed PTO. (Senneca, No. 26 at p. 2; Efficiency Advocates, No. 37 at p. 2) Bally suggested that the power consumption of the motor be completely removed from the energy consumption calculation, but ultimately supported the proposed PTO value. (Bally, No. 40 at p. 3) DOE has determined that motor power consumption contributes to direct and total energy consumption of the door and aids in the operation of the door. Therefore, the motor power should be included in the determination of energy consumption. Additionally, pursuant to its waiver regulations, as soon as practicable after the granting of any waiver, DOE will publish in the **Federal Register** a notice of proposed rulemaking to amend its regulations to eliminate any need for the continuation of such waiver. 10 CFR 431.401(l). For the reasons stated above, DOE is adopting the PTO value of 97 percent

[29] *See* HH Technologies, 83 FR 53457; Jamison Door Company, 83 FR 53460; Senneca Holdings, 86 FR 75; Hercules, 86 FR 17801.

for door motors in appendix A. DOE notes that the adoption of this PTO value would not require retesting or recertification because calculated daily energy consumption will be equal to or lower than currently certified values. New testing would only be required if the manufacturer wishes to make claims using the new, more efficient rating.

5. Energy Efficiency Ratio Values

As discussed in the April 2022 NOPR, the energy efficiency ratio (''EER'') values used in appendix A differ from the EER values in appendix C. 87 FR 23920, 23942. The values in appendix A are used to calculate the daily energy consumption associated with heat loss through a walk-in door, and the values in appendix C correspond to adjusted dew point temperature when testing refrigeration systems of walk-in unit coolers alone. In the July 2021 RFI, DOE requested comment on the difference in EER values used in appendices A and C and based on stakeholder feedback, DOE concluded in the April 2022 NOPR that there is no advantage to harmonizing the two values. *Id.* As discussed in the April 2022 NOPR, an envelope component manufacturer cannot control what refrigeration equipment is installed and the EER values are intended to provide a nominal means of comparison rather than reflect an actual walk-in installation. Additionally, the difference between the EER values used in appendix A for doors and those used in appendix C for unit coolers is seven percent for coolers and five percent for freezers; however, changing the EER values would require manufacturers to retest and rerate energy consumption without necessarily providing a more representative test procedure. *Id.* Therefore, in the April 2022 NOPR, DOE did not propose to harmonize the EER values between appendices A and C.

In response to the April 2022 NOPR, Anthony suggested that DOE adopt the EER values specified in AHRI 1250 to align all components of a WICF and stated that the modification of EER values would not require additional testing, as these values are only used in the mathematical energy calculations. (Anthony, No. 31 at pp. 6–7) DOE notes that Anthony's suggested approach would require recalculation and recertification of every basic model and would do so without necessarily providing a more representative test procedure. As such, DOE has determined that changing the reference EER values in either appendix A or C would be unduly burdensome. Therefore, DOE is not harmonizing the EER values in appendices A and C.

6. Air Infiltration Reduction

As discussed in the April 2022 NOPR, EPCA includes prescriptive requirements for doors used in walk-in applications intended to reduce air infiltration. 87 FR 23902, 23943. Specifically, walk-ins must have (A) automatic door closers that firmly close all walk-in doors that have been closed to within 1 inch of full closure (excluding doors wider than 3 feet 9 inches or taller than 7 feet), and (B) strip doors, spring-hinged doors, or other method of minimizing infiltration when doors are open. (42 U.S.C. 6313(f)(1)(A)–(B)) DOE previously proposed methods for determining the thermal energy leakage due to steady-state infiltration through the seals of a closed door and door opening infiltration. 75 FR 186, 196–197; 75 FR 55068, 55084–55085. DOE did not ultimately adopt these methods as part of the final test procedure because DOE concluded that steady state infiltration was primarily influenced by on-site assembly practices rather than the performance of individual components. 76 FR 21580, 21594–21595 (April 15, 2011). Similarly, DOE stated that, based on its experience with the door manufacturing industry, door opening infiltration is primarily reduced by incorporating a separate infiltration reduction device at the assembly stage of the complete walk-in. *Id.*

In the April 2022 NOPR, DOE did not propose to include air infiltration in the test procedure. 87 FR 23920, 23943. However, the Efficiency Advocates encouraged DOE to incorporate a measurement of air infiltration for walk-in doors because it would improve the representativeness and encourage the development and deployment of technologies that can save energy. (Efficiency Advocates, No. 37 at p. 4) DOE did not receive any data or recommendations for how to incorporate the measurement of air infiltration for walk-in doors into the test procedure in response to either the June 2021 RFI or the April 2022 NOPR. DOE has concluded that additional investigation is needed to adopt a test procedure that considers air infiltration for walk-in doors and thus is not adopting provisions pertaining to air infiltration at this time. DOE intends to consider data on the magnitude of air infiltration for walk-ins as it becomes available for appropriate evaluation of the representativeness of including it in the test procedure for walk-in doors.

As previously mentioned, EPCA requires air infiltration limiting devices on all doors. (42 U.S.C. 6313(f)(1)(A)–(B)) Even though air infiltration is not currently evaluated as part of the current test procedure and thus not part of the performance standard, all walk-in doors are subject to the prescriptive requirements in the energy conservation standard pertaining to air infiltration limiting devices. (10 CFR 431.306(a)(1)–(2))

D. Amendments to Appendix A for Display Panels

Appendix A specifies the test procedure to determine energy consumption of walk-in display panels, which are not currently subject to any daily energy consumption performance standards but are subject to the prescriptive requirements at 10 CFR 431.306. The existing test procedure for walk-in display panels is very similar to that of walk-in doors in that it requires a U-factor test using NFRC 100–2010, which is used to determine the thermal conduction through the display panel and ultimately the total daily energy consumption. The existing display panel test procedure differs, however, from that of walk-in doors in that direct and indirect electrical energy consumption are not included in the test procedure.

In the April 2022 NOPR, DOE proposed to apply all the test requirements proposed for determining display door conduction load and energy consumption to determining display panel conduction load and energy consumption, except for the provisions applicable to electrical components and PTO values. 87 FR 23920, 23943.

Anthony agreed that the test procedure for display panels should be similar to the test procedure for display doors, but it disagreed with DOE's proposal that provisions applicable to electrical components and PTO values should be excluded from the test procedure for display panels. (Anthony, No. 31 at p. 7) Anthony stated that display panels can have heaters and lights. (*Id.*)

DOE acknowledges Anthony's feedback regarding display panels; however, DOE does not currently have sufficient information on display panel electrical components and PTO values to adopt provisions for electrical components for display panels. DOE may do so in a future rulemaking, however at this time, DOE is adopting the changes to section III.C of appendix A for determining display panel conduction load and energy consumption as proposed in the April 2022 NOPR.

E. Amendments to Appendix B for Panels and Non-Display Doors

The insulation R-value of walk-in non-display panels and non-display doors is determined using appendix B. In the April 2022 NOPR, DOE proposed to modify appendix B to improve test representativeness and repeatability. 87 FR 23920, 23943. Specifically, DOE proposed to make the following revisions to appendix B: (1) reference the updated industry standard ASTM C518–17; (2) include more detailed provisions on measuring insulation thickness and test sample thickness; (3) provide additional guidance on determining parallelism and flatness of test specimen; and (4) reorganize appendix B so it is easier for stakeholders to follow as a step-by-step test procedure. *Id.*

In response to the appendix B proposals, Bally commented that the proposed regulations will be burdensome for laboratories to conduct. (Bally, No. 40 at p. 4) DOE acknowledges Bally's comment; however, DOE has concluded that the proposed amendments would not be unduly burdensome and would improve test representativeness and repeatability as discussed in sections III.E.1 through III.E.5 of this document. Test procedure costs and impacts because of the adopted changes are further discussed in section III.K.2 of this document. DOE does not expect that the adopted changes to appendix B, discussed further, will alter measured R-values; therefore, no retesting or recertification is required.

Additionally, AHRI commented generally that they would like to understand if display doors, non-display doors, and panels use the same calculation. (AHRI, No. 30 at p. 4) DOE defines each of these components separately (*see* subpart R of 10 CFR 431.302) and their respective test procedures are described in appendix A, and appendix B. The procedure for determining energy consumption of display doors begins at section 4.4 of appendix A. The procedure for determining energy consumption of non-display doors begins at section 4.5 of appendix A. Sections 4.4 and 4.5 of appendix A follow the same methodology of accounting for thermal conduction through the door (represented in the form of additional refrigeration system energy), the direct electrical energy consumption of electricity-consuming devices sited on the door, and the indirect electrical energy consumption of electricity-consuming devices represented in the form of additional refrigeration system energy consumption. Panels not classified as display panels follow the test procedure in appendix B, which determines the R-value of insulation for only the foam of the panel.

Furthermore, DOE clarifies that in the following sections, the changes discussed are specifically in the context of walk-in panels; however, DOE notes that non-display doors are also subject to the prescriptive R-value requirement at 10 CFR 431.306(a)(3) and that the R-value for walk-in door insulation is determined using appendix B. The following sections describe the modifications that DOE is adopting in appendix B.

1. 24-Hour Testing Window

As mentioned in the April 2022 NOPR, DOE is aware that the test specimen and conditioning instruction and example given in section 7.3 of ASTM C518–04 and ASTM C518–17 conflict with the provision in section 4.5 of the DOE test procedure at appendix B. The DOE test procedure requires testing be completed within 24 hours of specimens being cut for the purpose of testing, while ASTM C518–04 and ASTM C518–17 require that specimens be conditioned prior to testing based on material specifications, which could be longer than 24 hours. 87 FR 23920, 23942.

Bally commented that a cut sample should not be exposed to air for longer than 8 hours because foam samples become irreversibly de-conditioned once removed from a panel. (Bally, No. 40 at pp. 3–4) Bally included a technical bulletin from 1984 that states that, in general, a 1-inch cut section of foam can increase in K-factor about 5 to 10 percent in a few days. (Bally, No. 40, Attachment 2) [30]

It is DOE's understanding that since the technical bulletin referenced by Bally was published, there have been changes to the blowing agents used in polyurethane foam, the most common foam insulation type used in walk-in panels. Additionally, no specific data on the change in K-factor beyond 8 hours was provided. Recent tests conducted by DOE demonstrate that there is no measurable difference in K-factor for specimens tested immediately after extraction from the complete panel as compared to specimens tested 24 hours after extraction from the complete panel. DOE has not evaluated changes to K-factor of a test specimen beyond 24 hours of extraction from the panel. Given the existing technology on the market today, DOE believes 24 hours is an appropriate limit that balances K-factor representativeness with test burden, and therefore DOE is maintaining the current requirement that testing be completed within 24 hours of cutting a test specimen from the envelope component. Correspondingly, DOE is not referencing Section 7.3 of ASTM C518–17 regarding specimen conditioning as part of its update to appendix B.

2. Total Insulation and Test Specimen Thickness

Section 4.5 of appendix B currently requires that K-factor of a 1 ± 0.1-inch sample of insulation be determined according to ASTM C518–04.

To make the test procedure in appendix B more repeatable, DOE proposed in the April 2022 NOPR to include instructions for determining both the total insulation thickness as well as the test specimen insulation thickness prior to conducting the test to determine K-factor using ASTM C518–17, which is substantively the same as determining the K-factor according to ASTM C518–04. 87 FR 23920, 23944. DOE also proposed step-by-step instructions for specimen preparation, including detailed instructions of the number and locations of thickness and area measurements and from where the test specimen should be removed from the overall envelope component. *Id.* DOE proposed to require the following for determining the total thickness of the foam, t_{foam}, from which the final R-value is calculated:

• The thickness around the perimeter of the envelope component is determined as the average of at least 8 measurements taken around the perimeter that avoid the edge region.[31]

• The area of the entire envelope component is calculated as the width by the height of the envelope component.

• A sample is cut from the center of the envelope component relative to the envelope component's width and height. The specimen to be tested using ASTM C518–17 will be cut from the center sample.

• The thickness of the sample cut and removed from the center of the envelope component is determined as the average of at least 8 measurements, with at least 2 measurements taken in each quadrant.

[30] The Bally comment included two supplemental attachments: Attachment 1, ''Solid and Opaque Eval,'' and Attachment 2, ''BTB—Aging of Foam.'' DOE will reference as ''Attachment 1'' and ''Attachment 2'' throughout this document. Both attachments are available on the docket.

[31] *Edge region* means a region of the panel that is wide enough to encompass any framing members. If the panel contains framing members (*e.g.,* a wood frame), then the width of the edge region must be as wide as any framing member plus an additional 2 in. ± 0.25 in. See section 3.1 of appendix B.

- The area of the sample cut and removed from the center of the envelope component is determined as the width by the height of the cut sample.
- Any facers on the sample cut from the envelope component shall be removed while minimally disturbing the foam, and the thickness of each facer shall be the average of at least 4 measurements.
- The average total thickness of the foam shall then be determined by calculating an area-weighted average thickness of the complete envelope component less the thickness of the facers.

Id.

For preparing and determining the thickness of the 1-inch test specimen, DOE proposed the following:

- A 1 ± 0.1-inch-thick specimen shall be cut from the center of the cut envelope sample removed from the center of the envelope component.
- Prior to testing, the average of at least 9 thickness measurements at evenly spaced intervals around the test specimen shall be the thickness of the test specimen, *L.*

Id.

In the April 2022 NOPR, DOE requested feedback on the proposed provisions relating to test specimen and total insulation thickness and test specimen preparation prior to conducting the ASTM C518–17 test. Anthony agreed with both of the proposals. (Anthony, No. 31 at p. 7) Bally referenced the EPCA calculation for R-value and recommended that R-value remain calculated with that formula. (Bally, No. 40 at p. 3) Bally commented that it believes the tolerance of 1 ± 0.1 inch is not necessary because the sample preparation process would need to be restarted, but a smaller sample could have been used to determine K-factor. (Bally, No. 40 at p. 4)

In response to Bally's comment, DOE is not adopting any changes to the R-value formula; rather, DOE is providing additional instruction so that the inputs to the R-value formula, namely the K-factor, are determined in a consistent and more repeatable manner. At this time, DOE has determined that the 1 ± 0.1 inch tolerance is still necessary to appropriately and consistently measure K-factor. Therefore, DOE is adopting the provisions outlined in the April 2022 NOPR for determining test specimen and total thickness of insulation in appendix B.

3. Parallelism and Flatness

The test procedure for determining R-value requires that the two surfaces of the tested sample that contact the hot plate assemblies (as defined in ASTM C518–04 and ASTM C518–17) maintain a flatness tolerance of ±0.03 inches and maintain parallelism of one another with a tolerance of ±0.03 inches.[32] *See* section 4.5 of appendix B. As discussed in the April 2022 NOPR, the current test procedure does not provide direction to measure or calculate flatness and parallelism. DOE believes, however, that accurate and repeatable determination of a specimen's R-value requires the specimen under test to be both flat and parallel. 87 FR 23920, 23944.

In the April 2022 NOPR, DOE proposed to include several steps for determining the parallelism and flatness of the test specimen in appendix B:

- Prior to determining the specimen thickness, the specimen would be placed on a flat surface and gravity used determine the specimen's position on the surface. As specified previously, a minimum of nine thickness measurements would be taken at equidistant positions on the specimen. These measurements would be associated with side 1 of the specimen.
- The least squares plane of side 1 is determined based on the height measurements taken. The theoretical height of the least squares plane is determined at each measurement location in the x and y (length and width) direction of the specimen.
- The difference at each measurement location between actual height measurement and theoretical height measurement based on the least squares plane is calculated. The maximum value minus the minimum value is the flatness associated with this side (side 1). For each side of the specimen to be considered flat, this value would need to be less than or equal to 0.03 inches.
- Flip the specimen so that side 1 is now on the flat surface and let gravity determine the specimen position on the surface. Repeat the steps above for side 2 of the specimen.
- To determine if each side of the specimen is parallel, the theoretical height at the four corners (*i.e.,* at points (0,0), (0,12), (12,0), and (12,12)) of the specimen must be calculated using the least squares plane. The difference in the maximum and minimum heights would represent the parallelism of one side and would need to be less than or equal to 0.03 inches for the specimen to be considered parallel.

87 FR 23920, 23945.

AHRI and Anthony agreed with the proposed provisions relating to determining parallelism and flatness of the test specimen. (AHRI, No. 30 at p. 4; Anthony, No. 31 at p. 8) Bally stated that commercial devices used to measure K-factor using ASTM C518 have an internal check on flatness and parallelism so a sample that is out of tolerance will be flagged. (Bally, No. 40 at pp. 4–5)

DOE acknowledges Bally's comment, however, it is DOE's understanding that not all manufacturers or laboratories use the same commercial device to measure K-factor. Regardless of the device used, a consistent procedure for determining parallelism and flatness is necessary. DOE is adopting the method for determining parallelism and flatness in appendix B as described in the April 2022 NOPR. 87 FR 23920, 23945.

4. Insulation Aging

The current test procedure for determining panel R-value does not account for insulation aging. ''Aging'' of foam insulation refers to how diffusion of blowing agents out of the foam and diffusion of air into the foam impacts thermal resistance of insulation materials. The gaseous blowing agents contained in the foam provide it with much of its insulating performance, represented by the R-value of the foam material. Because air has a lower insulating value than the blowing agents used in foam insulation, the increased ratio of air to blowing agent reduces the foam insulation performance, which reduces the R-value of the foam material over time. The building industry uses long-term thermal resistance (''LTTR'') to represent the R-value of foam material over its lifetime by describing the insulating performance changes due to diffusion over time. The presence of impermeable facers on a foam structure may delay the rate of aging or reduce the decrease in R-value when compared to a foam structure that is unfaced or has permeable facers. Blowing agents and temperature and humidity conditions may also affect the amount or rate of aging that occurs in a foam structure.

In the April 2022 NOPR, DOE discussed its previous adoption and subsequent removal of a test procedure that considered aging of foam insulation. 87 FR 23920, 23945–23946. DOE rescinded the method that evaluated aging because of stakeholder concerns regarding test burden and the availability of laboratories to conduct the adopted test procedure. 79 FR 23788, 27405–27406. As such, DOE did

[32] Maintaining a flatness tolerance means that no part of a given surface is more distant than the tolerance from the ''best-fit perfectly flat plane'' representing the surface. Maintaining parallelism tolerance means that the range of distances between the best-fit perfectly flat planes representing the two surfaces are no more than twice the tolerance (*e.g.,* for square surfaces, the distance between the most distant corners of the perfectly flat planes minus the distance between the closest corners is no more than twice the tolerance).

not propose to add test procedure provisions regarding aging in the April 2022 NOPR. 87 FR 23920, 23945–23946. DOE also did not propose to consider the effects of aging in assessment and enforcement testing because a recent study at Oak Ridge National Laboratory (''ORNL'') found the effects of foam insulation aging for panels sold with facers to be minimal when panel facers remain attached to the foam (*i.e.,* when the panel remains intact).[33] *Id.* In the April 2022 NOPR, DOE requested comment on other comparable data or studies of foam panel aging that are representative of the foam insulation, blowing agents, and panel construction currently used in the manufacture of walk-in panels. *Id.* DOE also requested comment on whether manufacturers have been certifying R-value at time of manufacture or after a period of aging. *Id.*

In response, AHRI suggested that any aging criteria should be based on the conditioning requirements in ASTM C518. (AHRI, No. 30 at p. 4) AHRI also stated that typical aging periods to ensure dimensional stability of finished foam has been reached vary between 14 and 28 days. *Id.* Bally stated that it tests its foam without aging. (Bally, No. 40 at p. 5) RSG commented that it would like to limit the time between manufacture and testing as much as possible. (RSG, No. 41 at pp. 1, 11) RSG stated that it has conducted its own test, where it calculated R-value every 2 weeks for 6 months after manufacture; it found that R-value drops sharply at the beginning, followed by a slower rate of decline. (*Id.*)

In response to AHRI's suggestion regarding aging criteria, DOE testing has shown that there is no measurable difference in K-factor for specimens tested immediately after extraction from the complete panel as compared to specimens tested 24 hours after extraction from the complete panel, even though it would be expected that aging of a thinner sample without facers would be more significant than a fully intact panel. Therefore, DOE expects the aging of an intact panel to be negligible after 24 hours.

Bally's and RSG's comments suggest that manufacturers are rating R-value without considering the effects of aging and would prefer to limit the amount of time between manufacture and test. As stated previously, DOE has found that there are minimal effects of foam insulation aging for panels sold with facers when panel facers remain attached to the foam. For assessment and enforcement testing conducted to support the enforcement of DOE's energy conservation standards, DOE is generally able to test samples within one to three months after receipt. The time lag from when the panel is manufactured and when testing is conducted at a laboratory is typically significantly shorter than that evaluated in the ORNL study. Therefore, DOE expects any reduction in R-value to be minimal from date of manufacture to assessment or enforcement test date. Additionally, walk-in panels received by DOE for assessment and enforcement testing are evaluated upon arrival to ensure that they are received intact (*i.e.,* with facers) and undamaged, and testing of the specimen is completed within 24 hours of sample removal from the panel, as specified in section 4.5 of the DOE test procedure in appendix B. DOE does not expect any reduction in R-value within 24 hours of the sample being cut from the panel. Therefore, at this time, DOE will not consider insulation aging in the test procedure nor in the Department's assessment and enforcement testing based on the available data. DOE may consider additional data on this issue as it becomes available.

5. Overall Thermal Transmittance of Non-Display Panels

The current test procedure for non-display panels does not measure the overall thermal transmittance of a walk-in panel. 87 FR 23920, 23946. DOE previously adopted a test method for measuring overall thermal transmittance of a walk-in panel, including the impacts of thermal bridges[34] and edge effects (*e.g.,* due to structural materials and fixtures used to mount cam locks). 76 FR 21580. However, after receiving comments concerning test and cost burden and the lack of availability of laboratories to conduct the test procedure, DOE rescinded this portion of the walk-in panel test procedure. 79 FR 27388, 27405–27406. Based on past concerns, DOE did not propose any provisions to evaluate overall thermal transmittance of non-display panels in the April 2022 NOPR. 87 FR 23920, 23946.

In response, the Efficiency Advocates encouraged DOE to investigate appropriate methods to capture the overall thermal transmittance of walk-in panels. (Efficiency Advocates, No. 37 at p. 4) DOE did not receive any other feedback on its proposal or specific suggestions on how to implement a procedure that would measure overall thermal transmittance while minimizing the test cost burdens previously identified.

DOE continues to have the same concerns regarding test burden and lack of availability of test facilities to conduct any potential overall thermal transmittance testing of walk-in panels. Therefore, DOE is not including a test procedure in appendix B for determining overall thermal transmittance of non-display panels at this time.

F. Amendments to Appendix C for Refrigeration Systems

Appendix C provides test procedures to determine the AWEF and net capacity of walk-in refrigeration systems. DOE does not expect that the adopted changes to appendix C will alter measured capacity values or AWEF. Therefore, DOE expects no retesting or recertification will be required. Rather, the revisions for appendix C address repeatability issues that DOE has observed through its testing of walk-in refrigeration systems.

The following sections describe the modifications that DOE is making to appendix C, in this final rule.

1. Refrigeration Test Room Conditioning

The DOE test procedure for walk-in refrigeration systems specifies temperature and/or humidity conditions for the test chambers. (*See, e.g.,* Tables 3 through 16 of AHRI 1250–2009, which is incorporated by reference in the DOE test procedure.) Section C6.2 of AHRI 1250–2009 requires that the environmental chambers ''be equipped with essential air handling units and controllers to process and maintain the enclosed air to any required test conditions.'' This requirement is also in section C5.2.2 of AHRI 1250–2020. However, DOE is aware that some test facilities may rely on the test unit to cool and dehumidify the test room. When the test unit is used to cool and dehumidify the test room, frost accumulation on the test unit's coils during pretest conditioning is possible and can affect the results of the capacity test. 87 FR 23920, 23947. Section C5.1 of AHRI 1250–2020 states that the unit cooler under test may be used to aid in

[33] A presentation on ORNL's study can be found online at *www.osti.gov/biblio/1844325-impact-thermal-bridging-imperfections-agingeffective-value-walk-cooler-freezer-panels.* DOE acknowledges that panels are shipped for assembly in walk-ins with the foam already in final chemical form between facers. Thus, the most applicable evaluation of change in insulation R-value over time is demonstrated by the red data points (labeled ''2'') for the foam that remained intact with the facers on slides 26 through 30 of ORNL's presentation.

[34] Thermal bridging occurs when a more conductive material allows an easy pathway for heat flow across a thermal barrier.

achieving the required test chamber ambient temperatures prior to beginning a steady-state test but requires the unit under test to be free from frost before initiating steady-state testing. In the April 2022 NOPR, DOE proposed to specify that for applicable system configurations (matched pairs, single-packaged systems, and unit coolers tested alone), the unit under test may be used to help achieve the required test chamber conditions prior to beginning any steady-state test. 87 FR 23920, 23947. Additionally, DOE proposed to require a visual inspection of the test unit coils for frost before the steady-state test begins. *Id.* 87 FR 23920, 23947. DOE requested comment on the proposed pretest coil inspection requirement and asked for feedback on current chamber conditioning practices within the industry. 87 FR 23920, 23947.

AHRI, HTPG, Hussmann, KeepRite, Lennox, and National Refrigeration disagreed with allowing the unit under test to condition the test room because it cannot sufficiently remove humidity from the room. (AHRI, No. 30 at p. 4; HTPG, No. 32 at p. 4; Hussmann, No. 38 at p. 3; KeepRite, No. 36 at p. 1; Lennox, No. 35 at pp. 2–3; National Refrigeration, No. 39 at p. 1) The same group of commenters also stated that the requirement for the unit to be ''free from frost'' is too subjective. (*Id.*) Hussmann mentioned that defrost could reduce the frost present, but that would result in a frosted-coil test instead of a dry-coil test. (Hussmann, No. 38 at p. 3) AHRI and Hussmann suggested that, if the unit under test is used to condition the test chamber, the unit's capacity be tested both before and after the test to ensure that the unit's capacity is not decreasing due to frost load. (AHRI, No. 30 at pp. 4–5; Hussmann, No. 38 at p. 3) Lennox recommended that environmental chambers be equipped with air handlers to maintain test conditions. (Lennox, No. 35 at pp. 2–3) RSG agreed with the DOE's proposed inspection requirement. (RSG, No. 41 at p. 1)

2. DOE notes that the proposed test procedure allows the unit under test to aid in achieving the required test chamber conditions This implies that other conditioning equipment may be necessary and that the unit under test should never be the sole conditioner. In addition, DOE notes that the amendments to test procedure are in alignment with section C5 of AHRI 1250–2020, the most current industry test procedure. DOE has determined that a visual inspection is the most practical way to confirm that coils are free from frost and that while such an inspection may include subjective judgement about the presence of frost, it is better than no inspection at all. DOE has therefore determined that a visual inspection of the coils is sufficient. DOE also notes that the operating tolerances discussed in section III.F.5 of this document, appendix C to subpart R of 10 CFR part 431, and AHRI 420–2007 ensure that any significant impact of frost collection during a test would invalidate the test unless the unit capacity remains steady throughout a test.[35] These requirements make the pre- and post-test measurement of capacity unnecessary. Therefore, DOE is adopting the test procedure as proposed in the April 2022 NOPR. DOE is adding the new requirement to appendix C, which also carries over to appendix C1.

Temperature Measurement Requirements

a. Suction Line Temperature Measurement

The current DOE test procedure requires measuring refrigerant temperature entering or leaving the unit cooler using either thermometer wells or immersed sensors to determine refrigerant enthalpy as part of the capacity measurement for matched pairs and unit coolers tested alone (*see* 10 CFR part 431, subpart R, appendix C, section 3.2.1). The capacity determination for dedicated condensing units tested alone is based on the refrigerant conditions leaving the condensing unit and standardized conditions leaving the unit cooler, as specified in section 3.4.2.1 of appendix C. In the April 2022 NOPR, DOE proposed to clarify that, when testing dedicated condensing units, thermometer wells or immersed sensors can be used only at the condensing unit liquid outlet and are not required to be used for the suction line. 87 FR 23920, 23947.

AHRI, KeepRite, Lennox, National Refrigeration, and HTPG all commented that they do not support the proposal to forgo temperature measuring requirements for the suction line when testing dedicated condensing units. (AHRI, No. 30 at p. 5; KeepRite, No. 36 at p. 1; Lennox, No. 35 at p. 3; National Refrigeration, No. 39 at p. 1; HTPG, No. 32 at p. 4) AHRI also stated that legacy calculation and simulation systems use existing temperature measurements of the suction discharge. (AHRI, No. 30 at p. 5)

DOE acknowledges that existing systems and calculations may depend on suction line temperature measurements. For this reason, DOE retracts its proposal from the April 2022 NOPR and in this final rule maintains the requirements for thermometer wells or immersed sensors for both the suction and liquid lines when testing dedicated condensing units alone.

AHRI-Wine also commented that wine cellar manufacturers are concerned that the wells are not large enough for temperature measurements. (AHRI-Wine, No. 30 at p. 2) DOE notes that thermometer wells are required in the current DOE test procedure for temperature measurement. DOE addresses these concerns in the remainder of this section.

b. Surface-Mount Temperature Measurement Allowances for Small Diameter Tubing

As mentioned in the April 2022 NOPR, DOE has found that implementing the current thermometer well requirement for refrigerant lines with an outer diameter of 1–2 inch or less can restrict the refrigerant flow and thus affect temperature measurements. To rectify this issue and to ensure that all walk-in refrigeration systems can be tested according to the DOE test procedure, DOE proposed allowing an alternative approach when the refrigerant line tubing diameter is 1–2 inch or less, in which the temperature measurement would be made using two surface-mounted measuring instruments with a minimum accuracy of ±0.5 °F, which would be averaged to obtain the reading. Additionally, DOE proposed that the two measuring instruments must be mounted on the pipe separated by 180 degrees around the refrigerant tube circumference. To ensure

[35] For dedicated condensing units and matched pairs, new mass flow operating tolerances are adopted as discussed in section III.F.5, and existing refrigerant temperature tolerances are specified in section 3.1.1 of appendix C to subpart R of 10 CFR part 431. These two measurements would drift out of tolerance during a test if frost conditions were significantly affecting capacity measurements for such systems. Similarly, table C3 of AHRI 420–2007 includes a refrigerant mass flow tolerance and table C4 of AHRI 420–2007 includes inlet and outlet saturation temperature operating tolerances. These measurements would drift out of tolerance during a test if frost conditions were significantly affecting capacity measurements of unit coolers tested alone.

measurements are not affected by changes in ambient temperature, DOE proposed requiring use of 1-inch-thick insulation around the measuring instruments that extends 6 inches up- and downstream of the measurement locations. Where this technique is used to measure temperature at the expansion valve inlet, DOE proposed to require that the measurement be within 6 inches of the device.

With respect to tube surface measurements, AHRI and KeepRite stated that the temperature measurements on the tube surface are not accurate enough, and that this measurement is too critical to allow this. (AHRI, No. 30 at p. 5; KeepRite, No. 36 at p. 1) AHRI and KeepRite also stated that a low-temperature reading resulting from surface-mounted temperature measurement devices could lead to bubbling upstream of the expansion valve, resulting in inflated AWEF values. (AHRI, No. 30 at p. 5; KeepRite, No. 36 at p. 2) Lennox supported DOE's proposal to allow surface-mounted temperature sensors but encouraged DOE to work with industry to ensure the full scope of applications can be covered with these requirements. (Lennox, No. 35 at p. 3) Additionally, AHRI and KeepRite suggested allowing transition to a pipe large enough for a thermometer well. *Id.* National Refrigeration also recommended maintaining the thermometer well requirement for small diameter tubing and allowing for larger diameter tubing to accommodate thermometer wells. (National Refrigeration, No. 39 at p. 1) Regarding location of the temperature measurement, AHRI and KeepRite agreed with the allowance to locate the temperature sensor within 6 inches; however, they suggested that the test procedure should further clarify if the measurement is from the body of the expansion valve or the joint with the liquid line. (AHRI, No. 30 at p. 5; KeepRite, No. 36 at p. 2) KeepRite further suggested allowing the dual liquid temperature measurements to be further upstream in a thermometer well with a secondary surface measurement 6 inches from the expansion valve and with sufficient insulation such that the surface temperature reading does not differ by more than 2 °F from the thermometer well measurements. (KeepRite, No. 36 at p. 2)

Specific to the liquid line temperature measurement location, DOE clarifies that the measurement is from the center of the body of the expansion valve.

AHRI-Wine and HTPG agreed with the proposal to allow two external temperature measurements for small diameter tubing. (AHRI-Wine, No. 30 at p. 2; HTPG, No. 32 at p. 4)

DOE acknowledges the concerns from stakeholders regarding the use of surface measurements and will consider data from industry on this issue in future rulemakings. DOE has conducted testing using the approach proposed in the April 2022 NOPR and has determined that the approach provides representative measurements and prevents bubbling. Therefore, DOE is adopting the surface mount temperature measurement test provisions as proposed in the April 2022 NOPR. These requirements will be added to appendix C, and will also carry over to appendix C1.

3. Hierarchy of Installation Instruction and Specified Refrigerant Conditions for Refrigerant Charging and Setting Refrigerant Conditions

As discussed in the April 2022 NOPR, DOE is aware that sometimes multiple installation instructions may be available for a unit, and different test results could be obtained based on which instructions are used. 87 FR 23920, 23948. DOE proposed a hierarchy for installation instructions and setup of refrigerant conditions to improve test repeatability by indicating which manufacturer-specified conditions would be prioritized during setup.

Setup conditions or instructions may be stamped on the unit nameplate or otherwise affixed to the unit, shipped with the unit, or available online. DOE has encountered walk-in refrigeration units for which these three sources of instruction provide different values or conflicting directions. To ensure consistent setup during testing, DOE proposed in the April 2022 NOPR that instructions or conditions stamped on or adhered to a test unit take precedence, followed by instructions shipped with the unit. *Id.* Because online instructions can be easily revised, DOE proposed that instructions or other setup information found online would not be used to set up the unit for testing.

Furthermore, setting of refrigerant charge level or refrigerant conditions is a key aspect of setup of refrigeration systems, whether for field use or testing. In the April 2022 NOPR, DOE proposed that units be charged and set up at operating conditions specified in the test procedure (for outdoor refrigeration systems, DOE proposed use of operating condition A) based on the installation instructions, using the proposed hierarchy (*i.e.,* prioritizing instructions stamped or adhered to unit over instructions included in a manual shipped with the unit). *Id.* In cases where instructions for refrigerant charging or refrigerant conditions are provided only online or not at all, DOE proposed that a generic charging approach be used instead. If the installation instructions specify operating conditions to set up the refrigerant charge or refrigerant conditions, those conditions would be used rather than the conditions specified in the test procedure. *Id.*

DOE determined that in some cases, a manufacturer specifies a range of conditions for superheat,[36] subcooling, and/or refrigerant pressure. In these instances, DOE proposed to treat the midpoint of that range as the target temperature/pressure, and a test condition tolerance would be applied to the parameter that is equal to half the range. For example, if a manufacturer specifies a target superheat of 5 to 10 °F, the target for test would be 7.5 °F and the average value during operation at the setup operating conditions would have to be 7.5 °F ± 2.5 °F. Alternatively, installation instructions may specify a refrigerant condition value without a range or without indicated tolerances. In such cases, DOE proposed that standardized tolerances be applied as indicated in Table III.3. These tolerances depend on the kind of refrigerant expansion device used.

[36] Superheat is the difference between vapor-phase refrigerant temperature and the dew point corresponding to the pressure level.

TABLE III.3—TEST CONDITION TOLERANCES AND HIERARCHY FOR REFRIGERANT CHARGING AND SETTING OF REFRIGERANT CONDITIONS

Fixed orifice or capillary tube			Expansion valve		
Priority	Method	Tolerance	Priority	Method	Tolerance
1	Superheat	±2.0 °F	1	Subcooling	10% of the target value; no less than ±0.5 °F, no more than ±2.0 °F.
2	High Side Pressure or Saturation Temperature.	±4.0 psi or ±1.0 °F	2	High Side Pressure or Saturation Temperature.	±4.0 psi or ±1.0 °F.
3	Low Side or Saturation Temperature.	±2.0 psi or ±0.8 °F	3	Superheat	±2.0 °F.
4	Low Side Temperature	±2.0 °F	4	Low Side Pressure or Saturation Temperature.	±2.0 psi or ±0.8 °F.
5	High Side Temperature	±2.0 °F	5	Approach Temperature	±1.0 °F.
6	Charge Weight	±2.0 oz.	6	Charge Weight	0.5% or 1.0 oz., whichever is greater.

DOE also notes that zeotropic[37] refrigerants have become more common. When charging with such refrigerants (*i.e.,* any 400 series refrigerant), DOE proposed that the refrigerant charged into the system must be in liquid form. 87 FR 23920, 23948. Charging a system in liquid form is standard practice for charging of such refrigerants because the concentrations of the components of the blend present in the vapor phase of the charging cylinder are often skewed from the intended concentrations of the refrigerant blend.

If the installation instructions on the label affixed to (or shipped with) the unit do not provide instructions for setting subcooling or otherwise how to charge with refrigerant for a condensing unit tested alone or as part of a matched pair, DOE proposed requiring testing the unit in a way that is consistent with the DOE test procedure and the installation instructions and that also does not cause the unit to stop operating during testing, *e.g.,* by shutoff by the high-pressure switch. DOE believes that such installation would be most representative of the way a technician would set up a system in the field if there were no refrigerant charge or subcooling instructions. 87 FR 23920, 23948.

AHRI and Lennox commented that they agree with the hierarchy of charging methods, however, they recommended that DOE allow use of online documentation. (AHRI, No. 30 at p. 6; Lennox, No. 35 at p. 3) HTPG also suggested that electronic instructions be allowed in addition to paper. (HTPG, No. 32 at p. 5)

As discussed previously, DOE proposed in the April 2022 NOPR not to permit online instruction manuals in part because they can be easily revised. In consideration of these stakeholder comments, DOE has determined to allow use of online instruction manuals, with certain restrictions. Firstly, online instructions can be used only if no instructions or conditions are stamped on or adhered to a test unit or shipped with the unit. Secondly, to prevent revision to online documentation once a unit has been shipped by the manufacturer, online instruction manuals must include a version number or version date on the unit label or in the documents that are packaged with the unit.

In this final rule, DOE is amending the test procedure such that setup instructions or conditions stamped on or adhered to a test unit take precedence, followed by instructions shipped with the unit, followed by online instructions if the version number or date of the online instruction manual is referenced on the unit label or is included in documents that are packaged with the unit.

AHRI and Lennox recommended that outdoor units should be charged for condition C, not condition A. (AHRI, No. 30 at p. 6; Lennox, No. 35 at p. 4) DOE has considered the commentors' recommendations and validated this charging procedure through testing. DOE is therefore amending the test procedure such that units be charged and set up at operating conditions specified in the test procedure (for outdoor refrigeration systems, operating condition C) based on the installation instructions, using the hierarchy summarized in Table III.3 of this document. DOE notes that many outdoor condensing units achieve head pressure control that uses valves to ''flood'' the condenser with liquid refrigerant to maintain sufficiently high condensing temperature when outdoor air is cold. If such a condensing unit has insufficient charge, it will be more obvious during operation in condition C (where head pressure control is generally active) since more charge would be in the condenser during such operation under head pressure control. Hence, DOE concludes that charging in the C condition rather than the A condition is appropriate for dedicated condensing systems (dedicated condensing units, matched systems, and single-packaged dedicated systems) that use a flooded condenser design. DOE has encountered units that, when charged at the C condition, will not operate at the A condition with the same charge weight due to high pressure cut out. This suggests the possibility that following the charging instructions may lead to two different charge weights depending on the condition used for charging. DOE maintains that it is not representative of field operation to use different refrigerant charge weights for the two test conditions, since it is not expected that refrigerant charge would be adjusted as ambient temperature rises and falls for a dedicated condensing system in the field. As such, DOE is adopting test provisions such that if a dedicated condensing system is charged at the C condition but does not operate at the A condition due to excess charge causing high pressure cut out, then refrigerant charge shall be adjusted to the highest charge that allows operation at the A condition. To limit the test burden of determining this highest charge, the determination shall be subject to a stepwise charge adjustment. Specifically, refrigerant would be removed in increments of 4 ounces or 5

[37] A zeotropic refrigerant is a blend of two or more refrigerants that have different boiling points. Each refrigerant will evaporate and condense at different temperatures.

percent of the system's receiver capacity, whichever is larger, until operation at the A condition is possible. All tests, including those at condition C, will then be performed with this refrigerant charge.

DOE notes that when conducting the C condition test for a dedicated condensing system for which this charge removal has occurred as described above, it is possible that the refrigerant leaving the system no longer has measurable subcooling. If the measured subcooling of the refrigerant leaving the condenser is less than 0 °F, its state cannot accurately be determined based on the measurement. The most direct way to determine the state of the refrigerant would be to provide additional cooling to the liquid line after it leaves the condensing unit using a flow of a fluid such as water such that the water mass flow and temperature rise would be measured and such that the refrigerant is subcooled downstream of this heat exchange. Such an approach would allow determination of the enthalpy at the condensing unit exit as the enthalpy of its subcooled downstream state plus the additional cooling provided divided by the mass flow. However, DOE has determined that such an approach would require a chilled water, a refrigerant water heat exchanger, a water flow meter, temperature sensors, and provisions for flow and temperature measurements to be captured by the data acquisition system. DOE has determined that this additional equipment and time required to set up the additional equipment represent an inappropriate increase in test burden. DOE has finalized the test procedure requiring that if the calculated subcooling at the condensing unit exit is less than 0 °F, the liquid at this location will be assumed to be at saturated liquid conditions. DOE has determined that the departure from saturated conditions is likely to be small. Additionally, this change in calculation method would only take place at one of the three test points. These two factors would lead to very little, or no, influence over the final measured AWEF. Further, this would only be necessary when testing units using refrigerant enthalpy-based test methods.

DOE notes that it is also possible for dedicated condensing systems to maintain condensing temperature for low ambient operating conditions using fan controls rather than condenser flooding. Units that use fan control to maintain condenser temperature would not require significantly more refrigerant charge when operating at the C condition compared to the A condition. However, the fan controls of these systems may cause instability in refrigerant conditions at the lower ambient temperatures at the C test condition. As such, DOE has determined that, for dedicated condensing systems that exclusively use fan controls to maintain condensing temperature at low ambient temperatures, charging at the A condition is more appropriate than charging such units at C condition. The refrigerant charging proposals in the April 2022 NOPR sought to minimize test burden while ensuring the repeatability and representativeness of walk-in refrigeration system testing. Stakeholders correctly pointed out that charging at the A test condition would not be representative for systems with flooded-condenser head pressure control. Thus, the change to charging at the C test condition was necessary. However, DOE has determined through testing that it is possible that when such a system is charged under test condition C, it could fail to operate due to high pressure cutout when operating under test condition A. Therefore, in order to ensure that a valid test can be conducted, DOE is adding the additional provisions. DOE believes these amendments are consistent with the intent of proposed changes in the April 2022 NOPR while being responsive to stakeholder feedback. Hence, DOE concludes that charging in the C condition rather than the A condition is appropriate.

HTPG stated that it agrees that the unit under test should be set up according to a hierarchy of conditions. HTPG further stated, however, that it was unclear on the rationale for the inclusion and priority of ''High Side Pressure or Saturation Temperature,'' ''Low Side Pressure or Saturation Temperature,'' ''Approach Temperature,'' and ''Charge Weight'' in Table III.3. (HTPG, No. 32 at p. 5) HTPG did not provide detail on why these parameters should not be included, or otherwise reprioritized, in the hierarchy. DOE has developed the hierarchy summarized in Table III.3 based on its own testing experience and has observed that these parameters are specified operating conditions for certain units. Through that testing DOE has determined that the priority and inclusion of the methods listed in Table III.3 are appropriate.

Lennox stated that hierarchies in tables 1 and 19 should specify dew vs. bubble point to remove confusion with high-glide refrigerants. (Lennox, No. 35 at p. 4) DOE interprets Lennox's comment to be in reference to Table III.3 in this document, which in the proposed regulatory text was table 1 of appendix C (*see* 87 FR 23290, 24000–24001) and table 19 of appendix C1, respectively (*see* 87 FR 23920, 24021). DOE acknowledges that the proposed test procedure hierarchy did not clarify whether the dew or the bubble point should be used when the saturation point is specified. However, this should be addressed in the manufacturer's installation instructions, not specified by the test procedure. To clarify the intent in the hierarchy, DOE is adding a note in table 1 of appendix C and table 19 of appendix C1 to indicate that saturation temperature can refer to either bubble or dew point calculated based on a measured pressure, or a coil measurement, as specified by the installation instructions. DOE is adopting this clarification in this final rule.

AHRI, on behalf of wine cellar manufacturers, KeepRite, and National Refrigeration agreed with the charging hierarchy. (AHRI-Wine, No. 30 at p. 2; KeepRite, No. 36 at p. 2; National Refrigeration, No. 39 at p. 1)

DOE received no comment on the remaining proposals discussed in this section. In this final rule, DOE is adopting the testing hierarchy instructions proposed in the April 2022 NOPR into appendix C, and will also carry these provisions over to appendix C1.

a. Dedicated Condensing Unit Charging Instructions

For dedicated condensing units tested alone, subcooling is the primary setup condition. In the April 2022 NOPR, DOE proposed that if the dedicated condensing unit includes a receiver and the subcooling target leaving the condensing unit provided in the installation instructions cannot be met without fully filling the receiver, the subcooling target would be ignored. 87 FR 23920, 23948. Likewise, if the dedicated condensing unit does not include a receiver and the subcooling target leaving the condensing unit cannot be met without the unit cycling off on high pressure, the subcooling target would be ignored. Also, if no instructions for charging or for setting subcooling leaving the condensing unit are provided in the installation instructions, DOE proposed that the refrigeration system would be set up with a charge quantity and/or exit subcooling such that the unit operates during testing without shutdown (*e.g.,* on a high-pressure switch) and operation of the unit is otherwise consistent with the requirements of the test procedure and the installation instructions.

DOE received no comments in response to the proposals discussed in this section. In this final rule, DOE is adopting the dedicated condensing unit charging instructions proposed in the April 2022 NOPR into appendix C, and will also carry these provisions over to appendix C1.

b. Unit Cooler Setup Instructions

For unit coolers tested alone, superheat is the primary setup condition. Most WICF refrigeration systems use either thermostatic or electronic expansion valves (''EEVs'') that respond either mechanically or through a controller to adjust valve position to control for superheat leaving the unit cooler. If the unit under test is shipped with an adjustable expansion device, DOE proposed in the April 2022 NOPR that this would be the primary method to adjust superheat. 87 FR 23920, 23948. However, DOE has encountered units with expansion devices that are not adjustable or where the expansion device does not provide a sufficient adjustment range to achieve the superheat target. If the expansion valve associated with the unit under test reaches its limit before the superheat target is met, the specified superheat may not be met within the specified tolerance. In this case, DOE proposed in the April 2022 NOPR that the expansion valve should be adjusted to obtain the closest match to the superheat target. *Id.* DOE has also encountered unit coolers with inappropriate expansion devices. When this occurs, DOE proposed in the April 2022 NOPR that any expansion device specified for use with the unit cooler in manufacturer literature may be used for the purposes of DOE testing. *Id.*

In the April 2022 NOPR, DOE also proposed that an operating tolerance would not apply to superheat. Hence, if the system expansion valve control fluctuates (*i.e.,* if so-called ''hunting'' occurs, in which the valve position, temperatures, and/or pressures are unsteady), it would not invalidate a test. 87 FR 23920, 23948–23949. However, if the fluctuation is so great that a valid test cannot be performed (*i.e.,* any individual measurement of superheat during the test is zero or less), or if the operating tolerances for measurements that would be affected by expansion device hunting are exceeded (mass flow, pressure at the unit cooler exit, evaporator temperature difference),[38] the test procedure would allow for deviation from the installation instructions. DOE proposed in the April 2022 NOPR that deviation from the installation instructions would be at the discretion of the test laboratory and could include replacing the expansion device with a different expansion device that does not need to be listed in installation instructions, adjusting the expansion device to provide an average superheat that is greater than the target superheat, or both. 87 FR 23920, 23949.

If the unit's installation instructions do not include setting superheat for a unit cooler tested alone or as part of a matched pair, DOE proposed in the April 2022 NOPR that the target superheat would be 6.5 °F, the same value required in such circumstances in AHRI 1250–2020 (see Tables 16 and 17 of AHRI 1250–2020). *Id.*

AHRI commented that unit cooler charging should be done based on the expansion valve controlled by the room, not the supplied expansion valve. (AHRI, No. 30 at p. 6) Lennox stated that it is industry practice to test unit coolers with EEVs, because use of these valves eliminates ''hunting'' and is more reliable. (Lennox, No. 35 at p. 4) HTPG stated that it disagrees with the proposal in the April 2022 NOPR that operating tolerance would not apply to superheat and believes it conflicts with AHRI 1250–2020, as well as Table III.3. (HTPG, No. 32 at p. 5)[39]

After consideration, DOE has determined that using the expansion valve supplied with the unit cooler is most appropriate for testing because it most closely represents field performance. DOE notes that the expansion device provided with the unit cooler or specified in the unit cooler installation instructions may result in hunting behavior and may fluctuate outside the specified tolerances for superheat. Nevertheless, these results are expected to be more representative of field performance than using a laboratory controlled EEV that provides steady operation. As discussed in the preceding paragraphs, the amended test procedure provides test laboratories with alternatives if the expansion devices shipped with the unit, or specified in the installation instructions, result in hunting that interferes with test measurement tolerances.

DOE is aware that industry test practices are not currently consistent with this approach. As such, DOE recognizes that testing unit coolers with the expansion device shipped with the unit may require manufacturers to retest and recertify their unit cooler basic models. DOE is therefore not adopting the unit cooler expansion device requirements proposed in the April 2022 NOPR in appendix C. DOE is instead adopting those provisions only in appendix C1, which would be required for demonstrating compliance with any future amended WICF energy conservation standards. Manufacturers would therefore have additional time to retest and recertify unit cooler basic models impacted by these requirements.

c. Single-Packaged Dedicated System Setup and Charging Instructions

DOE has identified multiple setup issues while testing single-packaged dedicated systems. Compared to split refrigeration systems,[40] single-packaged dedicated systems have less adjustment flexibility due to lack of controls. Additionally, while many single-packaged dedicated systems are marketed as ''fully charged,'' DOE has found that many of its test units were undercharged.

In the April 2022 NOPR, DOE proposed that one or more pressure gauges (depending on the number of conditions that require a pressure measurement for validation) should be installed during setup according to the manufacturer's installation instructions to evaluate the charge of the unit under test and to accurately measure setup conditions. 87 FR 23920, 23949. The location of the pressure gauge(s) would depend on the test setup conditions given in the installation instructions. If charging is based on subcooling or liquid pressure, DOE proposed that the pressure gauge(s) would be installed at the service valve of the liquid line. If charging is based on superheat, low side pressure, or a corresponding saturation temperature or dew point temperature, DOE proposed that the pressure gauge(s) would be placed in the suction line. 87 FR 23920, 23949.

DOE is aware that installation instructions for some single-packaged dedicated systems recommend against installing charging ports; however, DOE has observed through testing that some such units that recommend against installing charging ports do not operate once installed due to high- or low-pressure compressor cut off, which is often a symptom of under- or over-charging or refrigerant loss. These units are representative of what a contractor

[38] Evaporator temperature difference (TD) is the difference in temperature between the entering air and the refrigerant dew point of the exiting refrigerant.

[39] DOE held an *ex parte* meeting with Lennox and HTPG to clarify these comments. *See* Docket No. EERE–2017–BT–TP–0010–0043.

[40] ''Split refrigeration systems'' refer to systems made up of a condensing unit and a unit cooler that are connected by refrigerant lines and are not contained in a single housing. Split refrigeration systems could be field-matched condensing units and unit coolers or condensing units and unit coolers sold as matched pairs.

would encounter when installing a walk-in single-packaged dedicated system in the field. Therefore, in cases where a unit under test is not operating due to high- or low-pressure compressor cut off, DOE proposed in the April 2022 NOPR that a charging port should be installed, the unit should be evacuated, and the nameplate charge should be added. 87 FR 23920, 23949. This approach would eliminate under- or over-charging of the unit which would address compressor cut off.

DOE received no comments in response to the proposals in this section. In this final rule, DOE is adopting the single-packaged dedicated system setup instructions proposed in the April 2022 NOPR into appendix C, and will also carry these provisions over to appendix C1.

d. Hierarchy of Setup Conditions if Manufacturer-Specified Setup Conditions Cannot Be Met

In DOE's experience, even when all the previously discussed measures are implemented during test setup, some manufacturer-specified setup conditions may not be met. In this case, DOE proposed in the April 2022 NOPR that the unit under test be set up according to a hierarchy of conditions like those used for central air-conditioning systems and heat pumps. 87 FR 23920, 23949. First, the installation instruction hierarchy previously discussed in section III.F.3 would be applied. Specifically, if a refrigerant-related setup instruction in the installation instructions affixed to the unit and a different instruction in the installation instructions shipped with the unit cannot both be achieved within tolerance, the instruction on the label takes precedence. Further, if multiple instructions within the relevant installation instructions cannot be met, the proposed hierarchy outlined in Table III.3 would be applied. The highest priority condition that can be satisfied, based on Table III.3, would need to be met, depending on what kind of expansion device the system uses. This approach would ensure that units are set up consistently across testing facilities, ensuring more consistent results.

DOE received no comments in response to this proposal. In this final rule, DOE is adopting the hierarchy of setup conditions proposed in the April 2022 NOPR into appendix C, and will also carry these provisions over to appendix C1.

4. Subcooling Requirement for Mass Flow Meters

Section C3.4.5 of AHRI 1250–2009 requires that refrigerant be subcooled to at least 3 °F and that bubbles should not be visible in a sight glass immediately downstream of the mass flow meter. Section 3.2.3 of appendix C allows use of the sight glass and a temperature sensor located on the tube surface under the insulation to verify sufficient subcooling. DOE testing has shown that even when the subcooling requirement is met downstream of the mass flow meter, the liquid temperature can be warmer upstream. This difference results in less subcooling, and mass flow measurements may not provide capacity within the required tolerances (*i.e.,* within 5 percent of each other [41] as required by section C8.5.3 of AHRI 1250–2009). 87 FR 23920, 23950. In the April 2022 NOPR, DOE proposed to include additional instruction to section 3.2.3 of appendix C, to ensure fully liquid flow at the mass flow meter. *Id.*

First, DOE proposed that the 3 °F subcooling requirement be applied at a location dependent on the location of the liquid-line mass flow meters. *Id.* Specifically, the proposed requirement applies downstream of any mass flow meter located in the chamber that contains the condensing unit under test, consistent with AHRI 1250–2009. However, for mass flow meters located in the chamber that contains the unit cooler under test, subcooling would need to be verified upstream. In the April 2022 NOPR, DOE requested comments on its proposal to clarify the location where the 3 °F subcooling requirement would apply. *Id.*

AHRI stated that the proposal to clarify the location where the 3 °F subcooling applies may be sufficient in most, but not all, cases. (AHRI, No. 30 at p. 6) AHRI, KeepRite, and National Refrigeration recommended measuring temperature before and after the mass flow meter and calculating subcooling using the higher of the two temperatures with the pressure downstream of the meter to guarantee fully liquid flow. (AHRI, No. 30 at p. 6; KeepRite, No. 36 at p. 2; National Refrigeration, No. 39 at p. 2)

HTPG recommended insulating the flow meter and line set to guarantee fully liquid flow. (HTPG, No. 32 at p. 5)

[41] Section C8.5.3 of AHRI 1250–2009 requires that the two refrigerant-side gross capacities calculated based on the two sets of independent temperature, pressure, and mass flow measurements are within 5 percent of each other to ensure adequate subcooling. In the absence of adequate subcooling, the two refrigerant-side gross capacities may not be within 5 percent of each other due to disagreement in the mass flow readings.

HTPG also recommended that for dedicated condensing unit testing, the temperature measurement should be made before the flow meter inlet and for unit cooler testing, temperature measurement should be taken after the flow meter outlet. *Id.*

Lennox and RSG agreed with DOE's proposal to clarify the subcooling condition measurement location. (Lennox, No. 35 at p. 4; RSG, No. 41 at p. 2)

DOE notes that, assuming the mass flow meters are in the same room as the dedicated condensing unit, insulating the flow meter and line set may or may not help ensure fully liquid flow, depending on whether the temperature surrounding the line set and flow meter are higher or lower than the liquid temperature. DOE agrees that HTPG's recommendation for measuring the subcooling before and after the mass flow meters may provide a more rigorous approach for ensuring adequate subcooling throughout the flow meter than the procedure proposed by DOE in the April 2022 NOPR. However, during testing, DOE has found that the subcooling measurement locations proposed in the April 2022 NOPR ensure adequate subcooling through the mass flow meters with reduced test burden. Therefore, DOE is adopting the subcooling measurement locations as proposed in the April 2022 NOPR. DOE is adding the new requirements to appendix C, and will also carry these provisions over to appendix C1.

Second, DOE proposed that active cooling of the liquid line may be used to achieve the required subcooling, because the subcooling at the mass flow meter outlet may not meet the 3 °F requirement when the subcooling at the condensing unit exit is within tolerance of its target. However, DOE also proposed requiring that if active cooling is done when testing a matched pair (not including single-packaged dedicated systems), the temperature also must be measured upstream of the location where cooling is provided, and the temperature used to calculate the enthalpy of the refrigerant entering the unit cooler be increased by the difference between the upstream and downstream measurements. DOE proposed this adjustment so that active cooling of the liquid to obtain a mass flow measurement does not provide a non-representative boost in calculated cooling capacity.

In the April 2022 NOPR, DOE sought comment on its active subcooling and capacity calculation adjustment proposals. 87 FR 23920, 23950. In response, AHRI and KeepRite recommended adjusting test results for active cooling based on suction pressure when testing matched pairs. (AHRI, No. 30 at p. 6; KeepRite, No. 36 at p. 2) KeepRite additionally stated that active subcooling should be constrained to prevent excessive subcooling and to obtain consistent results. (KeepRite, No. 36 at p. 2) KeepRite also recommended additional testing to determine best practices for an active subcooling system and presented some possible best practices. (KeepRite, No. 36 at p. 3) RSG agreed with DOE's proposal to require adjustment of the measured unit cooler for active cooling. (RSG, No. 41 at p. 2)

DOE acknowledges these comments and is making the following adjustments to the final test procedure to address stakeholder concerns. Instead of requiring an enthalpy adjustment if active subcooling is used, DOE is requiring that, if active subcooling is used, the line must be reheated such that the refrigerant is at the same temperature as it was upstream of the active subcooling device. This approach allows recording of an accurate mass flow measurement with no impact on the measured capacity of the unit under test. DOE is adopting the rest of the test procedures allowing active subcooling as proposed in the April 2022 NOPR. DOE is adding the new requirements to appendix C, and will also carry these provisions over to appendix C1.

5. Instrument Accuracy and Test Tolerances

The current DOE test procedure references AHRI 1250–2009 for instrument accuracy and test tolerances with some modifications (*see* 10 CFR part 431, subpart R, appendix C, section 3.1). As discussed in the April 2022 NOPR, some tolerances and instrumentation accuracy requirements in AHRI 1250–2020 are not consistent with the current DOE test procedure. 87 FR 23920, 23950. Specifically, DOE proposed to adopt the following changes from AHRI 1250–2020 into appendix C:

• Change the measurement accuracy for the temperature of air entering or leaving either the evaporator or condenser from ± 0.25 °F.

• Replacing the ASHRAE 23.1 refrigerant mass flow operating tolerance of ± 1 percent of the quantity measured with an operating tolerance of 3 pounds per hour (''lb/h'') or 2 percent of the reading (whichever is greater).

DOE did not receive comment on these proposals in the April 2022 NOPR. In this final rule, DOE is adopting the proposed changes from AHRI 1250–2020 into appendix C. These changes are not expected to impact measured values. DOE is adding the new requirements to appendix C, and will also carry these provisions over to appendix C1.

6. CO_2 Unit Coolers

As discussed in the April 2022 NOPR, CO_2 behaves differently than other refrigerants, as it has a critical temperature of 87.8 °F.[42] Ambient temperatures greater than 87.8 °F are common, and the performance of many refrigeration and air-conditioning systems are tested using a 95 °F ambient temperature, as indicated by the A test condition in Section 5 of AHRI 1250–2009 (and AHRI 1250–2020). At temperatures greater than the critical temperature, the CO_2 refrigerant is in a supercritical state. Since useful cooling is provided below the critical temperature, CO_2 cycles are said to be transcritical.

DOE has granted test procedure waivers to the manufacturers listed in Table III.1 of this document for certain basic models of walk-in refrigeration systems that use CO_2 as a refrigerant. Manufacturers requesting a waiver from the DOE test procedure for CO_2 unit coolers stated that the test conditions described in Tables 15 and 16 of AHRI 1250–2009, as incorporated by appendix C, with modification, cannot be achieved by, and are not consistent with the operation of, CO_2 direct expansion unit coolers. The alternate test procedure provided in these waivers modifies the test condition values to reflect typical operating conditions for a transcritical[43] CO_2 booster system. Specifically, the waiver test procedures require that CO_2 unit cooler testing is conducted at a liquid inlet saturation temperature of 38 °F and a liquid inlet subcooling temperature of 5 °F.

In the April 2022 NOPR, DOE proposed to adopt in appendix C (and also in appendix C1), the alternate test conditions specified in the waivers that DOE granted for CO_2 transcritical unit coolers for all CO_2 unit coolers. Also, consistent with the waiver alternate test procedure, DOE proposed that the EER values in Table 17 of AHRI 1250–2009 (or Table 18 of AHRI 1250–2020 for appendix C1) be used to determine the AWEF of all CO_2 unit coolers. 87 FR 23920, 23952. DOE requested comment on the appropriateness of traditional refrigerant compressor EER values for use in CO_2 unit cooler AWEF calculations. *Id.*

AHRI, HTPG, Hussmann, Lennox, and National Refrigeration all agreed with the proposal. (AHRI, No. 30 at p. 7; HTPG, No. 32 at p. 5; Hussmann, No. 38 at p. 6; Lennox, No. 35 at p. 4; National Refrigeration, No. 39 at p. 2) DOE is adopting the test procedure as proposed in the April 2022 NOPR for CO_2 unit coolers and adding the new requirements to appendix C, and will also carry these provisions over to appendix C1.

7. High-Temperature Unit Coolers

As discussed in the April 2022 NOPR, DOE is aware of wine cellar (high-temperature) refrigeration systems that fall within the definition of ''walk-in'' but are unable to be tested under the current version of the walk-in test procedure due to their operation at a temperature range of 45 °F to 65 °F. 87 FR 23920, 23952. Most of the high-temperature refrigeration systems that DOE is aware of are either single-packaged dedicated systems or matched pairs. However, DOE has granted an interim waiver for high-temperature unit coolers that are distributed into commerce without a paired condensing system.[44]

Under the current test procedure, these unit cooler-only models would be tested according to the provisions in the test procedure for unit coolers tested alone, for which the AWEF calculation requires an appropriate EER. DOE has determined that the EER values for medium- and low-temperature unit coolers tested alone are not appropriate for high-temperature applications because this equipment operates with a different suction dew point temperature, and the dedicated condensing units typically paired with medium- and low-temperature units likely use different compressor designs, which would have different efficiencies.

As discussed in the April 2022 NOPR, DOE calculated representative compressor EER levels for wine cellar walk-in unit coolers based on compressor performance data collected by DOE. 87 FR 23920, 23953. DOE used

[42] All refrigerants have a ''critical pressure'' and an associated ''critical temperature'' above which liquid and vapor phases cannot coexist. Above this critical point, the refrigerant will be a gas and its temperature will increase or decrease as heat is added or removed.

[43] CO_2 refrigeration systems are transcritical because the high-temperature refrigerant that is cooled by ambient air is in a supercritical state, above the 87.8 °F critical point temperature, above which the refrigerant cannot exist as separate vapor and liquid phases.

[44] DOE granted an interim waiver to LRC Coil Company for specific basic models of unit cooler-only walk-in wine cellar refrigeration systems on August 26, 2021. 86 FR 47631. (*See also* EERE–2020–BT–WAV–0040, No. 1.) In reviewing another petition for waiver and interim waiver from Vinotheque for single-packaged system and matched pair system basic models (Vinotheque, EERE–2019–BT–WAV–0038, No. 6), DOE noted that the manufacturer also offered unit cooler-only systems distributed without a paired condensing system.

the calculated compressor EER levels to develop different functions of EER for three distinct capacities, as summarized in Table III.4.

TABLE III.4—EER VALUES FOR HIGH-TEMPERATURE COMPRESSORS AS A FUNCTION OF CAPACITY FOR HIGH-TEMPERATURE REFRIGERATION SYSTEMS

Capacity (Btu/hr)	EER (Btu/(W-h))
<10,000	11.
10,000–19,999	(0.0007 × Capacity) + 4.
20,000–36,000	18.

The LRC Coil interim waiver includes additional test procedure provisions to obtain representations that are representative for high-temperature unit coolers, including both testing requirements and AWEF calculation requirements. 86 FR 47631. These include provisions for testing ducted fan coil unit evaporator systems. 86 FR 47631, 47635.

In the April 2022 NOPR, DOE proposed to include provisions for testing high-temperature unit coolers in appendix C. 87 FR 23920, 23953. These provisions, consistent with the LRC Coil interim waiver, would include conditions for testing these unit coolers at high-temperature refrigeration conditions, as well as the EER values in Table III.4 for calculation of AWEF. DOE also proposed to include these provisions in appendix C1 in the April 2022 NOPR. *Id.* AHRI-Wine agreed with DOE's inclusion of high-temperature unit cooler; however, they are concerned with the suitability of the test provisions and AWEF criteria. (AHRI-Wine, No. 30 at p. 2)

DOE notes that high-temperature unit coolers have the same function as medium- and low-temperature unit coolers, however, their suction dew point temperature differs, and counterpart-dedicated condensing units may use high-temperature compressors designed for higher temperatures. Therefore, DOE has concluded that the same test procedure can be used for low-, medium- and high- temperature unit coolers, as long as the EER values presented in Table III.4 are used for high-temperature operation. After consideration of stakeholder comments, DOE is adopting the test procedure provisions for high-temperature unit coolers as proposed in the April 2022 NOPR. DOE is adding the new requirements to appendix C, and will also carry these provisions over to appendix C1.

AHRI also stated that rating high-temperature unit coolers alone without a method to rate high-temperature dedicated condensing units disadvantages matched pairs and single-packaged dedicated systems. (AHRI, No. 30 at p. 2) DOE will evaluate standards for high-temperature equipment, including any appropriate equipment classes, in the ongoing walk-in energy conservation standards rule making. DOE's evaluation of the wine cellar market indicates that specific high-temperature dedicated condensing units are rarely, if ever, sold outside of matched-pair configurations. The dedicated condensing units DOE has encountered that are sold outside of a matched-pair configuration and that may be used in high-temperature applications are general-purpose condensing units often marketed for medium- and high-temperature, or only medium-temperature applications. Based on the definition of walk-in coolers (*i.e.,* medium-temperature refrigeration systems; *see* 10 CFR 431.302), DOE has determined that the dedicated condensing units used for high-temperature applications are medium-temperature dedicated condensing units. As such, these units do not need to be certified for high-temperature applications but do need to be certified for medium-temperature applications.

G. Establishing Appendix C1 for Refrigeration Systems

In the April 2022 NOPR, DOE proposed to establish a new appendix C1 to subpart R of part 431, which would be required to demonstrate compliance coincident with the compliance date of any amended energy conservation standards that DOE may promulgate as part of a separate standards rulemaking. 87 FR 23920, 23953.

As the changes included in appendix C1 are expected to change measured values for walk-ins, DOE is establishing a new annual walk-in efficiency factor metric, AWEF2, that will replace the current metric, AWEF, once appendix C1 is required for use. In many cases, AWEF2 of a given refrigeration system will not be the same as AWEF. For any amended energy conservation standards that DOE may promulgate as part of a separate standards rulemaking, the standards will be set based on AWEF2.

While AHRI 1250–2009 provides a method for determining off-cycle fan power, AHRI 1250–2020 includes off-cycle power measurement for additional auxiliary components (*e.g.,* crankcase heaters, pan heaters, and controls). AHRI 1250–2020 also adds test procedures that allow for the testing of single-packaged dedicated systems and account for the thermal loss of these systems. Taking into consideration the additions just described, DOE has determined that AHRI 1250–2020 improves representativeness and expands the applicability of the walk-in refrigeration system test procedure. Additionally, DOE test procedures strive to be consistent with industry test methods. As AHRI 1250–2020 is the most recent revision to the industry test procedure for walk-in refrigeration systems, it is the best representation of current industry testing practices. Therefore, DOE is incorporating AHRI 1250–2020 by reference into its test procedure at appendix C1 for walk-in refrigeration systems.

The test procedure changes that DOE is adopting as a part of appendix C1 are discussed in the following sections.

1. Off-Cycle Power Consumption

For walk-in refrigeration systems, the term ''off-cycle'' refers to the period when the compressor is not running and defrost (if applicable) is not active. During off-cycle, unit cooler fans and other auxiliary equipment (crankcase heater, receiver heater, etc.)[45] may typically run or cycle on and off, consuming energy. The DOE test procedure currently accounts for only unit cooler fan energy use during the off-cycle period. 10 CFR part 431, subpart R, appendix C, section 3.3.3. Specifically, the current test procedure requires manufacturers to measure the integrated average off-cycle fan wattage[46] for matched pairs and unit coolers tested alone. Dedicated condensing units tested alone use default fan energy values rather than tested values. 10 CFR part 431, subpart R, appendix C, section 3.4.2.2. When calculating AWEF, the unit cooler fans are assumed to run at this average integrated wattage throughout the entire off-cycle duration. *Id.*

In the April 2022 NOPR, DOE discussed the recommendation of the ASRAC Working Group (Docket No.

[45] A crankcase heater prevents refrigerant migration and mixing with the crankcase oil when the compressor is off by heating the crankcase of the compressor. A receiver heater warms refrigerant in the receiver to prevent flooded starts of the compressor and cycling on low pressure to reduce the potential for compressor damage. Both heaters are used for outdoor dedicated condensing units in colder climates.

[46] Fans using periodic stir cycles are tested at the greater of a 50 percent duty cycle or the manufacturer's default. Fans with two-, multi-, or adjustable-speed controls are tested at the greater of 50% fan speed or the manufacturer's default fan speed. Fans with no controls are tested at their single operating point. (*See* 10 CFR part 431, subpart R, appendix C, section 3.3.3.)

EERE–2015–BT–STD–0016, No. 56,[47] Recommendation #6) to revise the off-cycle test procedure to account for all other components that consume energy during the off-cycle, such as pan heaters, crankcase heaters, and controls. 87 FR 23920, 23953. DOE noted that AHRI 1250–2020 includes a method for determining energy consumption during off-cycle for many of these components. *Id.*

DOE is adopting the off-cycle procedure in sections C3.5, C4.2, and Table C3 in AHRI 1250–2020 with some modifications. The following sections describe DOE's modifications to the off-cycle test method and metric in more detail.

a. Off-Cycle Test Duration and Repetition

The current DOE test procedure references the 30-minute off-cycle test duration prescribed in section C3.6 of AHRI 1250–2009. AHRI 1250–2020 was updated to include two off-cycle test durations: (1) 30 minutes for evaporator fans and ancillary equipment with controls that are time-varying or respond to ambient or refrigerant temperatures (*e.g.,* a crankcase heater or fan cycling control), and (2) 5 minutes for evaporator fans and ancillary equipment without such controls.

DOE has concluded that these durations balance the need to minimize test burden with the need for an accurate and representative test method. In the April 2022 NOPR, DOE proposed to reference these test durations. 87 FR 23920, 23954.

AHRI 1250–2020 also added two sets of test repetition requirements: one for evaporator fans and ancillary equipment with controls that are time-varying or respond to ambient or refrigerant temperatures (*e.g.,* a crankcase heater or fan cycling control), and one for evaporator fans and ancillary equipment without such controls. For the former, AHRI 1250–2020 requires that the off-cycle test for each applicable load point[48] consists of three initial test cycles, with the potential for three supplemental cycles. As discussed in the April 2022 NOPR, AHRI 1250–2020 only requires the three supplemental tests if the integrated power of the first three cycles is not within 2 percent of the average of the first three cycles. 87 FR 23920, 23954. If the same variation occurs for the supplemental test cycles, then AHRI 1250–2020 requires that off-cycle power be reported as the maximum value of all six integrated power readings. Alternatively, for equipment lacking evaporator fans and ancillary equipment controls, AHRI 1250–2020 requires measuring integrated power over a single cycle. A summary of test durations and fan settings based on fan control configuration and ancillary equipment control configuration is listed in Table III.5.

TABLE III.5—OFF-CYCLE TEST SETTINGS AND DURATIONS

Fan control configuration	Ancillary equipment control configuration	Fan setting for test	Test duration
No Control	No Control	Default setting, as shipped	5 minutes.
No Control	With Control	Default setting, as shipped	30 minutes.
User-Adjustable Speed Controls.	No Control	The greater of 50% fan speed or the manufacturer's default fan speed.	5 minutes.
User-Adjustable Speed Controls.	With Control	The greater of 50% fan speed or the manufacturer's default fan speed.	30 minutes.
User-Adjustable Stir Cycles	With or Without Control	The greater of a 50% duty cycle or the manufacturer default..	The greater of 30 minutes or three full "stir cycles."
Non-User Adjustable Controls.	With or Without Control	Default setting, as shipped	30 minutes.

DOE has concluded that the repetition requirements specified by AHRI 1250–2020 are adequate and not overly burdensome. If the variance is small among the first three cycles, then the testing burden is reduced by not requiring any more cycles. If variance exceeds 2 percent of the average when three additional cycles are taken, then the conservative approach is taken by reporting the maximum integrated power reading, and test burden is reduced by not requiring additional tests. In the April 2022 NOPR, DOE proposed to adopt the repetition requirements included in AHRI 1250–2020. 87 FR 23920, 23954.

In response to the off-cycle test durations and repetitions proposed in the April 2022 NOPR, the Efficiency Advocates stated that they supported updating off-cycle testing to include a unit's total input wattage. (Efficiency Advocates, No. 37 at p. 1) Lennox supported DOE proposals regarding off-cycle test duration and repetition. (Lennox, No. 35 at pp. 4–5) In this final rule, DOE is adopting the off-cycle test duration and repetition test procedures as proposed.

b. Off-Cycle Operating Tolerances and Data Collection Rates

In the April 2022 NOPR, DOE proposed to adopt Section C3.5 of AHRI 1250–2020 to establish off-cycle data collection requirements in the DOE test procedure. 87 FR 23920, 23955. AHRI 1250–2020 excludes the first 10 minutes that follow the termination of the compressor on-cycle interval from the general operating tolerances (indoor/outdoor temperatures and power readings) established for the on-cycle steady state test because during this time period, the test room conditioning equipment is transitioning from steady state on-cycle operation into off-cycle operation.

Additionally, AHRI 1250–2020 requires that the minimum data collection rate be increased (with respect to steady-state requirements) from 30 to 60 test readings per hour for temperature measurements and condensing unit electric power measurements, and from 3 to 60 test readings per hour for unit cooler electric power measurements. AHRI 1250–2020 also requires that off-cycle power measurements be integrated and averaged over the recording interval with a sampling rate of no less than 1 second unless an integrating watt/hour meter is used.

In response to the April 2022 NOPR, Lennox commented that it supports DOE's off-cycle power measurement proposals but requested clarification on

[47] Appliance Standards and Rulemaking Federal Advisory Committee Refrigeration Systems Walk-in Coolers and Freezers Term Sheet, available at *www.regulations.gov/document/EERE-2015-BT-STD-0016-0056.*

[48] Off-cycle load points are discussed later in this section.

unit cooler ''steady-state ambient conditions,'' specifically whether 35 °F and –10 °F for unit cooler refers to air entering dry-bulb in Tables 16 and 17 of AHRI 1250–2020. (Lennox, No. 35 at pp. 4–5) DOE clarifies that the unit cooler ''steady-state ambient conditions'' of 35 °F and –10 °F refer to the entering air dry-bulb temperatures of medium-temperature and low-temperature unit coolers, respectively. DOE did not receive any additional comments on this topic and is adopting section C3.5 of AHRI 1250–2020 for off-cycle operating tolerances and data collection requirements, as proposed.

c. Off-Cycle Load Points

Currently, the DOE test procedure specifies measuring off-cycle evaporator fan power and provides no ambient condition detail; however, DOE expects that the integrated power of ancillary equipment may vary with ambient conditions depending on the refrigeration system design. Consequently, in the April 2022 NOPR, DOE proposed that the off-cycle power test described in section III.G.1.a of this document be run at each steady-state ambient test condition as specified in Tables 4 through 17 of AHRI 1250–2020. 87 FR 23920, 23955. Accordingly, DOE proposed that refrigeration systems with dedicated condensing units located indoors would evaluate off-cycle power at a single outdoor ambient condition (90 °F dry-bulb), while systems with dedicated condensing units located outdoors would determine off-cycle power at three ambient conditions (95 °F, 59 °F, and 35 °F dry-bulb). The measured integrated off-cycle power results would then be used to calculate AWEF2, as described in the following section.

In response to the April 2022 NOPR, KeepRite commented that the benefit from additional off-cycle power tests is minimal, capturing less than 1 percent of total system energy. (KeepRite, No. 36 at p. 3) DOE acknowledges that off-cycle power tests account for significantly less energy consumption than on-cycle tests. However, DOE's testing using the three ambient temperature off-cycle load points in AHRI 1250–2020 has measured up to 60 percent more off-cycle power use than the off-cycle power measurements in the current test procedure. This result indicates that the current test procedure does not fully represent off-cycle power use for walk-in refrigeration systems.

HTPG disagreed with the additional off-cycle testing requirement proposed in the April 2022 NOPR (HTPG, No. 32 at p. 6) and stated that it would increase test burden. (HTPG, No. 32 at p. 8) AHRI-Wine stated that they expect the change related to off-cycle power measurement requirements will increase test burden. (AHRI-Wine, No. 30 at p. 3) DOE acknowledges that adopting the off-cycle power measurements in AHRI 1250–2020 may incrementally increase test time. However, in its testing, DOE has found that conducting off-cycle power measurements accounts for less than 10 percent of the overall setup and test duration for walk-in refrigeration systems.

Lennox stated that using a single condition to measure off-cycle power may not be sufficient for indoor matched systems. (Lennox, No. 35 at p. 5) Lennox also recommended working with industry to establish running conditions for equipment that is not part of a matched pair. *Id.* DOE notes that the number and specified conditions of off-cycle tests correspond to the number and specified conditions of the refrigeration capacity tests that are run for each unit. Outdoor units have three capacity tests and three ambient conditions to represent the three ambient conditions that the unit would be exposed to, therefore they have three off-cycle tests. Indoor units have one capacity test at one ambient condition that the unit would be exposed to, therefore they have one off-cycle test. The ambient conditions inside the walk-in box do not fluctuate and therefore one ambient condition is representative for both on-cycle and off-cycle tests. DOE has concluded that this is the most appropriate approach to balance test procedure consistency and test burden.

DOE is adopting the off-cycle test points for (1) the A test specified in AHRI 1250–2020 for fixed-capacity refrigerator and freezer matched-pair and dedicated condensing units located indoors, (2) the A, B, and C tests specified in AHRI 1250–2020 for refrigerator and freezer matched-pair and dedicated condensing units located outdoors, and (3) the A test specified in AHRI 1250–2020 for refrigerator and freezer unit coolers. DOE clarifies that a single off-cycle test is representative for both split-system unit coolers and indoor matched systems.

d. AWEF2 Calculations

In the April 2022 NOPR, DOE proposed to adopt the off-cycle calculations in AHRI 1250–2020, which replace integrated off-cycle evaporator fan power with the combined integrated off-cycle power from the unit cooler and condensing unit in each equation. 87 FR 23920, 23955. Additionally, DOE proposed to adopt the off-cycle calculations in AHRI 1250–2020, which replace integrated off-cycle fan power with integrated off-cycle power in the unit cooler equation. *Id.* This aspect of the unit cooler test method is consistent with the current method specified in appendix C to subpart R of 10 CFR part 431.

For outdoor refrigeration systems, DOE proposed to deviate from the AHRI 1250–2020 calculations for off-cycle energy use in the April 2022 NOPR. 87 FR 23920, 23955. DOE notes that the AHRI 1250–2020 equations for average refrigeration system total power input for bin temperature T_j, (*e.g.,* Equation 13), do not appear to use off-cycle power values for the unit cooler and/or the condensing unit that vary with T_j. In fact, there are no equations providing the off-cycle power for either component as a function of T_j in section 7 of AHRI 1250–2020, such as there are for net capacity and on-cycle power input (*e.g.,* Equations 14 through 17). Since the off-cycle power may vary as a function of outdoor temperature as discussed previously, DOE proposed in the April 2022 NOPR to adopt instructions for calculating off-cycle power as a function of outdoor temperature based on the measurements made at the three outdoor test condition temperatures. 87 FR 23920, 23955–23956.

For condensing unit off-cycle power, DOE proposed in the April 2022 NOPR to require that off-cycle power for T_j less than or equal to 35 °F would be equal to the power measured for the test condition C off-cycle power test. 87 FR 23920, 23956. For T_j higher than 95 °F, DOE proposed that that off-cycle power would be equal to the power measured for the test condition A off-cycle power test. *Id.* Between these two temperatures, DOE proposed that condensing unit off-cycle power would be determined based on the test condition B and C measurements when T_j is below 59 °F, and based on the A and B measurements when it is above 59 °F, similar to Equations 14 through 17 for on-cycle capacity and power in AHRI 1250–2020. *Id.*

For unit cooler off-cycle power, DOE proposed in the April 2022 NOPR that the three unit cooler off-cycle power measurements taken when testing a matched-pair or single-packaged dedicated system would be averaged, and that the resulting average, with no dependence on T_j, would be used in the AWEF2 calculations. *Id.*

DOE requested comment on its proposals to align the test procedures for appendix C1 with AHRI 1250–2020, except for the use of off-cycle power measurements in the AWEF2 calculations for dedicated condensing units, matched pairs, and single-packaged dedicated systems intended for outdoor installation. *Id.* DOE also requested comment on its proposals to use three sets of unit cooler and outdoor dedicated condensing unit off-cycle measurements in the AWEF calculations. *Id.*

In response, KeepRite stated that the AWEF2 calculations could be non-representative depending on what temperature the crankcase heater turns on and recommended an option for constant crankcase heater power below the 35 °F test bins. (KeepRite, No. 36 at p. 3) DOE notes that the proposed AWEF2 calculations are incorporated from AHRI 1250–2020. DOE notes that industry agreed to these calculations during the development of AHRI 1250–2020; therefore, DOE will not consider alternative calculations for representing off-cycle dedicated condensing unit power at this time.

RSG recommended that DOE further define off-cycle unit cooler fan speed as either 50 percent of full speed or the factory low speed setting (if the low-speed setting is less than 50 percent and not adjustable by the end user). (RSG, No. 41 at p. 5) DOE notes that section 4.2 of Appendix C to AHRI 1250–2020 states that for variable-speed unit cooler fan controls, the greater of 50 percent fan speed or the manufacturer's default fan speed shall be used for measuring off-cycle fan energy. Since this is the test practice agreed on by industry, DOE is not allowing fan speeds of less than 50 percent for off-cycle unit cooler testing in this final rule.

Lennox stated that the test procedure requires three measurements at different ambient conditions for matched-pair and single-packaged dedicated systems but does not explicitly state what to do for split-system unit coolers. (Lennox, No. 35, at p. 5) Additionally, Lennox stated that a single test condition may not be sufficient for split-system unit coolers. *Id.* DOE clarifies that for matched-pair and single-packaged dedicated systems located outdoors, there are three ambient conditions at which the dedicated condensing system is tested, therefore there are three corresponding off-cycle unit cooler power measurements. These off-cycle test conditions are specified in Tables 5 and 9 of AHRI 1250–2020 for fixed-capacity matched pairs. AWEF2 is calculated as the average of these three measurements since these measurements should not vary with ambient temperature. For split-system unit coolers tested alone, there is no component exposed to outdoor ambient conditions, therefore there is only one condition at which the unit cooler is tested and one corresponding off-cycle power measurement. These conditions are listed in Tables 16 and 17 of AHRI 1250–2020. As there is only one ambient condition at which the unit cooler is tested, DOE believes that the single off-cycle measurement is sufficient for split-system unit coolers.

In this final rule, DOE is adopting the procedures as proposed in the April 2022 NOPR into appendix C1.

2. Single-Packaged Dedicated Systems

a. AHRI 1250–2020 Methods for Testing

As discussed in the April 2022 NOPR, the Direct Expansion (''DX'') dual instrumentation method is impractical for testing single-packaged dedicated systems. 87 FR 23920, 23958. AHRI 1250–2020 expanded methods of test for single-packaged dedicated systems to include air enthalpy, calorimetry, and compressor calibration. Specifically, AHRI 1250–2020 incorporates the following test procedures by reference:

(1) *Air enthalpy method:* ASHRAE 37–2009, ''Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat-Pump Equipment,'' and ANSI/ASHRAE 41.6–2014, ''Standard Method for Humidity Measurement'';

(2) *Calorimeter methods:* ASHRAE 16–2016, ''Method of Testing for Rating Room Air Conditioners, Packaged Terminal Air Conditioners, and Packaged Terminal Heat Pumps for Cooling and Heating Capacity''; and

(3) *Compressor calibration methods:* ASHRAE 37–2009, ''Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat-Pump Equipment,'' and ANSI/ASHRAE 23.1-2010, ''Methods of Testing for Rating the Performance of Positive Displacement Refrigerant Compressors and Condensing Units that Operate at Subcritical Temperatures of the Refrigerant.''

AHRI 1250–2020 requires two simultaneous measurements of system capacity (*i.e.,* a primary and a secondary method) for single-packaged dedicated systems, and section C9.2.1 of AHRI 1250–2020 requires that the measurements agree within 6 percent. Table C4 in AHRI 1250–2020 specifies which test methods (calorimeter, air enthalpy, compressor calibration) qualify as primary and/or secondary methods. However, as summarized in Table III.6, DOE is adopting the method of test and the test hierarchy table in AHRI 1250–2020 with one modification—the addition of a single-packaged refrigerant enthalpy method. DOE is adopting this change to support testing of multi-circuit single-packaged dedicated systems, which is discussed in detail in section III.G.2.f of this document.

TABLE III.6—SINGLE-PACKAGED SYSTEM TEST METHODS AND TEST HIERARCHY

Method of test	Test hierarchy
Balanced Ambient Indoor Calorimeter	Primary.
Balanced Ambient Outdoor Calorimeter	Primary or Secondary.
Indoor Air Enthalpy	Primary or Secondary.
Indoor Room Calorimeter	Primary or Secondary.
Single-packaged Refrigerant Enthalpy [49]	Secondary.
Outdoor Room Calorimeter	Secondary.
Outdoor Air Enthalpy	Secondary.
Compressor Calibration	Secondary.

b. Waivers

As discussed in the April 2022 NOPR, DOE granted a waiver to Store It Cold for single-packaged dedicated systems on August 9, 2019. 87 FR 23920, 23956. DOE also granted waivers to Air Innovations, CellarPro, Vinotemp, and Vinotheque for walk-in refrigeration systems used in wine cellar applications, where some of the basic models included in these waivers were single-packaged dedicated systems.[50] The alternate test methods included in each of these waivers require the

[49] As described in section III.G.2.f of this document, this method of test does not apply to CO_2 single-packaged units.

[50] Table III.1 lists the manufacturers that have received a test procedure waiver or interim waiver for walk-in refrigeration systems designed for wine cellar applications.

specified basic models to be tested in accordance with the air enthalpy methods specified in ASHRAE 37–2009 for testing single-packaged dedicated systems, which is now referenced by AHRI 1250–2020. Additionally, DOE granted an interim waiver to RSG for multi-circuit single-packaged dedicated systems (''the RSG waiver''). 87 FR 43808. The alternate test method included in that waiver is further discussed in sections III.G.2.d through III.G.2.f of this document.

In appendix C1, DOE is referencing the methods of test for single-packaged dedicated systems from section C9 of AHRI 1250–2020, with some modifications. Since appendix C1 will be required on the compliance date of any amended energy conservation standards, were such standards to be adopted, the current test procedure waivers for specified single-packaged basic models will expire on the compliance date of appendix C1.

c. Suitability of the Single-Packaged Test Methods in AHRI 1250–2020

In the April 2022 NOPR, DOE discussed the suitability of the AHRI 1250–2020 test methods for single-packaged dedicated systems. 87 FR 23920, 23957. Specifically, DOE discussed stakeholder feedback from the June 2021 RFI that freezing of the calorimetry loop and the need for a pressure equalizing device on the test chamber are potential issues with the ASHRAE 16–2016 calorimeter method. DOE has tested multiple single-packaged dedicated systems at multiple labs and did not observe freezing of the calorimetry loop. Therefore, DOE has determined that the ASHRAE 16–2016 calorimetry methods are suitable for testing single-packaged dedicated systems. Furthermore, DOE concluded that the equalizer device for calorimeter room testing, which is required in ASHRAE 16–2016, is not necessary for the testing of single-packaged dedicated systems. As a result, DOE did not propose to require an equalizer device for calorimeter room testing in the April 2022 NOPR. *Id.* Therefore, in the April 2022 NOPR, DOE proposed to adopt the ASHRAE 16–2016 methods of test as referenced in AHRI 1250–2020 to provide flexibility to manufacturers.

DOE further discussed in the April 2022 NOPR that its testing on single-packaged dedicated systems using the room calorimeter and air enthalpy methods as described in AHRI 1250–2020 appropriately accounted for the thermal losses that are typical for this equipment. *Id.* DOE additionally noted that while there may not be extensive experience applying these test methods to walk-in refrigeration systems, all the proposed test methods have been evaluated and are used extensively for testing other heating, ventilation, and air-conditioning (''HVAC'') equipment. *Id.* Therefore, in the April 2022 NOPR, DOE tentatively determined that these methods are representative of single-packaged dedicated system energy use and proposed to adopt the single-packaged dedicated system test procedure in AHRI 1250–2020 with the modifications outlined in sections III.G.2.d and III.G.2.e of this document. *Id.*

In response to the April 2022 NOPR, the CA IOUs commented that they support DOE including a test method for single-packaged dedicated systems. (CA IOUs, No. 42 at p. 6) Based on DOE's experience testing this equipment and the comments received, DOE is adopting the test procedures for single-packaged dedicated systems in AHRI 1250–2020 as proposed in the April 2022 NOPR into appendix C1.

d. Single-Packaged Refrigerant Enthalpy Method

In the April 2022 NOPR, DOE proposed to adopt a single-packaged refrigerant method similar to the alternate test procedure outlined in RSG's waiver request. 87 FR 23920, 23958. On July 22, 2022, DOE issued an interim waiver to RSG for testing single-packaged dedicated systems with multiple refrigeration circuits using a modified refrigerant enthalpy method. 87 FR 43808.

As previously discussed, AHRI 1250–2020 includes four potential primary and six potential secondary test methods for testing single-packaged dedicated systems (*see* Table C4 in AHRI 1250–2020). The refrigerant enthalpy method is not included in these lists. The procedure that DOE proposed to adopt in the April 2022 NOPR uses the refrigerant-side measurements of the DX calibrated box method in section C8 of AHRI 1250–2020 while simultaneously using one of the ''primary'' methods listed in Table C4 in AHRI 1250–2020 for single-packaged methods of test as an air-side measurement. The details of the primary test methods were discussed in the April 2022 NOPR. 87 FR 23920, 23958.

In the April 2022 NOPR, DOE requested comment on its proposed procedure for testing single-packaged dedicated systems. AHRI recommended allowing DX dual instrumentation testing, since requiring air-side enthalpy testing would impose considerable test burden on test labs that do not have air-side measurement capacity. (AHRI, No. 30 at p. 7) Lennox stated that it can support the proposed refrigerant enthalpy approach as a secondary approach but recommended that the DX dual instrumentation method be maintained as an option. (Lennox, No. 35 at p. 5) Lennox also commented that requiring the air enthalpy test method would impose significant test burden. *Id.* In response to the recommendation by Lennox to maintain the DX dual instrumentation method, DOE's testing, in addition to the information received in the waivers for testing of single-packaged dedicated systems, indicates that the DX dual instrumentation method is inappropriate for single-packaged units because the internal volume of the added liquid line and mass flow meters adds substantially to the required refrigerant charge, and the entire assembly adds substantial pressure drop.[51] However, DOE notes that the DX dual instrumentation method continues to be an accurate test method for dedicated condensing units tested alone. Additionally, in response to Lennox's comment regarding the burden associated with the air enthalpy method, DOE has determined that the representativeness achieved through this method outweighs the additional burden.

AHRI and Lennox commented that piercing a refrigeration system to use the refrigerant enthalpy as a secondary check may not duplicate the primary result. (AHRI, No. 30 at p. 7; Lennox, No. 35 at p. 5) HTPG disagreed with the proposal to use the refrigerant enthalpy test for single-packaged dedicated units, as they are critically charged and piercing their lines could affect measured capacity. (HTPG, No. 32 at p. 6) The proposed procedure requires a primary test to be completed before the system is pierced. The capacity measured from the primary test would be compared to the capacity measured from the secondary test to ensure that the capacity is not affected from piercing the refrigeration system. Based on its testing, DOE has determined that a secondary test that does not materially alter the system operation would duplicate, and serve as a check for, the primary test. DOE also notes that there are secondary test options provided in Table C4 of AHRI 1250–2020 that do not require piercing of the refrigerant lines.

Lennox also stated that the refrigerant enthalpy test should be allowed to penetrate the system for the primary test since the secondary test would require the system to be penetrated. (Lennox, No. 35 at p. 5) DOE interprets this comment to be a request to allow the DX

[51] *See* Store It Cold Decision and Order, 84 FR 39286, 39287 (Aug. 9, 2019).

dual instrumentation test, or other refrigerant enthalpy tests, as a primary test for single-packaged dedicated systems. As discussed previously, DOE has concluded that the DX dual instrumentation test is not representative for single-packaged dedicated systems because it does not account for thermal losses. DOE reiterates that the purpose of the primary test, conducted prior to penetration of the refrigerant system, is to compare the primary and secondary results to ensure that the system is not affected from penetrating the liquid lines.

AHRI-Wine stated that they do not support the proposed refrigerant enthalpy test procedure because they do not see an advantage unless the method is used in parallel with others. (AHRI-Wine, No. 30 at p. 3) DOE notes that the single-packaged refrigerant enthalpy test procedure would be used only as a secondary test when paired with one of the primary options provided in Table C4 of AHRI 1250–2020.

RSG agreed with DOE's proposed test procedure. (RSG, No. 41 at p. 2) DOE is adopting the single-packaged refrigerant enthalpy test method as a secondary test as proposed in the April 2022 NOPR into appendix C1.

e. Calibrated Box Method for Single-Packaged Dedicated Systems

In the RSG waiver DOE allowed RSG to use a modified version of the calibrated box method. 87 FR 43808, 43813–43814. As discussed in the notification of interim waiver, the modified calibrated box method involves mounting the system on the calibrated box, like its installation on a walk-in for field use and exchanging air with the box interior to cool it. 87 FR 43808, 43812. The exterior of the calibrated box would be conditioned such that the air conditions entering the single-packaged dedicated system condenser match the specified targets. The warm condensing unit portion of the single-packaged dedicated system and its condenser discharge air may in some cases add to the thermal load imposed on the calibrated box. The interim waiver therefore provided additional optional test methods to quantify this additional thermal load on the calibrated box, and to adjust for it in the determination of system capacity. Determining the additional thermal load requires temperature sensors mounted on the box exterior surface for box calibration and box load determination, rather than measuring air temperature just outside the box (the approach described for the calibrated box method in section C8 of AHRI 1250–2020). Since the modified calibrated box method accounts for the thermal losses associated with single-packaged dedicated systems and is very similar to the indoor room calorimeter method, DOE tentatively determined in the RSG waiver that it would be appropriate for the calibrated box method to be a primary test method (*i.e.,* the capacity determined from this method would be used for rating purposes) 87 FR 43808, 43812. DOE proposed to adopt the method described in the RSG waiver in the April 2022 NOPR. *Id.* A full discussion of the test procedures proposed by RSG are discussed in the interim waiver notification. *Id.*

As mentioned previously, DOE received no stakeholder comments on the RSG waiver. Therefore, DOE is adopting the test provisions outlined in the RSG waiver in addition to the test provisions for single-packaged dedicated systems proposed in the April 2022 NOPR.

f. Multi-Circuit Single-Packaged Dedicated Systems

As discussed in the April 2022 NOPR, neither the current DOE test procedure nor AHRI 1250–2020 provides a method for testing single-packaged dedicated systems with multiple refrigeration circuits. As previously discussed, DOE granted RSG an interim waiver for testing multi-circuit single-packaged dedicated systems. 87 FR 43808. This test procedure is based on the single-packaged refrigerant enthalpy method discussed in section III.G.2.d of this document. The procedure is duplicated for each refrigeration circuit contained in the unit such that each circuit returns mass flow, enthalpy in, and enthalpy out values. The resultant mass flow and enthalpy values are used to calculate the gross refrigeration capacity for each circuit. Each circuit's gross capacity is then summed to determine the total capacity of the system.

In the April 2022 NOPR, DOE tentatively determined that the alternate approach would provide a reasonable method for determining the capacity of multi-circuit single-packaged dedicated systems. 87 FR 23920, 23958. However, DOE had also determined the approach may not adequately capture the heat loss associated with single-packaged dedicated systems; therefore, DOE proposed to adopt the test procedures in section C8 of AHRI 1250–2020 for testing single-packaged dedicated systems, with the additional requirement that the primary test would be an indoor air refrigeration capacity test where the allowable refrigeration capacity heat balance is 6 percent. *Id.*

In response to the April 2022 NOPR, HTPG commented that it agreed with DOE's proposal for testing multi-circuit single-packaged dedicated systems. (HTPG, No. 32 at p. 6) DOE is adopting the test procedure as proposed in the April 2022 NOPR into appendix C1.

g. CO_2 Single-Packaged Dedicated Systems

As discussed in the April 2022 NOPR, the current DOE test procedure for single-packaged dedicated systems does not provide representative values for single-packaged dedicated systems that use CO_2 as a refrigerant. 87 FR 23920, 23959. However, the single-packaged dedicated system test methods in AHRI 1250–2020 use air enthalpy measurements and do not require any refrigerant mass flow measurements. In the April 2022 NOPR, DOE proposed that single-packaged dedicated systems that use CO_2 as a refrigerant be tested using the test methods for single-packaged dedicated systems outlined in AHRI 1250–2020. *Id.*

In response, HTPG stated that it agreed with DOE's proposal for the air enthalpy test procedure for CO_2 single-packaged dedicated systems. (HTPG, No. 32 at p. 6) DOE is adopting the test as proposed in the April 2022 NOPR into appendix C1.

3. Detachable Single-Packaged Dedicated Systems

As discussed in section III.A.2.g, DOE is aware of refrigeration systems that are installed with the evaporator unit exchanging air through the wall or ceiling of the walk-in, but with the condensing unit installed remotely and connected to the evaporator with refrigerant lines. DOE has defined this equipment as a ''detachable single-packaged dedicated system.'' Neither appendix C nor AHRI 1250–2020 contain provisions for testing detachable single-packaged dedicated systems. DOE is aware that, currently, detachable single-packaged dedicated systems may be tested either with the condensing unit and unit cooler housings separated or mounted adjacent to each other, the latter of which is the more common arrangement for single-packaged dedicated systems. Testing in the latter arrangement would account for the heat loss of the evaporator installation, and any additional heat loss from the condensing unit being mounted to the evaporator unit; therefore, in the April 2022 NOPR, DOE proposed as part of the new appendix C1 and 10 CFR 429.53(a)(2)(i)(C) that detachable single-packaged dedicated systems would be tested using the test procedure for single-packaged dedicated systems. 87 FR 23920, 23959.

HTPG and Lennox agreed with the proposal. (HTPG, No. 32 at p. 6; Lennox, No. 35 at p. 5) AHRI, on behalf of wine cellar manufacturers stated that the proposal is sufficient. (AHRI-Wine, No. 30 at p. 4) RSG agreed with the proposal if the calibrated box method is included in allowable test methods. (RSG, No. 41 at p. 2) As discussed in section III.G.2.e, DOE is adopting the test provisions outlined in the interim waiver granted to RSG in July 2022. These include a calibrated box test procedure for single-packaged dedicated systems.

AHRI stated that the current test procedure is sufficient. (AHRI, No. 30 at p. 8) DOE interprets this comment as AHRI stating that the DX dual instrumentation method is sufficient for detachable single-packaged dedicated units. As discussed in section III.G.2.d, DOE's testing, in addition to information received in waivers for testing of single-packaged dedicated systems, indicates that the DX dual instrumentation method is inappropriate for single-packaged units.

Since detachable single-packaged dedicated systems have thermal losses similar to those for single-packaged dedicated systems, DOE is adopting the test procedure for detachable single-packaged dedicated systems as proposed in the April 2022 NOPR (87 FR 23920, 23959) into appendix C1.

AHRI-Wine also requested clarification for whether wine cellar manufacturers must test all configurations or the most common if multiple configurations apply to a single system. (AHRI-Wine, No. 30 at p. 2) The definition of ''detachable single-packaged dedicated system'' that DOE is adopting in this final rule states that it is a system that can be configured as either a split system or as a single-packaged dedicated system. Based on the procedure DOE is adopting, such a system would be tested as a single-packaged dedicated system.

4. Attached Split Systems

As discussed in section III.A.2.f, DOE is aware of refrigeration systems that are sold as matched systems and permanently attached to each other with beams. In this final rule, DOE is defining these systems as ''attached split systems.'' DOE has confirmed through testing that these systems still experience some heat leakage when compared to traditionally installed systems that have the dedicated condensing unit and the unit cooler in separate housings. However, this heat leakage has not been studied extensively and DOE is aware that it may be difficult to calculate.

DOE proposed in the April 2022 NOPR testing attached split systems as a matched pair using refrigerant enthalpy methods. 87 FR 23920, 23959. HTPG agreed with the proposal. (HTPG, No. 32 at p. 7) In this final rule, DOE is adopting the test procedure as proposed in the April 2022 NOPR into appendix C1 and 10 CFR 429.53(a)(2)(i)(D).

5. Systems for High-Temperature Freezer Applications

As discussed in the April 2022 NOPR, DOE recognizes that testing high-temperature freezer refrigeration systems at a consistent test condition is important to ensure test procedure consistency and to provide comparable performance values in the market. 87 FR 23920, 23961. DOE acknowledges that testing high-temperature freezer refrigeration systems at a temperature less than 35 °F would be more representative of their actual energy use; however, it is not clear if the potential additional test burden justifies including an additional test condition for walk-in cooler refrigeration systems. Therefore, in the April 2022 NOPR, DOE determined that medium-temperature dedicated condensing units used in high-temperature freezer applications would continue to be tested according to appendix C. *Id.*

In response to the April 2022 NOPR, HTPG stated that it agreed with DOE continuing to test high-temperature freezers in accordance with appendix C. (HTPG, No. 32 at p. 7) The Efficiency Advocates encouraged DOE to establish a standardized rating temperature for high-temperature freezers that is below 35 °F, since it is more characteristic of the temperature that these products operate between. (Efficiency Advocates, No. 37 at p. 3) As discussed in the April 2022 NOPR, DOE acknowledges that testing high-temperature freezer refrigeration systems at a temperature less than 35 °F would be more representative of their actual energy use; however, doing so would require an additional test condition. At this time, DOE does not think the relatively small gain in representativeness that this additional test condition would provide justifies the additional test burden for evaluating the performance of walk-in cooler refrigeration systems. Therefore, DOE is maintaining its determination to keep testing systems for high-temperature freezer applications as medium-temperature systems.

6. Systems for High-Temperature Applications

As discussed previously in section III.A.2.c, DOE is aware of wine cellar (high-temperature) refrigeration systems that fall within the definition of ''walk-in'' but operate at a temperature range of 45 °F to 65 °F and, therefore, are incapable of being tested in a manner that would yield a representative average use cycle under the current version of the walk-in test procedure. DOE has granted waivers or interim waivers to the manufacturers listed in Table I.1 for an alternate test procedure for specific basic models of single-packaged dedicated systems, matched pair, and unit cooler-only high-temperature refrigeration systems.

In the April 2022 NOPR, DOE proposed to include provisions for testing and rating high-temperature matched-pair systems that specify an air entering dry-bulb temperature of 55 °F. 87 FR 23920, 23961. DOE also proposed to test high-temperature refrigeration systems that are single-packaged dedicated systems using one of the following methods, as specified in Table C4 of AHRI 1250–2020: indoor air enthalpy, outdoor air enthalpy, compressor calibration, indoor room calorimeter, outdoor room calorimeter, balanced ambient indoor calorimeter, or balanced ambient outdoor calorimeter. *Id.*

In response to the April 2022 NOPR, the Efficiency Advocates commented that they support adding unique test procedures for high-temperature walk-ins. (Efficiency Advocates, No. 37 at p. 2)

The alternate test approach in the waivers requires that testing of ducted units be conducted at 50 percent of the maximum external static pressure (''ESP''), subject to a tolerance of −0.00/+0.05 in. wc.[52] Consistent with the waivers that DOE has granted for high-temperature refrigeration systems, in the April 2022 NOPR DOE proposed that testing for ducted systems be conducted with ducts fitted and at 50 percent of the unit's maximum ESP, subject to a tolerance of −0.00/+0.05 in. wc. *Id.* DOE proposed to include this provision for all ducted units (*i.e.,* any ducted low-temperature, medium-temperature, or high-temperature refrigeration system). *Id.* DOE also proposed clarifying that if testing using either the indoor or outdoor air enthalpy method, which includes a measurement of the air volume rate, the airflow measurement apparatus fan would be

[52] Inches of water column (''in. wc'') is a unit of pressure conventionally used for measurement of pressure differentials.

adjusted to set the ESP—otherwise, the ESP could be set by symmetrically restricting the outlet of the test duct. *Id.* If the ESP is not provided, DOE proposed that it would be set such that the air volume rate for the test is equal to two-thirds of the value that is measured for zero ESP operation. *Id.*

AHRI-Wine stated that wine cellar manufacturers agree with the proposed ESP requirements for ducted units; however, they commented that the proposed procedure for when ESP is not provided represents an unrealistic reduction in airflow. (AHRI-Wine, No. 30 at p. 4) AHRI-Wine provided no data or alternative recommendation for a procedure when ESP is not provided. DOE has determined that the two-thirds air volume rate is an appropriate value to use when no maximum ESP is provided. DOE notes that manufacturers can provide maximum ESP to avoid testing using the two-thirds air volume rate.

AHRI-Wine also commented that wine cellar manufacturers seek clarification about whether the air surrounding the ducted evaporator or ducted condenser must be at the required 90 °F indoor temperature. (AHRI-Wine, No. 30 at p. 3) Furthermore, wine cellar manufacturers recommended that all wine cellar units, regardless of specified condenser location, be tested only at 90 °F to clarify the test procedure and reduce test burden. *Id.* DOE incorporates by reference section 7.3.3.3 of ASHRAE 37–2009, which includes provisions for testing ducted units and accounting for duct losses; therefore, DOE has determined that the ambient temperature surrounding ducts should not affect the test results. Consistent with appendix C and the wine cellar test procedure waivers, DOE is requiring in appendix C1 that dedicated condensing units located outdoors to be tested at three temperatures—35 °F, 59 °F, and 95 °F—while dedicated condensing units located indoors must be tested at 90 °F.

7. Variable-, Two-, and Multiple-Capacity Systems

a. Dedicated Condensing Units

In the April 2022 NOPR, DOE proposed test procedures for variable-, two-, and multiple-capacity condensing units. The proposals addressed numerous aspects of how such systems would be tested, including (a) test conditions (saturated suction temperature and suction temperature) for part-load operation, (b) compressor operating levels for part-load testing, (c) default unit cooler fan wattage to use in AWEF2 calculations as a function of compressor operating level, and (d) calculation of AWEF2 using multiple levels of compressor operation. 87 FR 23920, 23962–23967.

(1) Need for Test Procedures for Variable-, Two- and Multiple-Capacity Condensing Units

In response to the DOE's proposal, some comments addressed the need for test procedures for multi-/variable-capacity condensing units and the potential utility and cost-effectiveness of such systems. Specifically, AHRI and KeepRite commented that the market for such systems is very small, and that the small market size is not driven by lack of test method. AHRI and KeepRite further stated that variable-capacity system purchases are driven by temperature operating tolerance requirements rather than energy savings and suggested that energy cost savings would not offset upfront purchase and installation costs. (AHRI, No. 30 at p. 8; KeepRite, No. 36 at p. 3) National Refrigeration commented that there is no need for multi-/variable-capacity test procedures at this time, indicating also that there is limited to no evidence that variable-capacity units are more efficient. (National Refrigeration, No. 39 at p. 2) In response, DOE notes that the DOE test procedures already include test methods for variable-, two-, and multi-capacity matched-pair refrigeration systems through incorporation by reference of AHRI 1250–2009. With the proposal and this final rule, DOE is extending this test method to dedicated condensing units tested alone, which was included in the ASRAC Term Sheet. (Docket EERE–2015–BT–STD–0016, No. 56 at p. 3, recommendation #6)

Despite questions about the need for test procedures for variable-, two-, and multi-capacity condensing units, AHRI and KeepRite did indicate that the proposal was reasonable. (AHRI, No. 30 at p. 8; KeepRite, No. 36 at p. 4) Other commenters' overall comments were generally supportive regarding DOE's proposed test methods. (RSG, No. 41 at p. 2; CA IOUs, No. 42 at p. 1; Efficiency Advocates, No. 37 at p. 2)

(2) Unit Cooler Fan

DOE requested comment on its assumptions regarding the unit cooler with which a two-, multi-, or variable-capacity condensing unit rated alone would be paired in the field, including whether the unit cooler fan(s) would have a full speed and a half-speed, the compressor operating level at which the unit cooler fan(s) would switch to half-speed, and the half-speed wattage of the fan(s). 87 FR 23920, 23966.

AHRI and KeepRite commented that a calculation method should be allowed for unit cooler fan power rather than just high or low speed, indicating that some variable compressor systems would reduce capacity only to 75 percent of full capacity and would not realize a gain from unit cooler fan power. (AHRI, No. 30 at pp. 8–9; KeepRite, No. 36 at p. 4) DOE understands this comment to mean that there would be limited efficiency gain for a variable-speed compressor whose lowest capacity is no lower than 75 percent of full capacity, and that it would be important to consider optimization of unit cooler fan speed. National Refrigeration commented that requiring a variable-speed or two-speed unit cooler fan would be ideal, but the effectiveness is unknown and more research is necessary to determine how to handle it. (National Refrigeration, No. 24 at p. 2) Lennox commented that unit coolers with which two-, multi-, and variable-capacity dedicated condensing units are paired may use technology in addition to two-speed fans, such as electronic expansion valves (''EEVs''), dampers, or other electronic control valves. (Lennox, No. 35 at p. 6)

In response, DOE notes that if a manufacturer decides to optimize unit cooler fan operation or other design details for a given condensing unit's compressor technology, the manufacturer has the option of certifying the two components together as a matched pair—this is already an established part of the test procedure for outdoor matched pairs, and DOE is extending the approach to indoor matched pairs in this document (*see* section III.G.7.b of this document).

DOE notes that the test method under consideration applies to dedicated condensing units tested alone—these units would be paired with a unit cooler in the field, so it is not clear what technology the paired unit cooler might have. For this reason, DOE developed the proposal for two-, multi-, and variable-capacity dedicated condensing units based on the assumption of limited unit cooler technology options. DOE's analysis suggests that use of part-load compressor operation has limited to no efficiency benefit when the unit cooler fan(s) run at full speed. However, DOE is aware that many unit coolers are now sold with two-speed fan motors to meet the current energy conservation standards. (No. 44 at p. 2) Hence, DOE determined that it is reasonable to assume that field matches of dedicated condensing units tested alone would involve, at minimum, a unit cooler with a two-speed fan. DOE does not have information that would suggest that unit coolers sold alone would typically have fully variable-speed fans, EEVs, dampers, or other electronic control valves. For this reason, DOE does not believe it is appropriate to establish a test procedure for dedicated condensing units tested alone, assuming such technology is available in a field-paired unit cooler, therefore DOE has not modified the test procedure to reflect the potential benefits of these technologies.

Some commenters indicated that, although unit cooler fans may have two speeds, the low speed may be triggered by the off-cycle rather than by on-cycle compressor operation. (AHRI, No. 30 at p. 8; Lennox, No. 35 at p. 6; National Refrigeration, No. 39 at p. 2) As mentioned, DOE concluded that running unit cooler fans at full speed during part-load operation significantly limits the part-load efficiency benefits. Given the prevalence of unit coolers being sold with two-speed fans, DOE concludes it is reasonable to assume that such unit coolers would be controlled to allow two-speed fan operation during part-load when field-matched with a two-, multi-, or variable-speed dedicated condensing unit.

DOE requested comment on its assumptions regarding the compressor operating level at which the unit cooler fan(s) would switch from full- to half-speed operation. 87 FR 23920, 23966. AHRI commented that no change was needed, and National Refrigeration was supportive. (AHRI, No. 30 at p. 9; National Refrigeration, No. 39 at p. 2) No commenters suggested that switching to half-speed operation should occur at different compressor operating levels. Hence, DOE is finalizing the test procedure using the same 65 percent compressor operating level below which the unit cooler fan(s) would be assumed to operate at half-speed.

DOE requested comment on the proposal that the unit cooler fan half-speed power input would be 20 percent of full speed power. 87 FR 23920, 23966. Several commenters agreed with this approach. (AHRI, No. 30 at p. 9; National Refrigeration, No. 39 at p. 2; Lennox, No. 35 at p. 6) DOE is finalizing its test procedure using the 20 percent half-speed power level.

(3) Part-Load Test Conditions

DOE requested comment on the compressor part-load operating levels for multi- and variable-speed dedicated condensing units tested alone. 87 FR 23920, 23966. Lennox, AHRI, and National Refrigeration supported the proposed levels. (Lennox, No. 35 at p. 6; AHRI, No. 30 at p. 9, National Refrigeration, No. 39 at p. 2) DOE is finalizing the test procedure using the compressor part-load operating levels proposed in the April 2022 NOPR.

Regarding the test conditions proposed for part-load operation of variable-, two-, or multiple-capacity dedicated condensing units, several commenters suggested that the differing refrigerant conditions specified for the different tests were excessively complex and should be simplified. (AHRI, No. 30 at p. 9; Lennox, No. 35 at p. 6; National Refrigeration, No. 39 at p. 2) In response to DOE's specific question about whether a tabular method for specifying test operating conditions or a correlation-based approach should be used, Lennox expressed a clear preference for a tabular approach, indicating that the correlation approach may provide more flexibility but would require more data collection and should be evaluated for accuracy. (Lennox, No. 35 at p. 6) Other commenters did not express a clear position. For example, AHRI commented that, while the correlation approach may provide more flexibility, it should be used only if it is shown to be more accurate. (AHRI, No. 30 at p. 9)

DOE's intent in allowing different suction conditions for testing was to make the test method more representative of actual operation, in which unit cooler effectiveness would improve at part load, suction line pressure drop would decrease, and suction line heat transfer would be more effective. These factors would combine generally to raise the dedicated condensing unit inlet pressure (specified as saturated suction temperature in the test procedures) and also the suction temperature. 87 FR 23920, 23964.

Some commenters indicated that these variations would make little impact in test results. (Lennox, No. 35 at p. 6) DOE analyzed the proposed test conditions to evaluate this statement for outdoor refrigeration systems using R–448A, calculating the impact on compressor EER[53] and isolating the impact of the change in suction conditions as compared with the full-load test conditions,[54] and not including the potential benefits of improved condenser effectiveness at part load nor the potential change in the compressor's compression efficiency for different operating conditions. The analysis showed that, for medium-temperature dedicated condensing units, the impact of the modified suction conditions ranged from −2.3 percent (a decrease) to 7.7 percent, with an average of 2.8 percent. For low-temperature condensing units, the range of impact was from −3.0 percent to 2.4 percent, with an average of −0.2 percent. This analysis shows that an increase in saturated suction temperature improves compressor EER, while an increase in suction temperature reduces compressor EER. These factors appear to balance out on average for low-temperature systems, while for medium-temperature systems, the improvement associated with the saturated suction temperature increase makes more impact than the suction temperature increase. In addition, the results do not change significantly when considering other refrigerants commonly used in WICF refrigeration systems, *e.g.* R–404A and R–407A. For indoor medium-temperature refrigeration systems, the overall impact of the changes is less pronounced, since testing only with the A conditions using 90 °F condenser ambient air increases the impact of the refrigerant temperature rise in the suction line. For outdoor medium-temperature systems, DOE found that raising the saturated suction temperature 1 °F for all part-load conditions to 24 °F and leaving the suction temperature unchanged at 41 °F provided the best overall agreement in compressor EER compared with the average EER impact of the different proposed test conditions. Consequently, DOE is finalizing the specification of suction conditions for testing variable-, two-, and multiple-capacity dedicated condensing units with the following simplifications: For low-temperature and indoor medium-temperature dedicated condensing units, the required part-load test conditions will match the full-capacity conditions. For outdoor medium-temperature dedicated condensing units, the part-load saturated suction temperature will be raised 1 °F to 24 °F, without changing the 41 °F suction temperature requirement. DOE believes this approach provides the best balance between test procedure simplicity and providing some adjustment of operating conditions to represent the impacts of changes in unit cooler and suction line response to part load.

b. Indoor Matched Pair and Single-Packaged Units

DOE proposed in the April 2022 NOPR to establish test procedures for indoor matched-pair and single-

[53] Evaporator capacity divided by compressor input power.

[54] 23 °F saturated suction temperature and 41 °F temperature for medium-temperature systems; −22 °F saturated suction temperature and 5 °F temperature for low-temperature systems.

packaged dedicated systems. 87 FR 23920, 23966.

National Refrigeration stated that indoor matched pairs have less potential for part-load energy savings than their outdoor counterparts due to their constant condensing inlet temperature. (National Refrigeration, No. 39 at p. 2) KeepRite stated that the proposed approach for indoor matched pairs is acceptable, even though these units have even less potential for part-load energy savings due to the constant condenser inlet temperature. (KeepRite, No. 36 at p. 4) DOE understands that these commenters were referring to constant condenser air inlet temperature, which would result in constant condensing temperature. Lennox supported the proposal to establish test methods for indoor two-, multi-, or variable-capacity condensing units tested alone. (Lennox, No. 35 at p.6) No commenters indicated that DOE should not establish test methods for such systems. Hence, DOE is adopting the test method as proposed.

c. Revision to EER Calculation for Outdoor Variable-Capacity and Multiple-Capacity Refrigeration Systems

In the April 2022 NOPR, DOE proposed to revise the EER calculations for outdoor variable-capacity and multiple-capacity refrigeration systems to use a piecewise linear calculation approach rather than the parabolic equation provided in AHRI 1250–2020. 87 FR 23920, 23966. DOE did not receive any comments specifically addressing this proposal and is finalizing the test procedure with the revisions as proposed.

d. Digital Compressors

In the April 2022 NOPR, DOE discussed specific proposals associated with digital compressors. To clarify the test procedure for digital compressors, DOE proposed to define ''digital compressor'' as a compressor that uses mechanical means for disengaging active compression on a cyclic basis to provide a reduced average refrigerant flow rate in response to an input signal. 87 FR 23920, 23967. DOE received no comments specifically addressing the digital compressor definition and will adopt the definition as proposed.

As discussed in the April 2022 NOPR, DOE had conducted testing and found that the refrigerant enthalpy method for measuring capacity is accurate if the liquid subcooling at the mass flow meter is sufficiently low, as required in section C3.4.5 of AHRI 1250–2020. *Id.* DOE proposed that testing refrigeration equipment with digital compressors operating at part load may use the refrigerant enthalpy method as a secondary test method, with the following provisions and adjustments: (1) pressure and temperature measurement would be at a frequency of once per second or faster, (2) the operating tolerances for pressure and temperature at both the inlet and outlet connections and for mass flow would not apply, and (3) enthalpies determined for the capacity calculation would be based on test-period-average pressure and temperature values. *Id.*

DOE also proposed that the selection of the primary test method for measuring capacity would depend on the refrigeration system configuration. *Id.* For single-packaged dedicated systems, the test methods adopted as primary methods for any single-packaged dedicated system would be used, as discussed in section III.G.2 of this document. Matched pairs would use the same primary methods used for single-packaged dedicated systems. For dedicated condensing units, the primary methods include outdoor air enthalpy method, balanced ambient outdoor calorimeter, and outdoor room calorimeter measurements.

Lennox supported the proposals for the part-load test procedure for refrigeration systems with digital compressors. (AHRI, No. 30 at p. 10; Lennox, No. 35 at p. 7) KeepRite and AHRI commented that the refrigerant enthalpy method may be unreliable for digital compressors because they cannot achieve steady state. However, these commenters did not provide evidence that the method would be unreliable. (KeepRite, No. 36 at p. 4; AHRI, No. 30 at p. 9) KeepRite and AHRI also indicated that 1-second intervals for power measurements would not be sufficient for energy measurement of digital compressors and that integrating power meters must be used. *Id.* However, AHRI also stated that the part-load test procedure for refrigeration systems with digital compressors is sufficient as written. (AHRI, No. 30 at p. 9) AHRI provided further specific comments, including (a) wider refrigerant pressure and mass flow tolerances look acceptable, (b) the 1-second or higher data acquisition rate looks acceptable, but that industry-wide ability to sample at this rate should be assessed, (c) that when using the refrigerant enthalpy method with single-package systems with digital compressors, the existing primary methods look acceptable, and (d)–(e) when using the refrigerant enthalpy method to test matched pairs or condensing units alone with digital compressors, the existing dual instrumentation method should be an acceptable primary method for measuring capacity. (AHRI, No. 30 at pp. 9, 10)

DOE notes that the industry standard, AHRI 1250–2020, already has a requirement that energy measurements be made using an integrating watt-hour meter and that power measurements be made with a sampling rate of no less than 1 per second (*see* section C10.2.1.4 of AHRI 1250–2020)—thus, through incorporation by reference of AHRI 1250–2020, the proposal is already consistent with the KeepRite and AHRI comments regarding use of an integrating power meter for energy measurements and already adopts 1-second intervals for data acquisition. It is DOE's understanding that test laboratories already use data acquisition systems with this level of capability. As indicated, the commenters did not provide data countering the cited DOE evidence that the refrigerant enthalpy method measurement is accurate. Given the limited data available on this issue, DOE is not deviating from its proposal that the refrigerant enthalpy method only be used as a secondary capacity measurement, *i.e.,* the test procedure as finalized in this document does not allow it to be used as a primary capacity measurement as recommended by AHRI for matched pairs and dedicated condensing units tested alone. Therefore, DOE is adopting the proposals for digital compressor systems as stated in the April 2022 NOPR.

8. Defrost

The current test procedure references section C11 of AHRI 1250–2009 to measure defrost. In section C11 of AHRI 1250–2009, the moisture to provide a frost load is introduced through the infiltration of air at a 75.2 °F dry-bulb temperature and a 64.4 °F wet-bulb temperature into the walk-in freezer at a constant airflow rate that depends on the refrigeration capacity of the tested freezer unit (Equations C11 and C12 in section C11.1.1 of AHRI 1250–2009). A key issue with this approach is the difficulty in ensuring repeatable frost development on the unit under test, despite specifying the infiltration air dry-bulb and wet-bulb temperatures. For example, in addition to frost accumulating on the evaporator of the unit under test, frost may also accumulate on the evaporator of other cooling equipment used to condition the room, which could subsequently affect the rate of frost accumulation on the unit under test by affecting the amount of moisture remaining in the air.

Since there are recognized limitations to the defrost test procedure in section C11 of AHRI 1250–2009, AHRI 1250–

2020 does not include a frosted-coil test but does include provisions for a dry-coil defrost test.[55] Industry is currently evaluating how to create and validate consistent evaporator coil frost loads; therefore, in the April 2022 NOPR, DOE proposed to maintain the current calculation-based approach for estimating defrost energy consumption. Specifically, DOE proposed to incorporate by reference section C10 of AHRI 1250–2020 for unit coolers with either electric or hot gas defrost, except for section C10.2.1.1, ''Test Room Conditioning Equipment.'' At this time, DOE does not have sufficient data to fully evaluate how the test room condition requirements in section C10.2.1.1 of AHRI 1250–2020 would impact the representativeness of the test procedure during the dry-coil defrost test relative to potential additional test burden.

In response to the April 2022 NOPR, HTPG commented that it agreed with the proposal to incorporate the entirety of Section C10 of AHRI 1250–2020, except for section C10.2.1.1. (HTPG, No. 32 at p. 7) HTPG also agreed that all systems would use the same default calculated values to rate defrost power. *Id.*

The CA IOUs stated that they support DOE adopting a test method for measuring defrost energy use in a future test procedure and that if DOE adopts a test method, DOE should reconsider the frequency at which defrost is used. (CA IOUs, No. 42 at p. 2) DOE will continue to evaluate defrost energy use and may address defrost energy in a future test procedure rulemaking. In this final rule, DOE is adopting the procedures as proposed in the April 2022 NOPR in appendix C1.

a. Adaptive Defrost

Adaptive defrost refers to a factory-installed defrost control system that reduces defrost frequency by initiating defrosts or adjusting the number of defrosts per day in response to operating conditions, rather than initiating defrost strictly based on compressor run time or clock time. 10 CFR 431.303. In the April 2022 NOPR, DOE proposed to maintain its current requirements for adaptive defrost. 87 FR 23920, 23969. DOE received no comments on its proposal. In this final rule, DOE is maintaining the current regulatory approach to include the optional representation strategy for adaptive defrost.

b. Hot Gas Defrost

In the April 2022 NOPR, DOE proposed that manufacturers may account for a unit's potential improved performance with hot gas defrost in its market representations. 87 FR 23920, 23970. DOE proposed that this hot gas defrost ''credit'' may be used in marketing materials for all refrigeration system varieties sold with hot gas defrost (*i.e.,* matched pairs, standalone unit coolers, and standalone condensing units). *Id.*

However, due to the variation of hot gas defrost applications across the refrigeration systems market, and a lack of consensus on the definition of ''hot gas defrost'' systems (*see* discussion in section III.A.2.i of this document), DOE is not adopting a hot gas defrost ''credit'' for representation purposes.

9. Refrigerant Glide

Refrigerant glide refers to the increase in temperature at a fixed pressure as liquid refrigerant vaporizes during its conversion from saturated liquid (at its bubble point) to saturated vapor (at its dew point). R–404A—a common walk-in refrigerant—has very little glide, while R–407A—another common walk-in refrigerant—can exhibit glide of up to 8 °F.

The current DOE test procedure specifies unit cooler test conditions based on the dew point at the evaporator exit. For zero-glide refrigerants, the average evaporator temperature will typically be equivalent to the specified dew point. However, for high-glide refrigerants, the average evaporator temperature will be significantly lower than the dew point since the refrigerant temperature will increase (up to the dew point) as it travels through the evaporator. As a result, two identical unit coolers, one charged with R–404A and one with R–407A, will be tested at different evaporator-to-air temperature differences (''TD''), but with the same evaporator airflow. Measured capacity is directly correlated with the product of TD and airflow; therefore, the high-glide R–407A unit cooler would achieve a higher rated capacity than the R–404A unit cooler. However, this capacity difference is an artifact of the test procedure, which requires that unit coolers and dedicated condensing units be tested alone. In the field, a unit cooler will be paired with a dedicated condensing unit, and R–407A unit coolers will not actually provide additional capacity when compared to their R–404A counterparts. For these reasons, the current test procedure is not refrigerant-neutral.

In the April 2022 NOPR, DOE discussed how the current test procedure is not refrigerant-neutral in terms of high-glide and zero-glide refrigerants because it uses dewpoint throughout the test procedure. 87 FR 23920, 23970. DOE also discussed the modified midpoint approach, which is more refrigerant-neutral. The modified midpoint approach attempts to standardize the average evaporator temperature, rather than standardizing the evaporator dew point. In doing so, identical unit coolers using zero- and high-glide refrigerants would exhibit identical TDs, thus alleviating concerns of overstated capacity.

While a modified midpoint approach may be more refrigerant-neutral, DOE notes that the AHRI 1250–2020, which DOE is referencing in appendix C1, uses a dewpoint rather than a modified midpoint approach. DOE does not have enough information at this time to justify the use of a modified midpoint approach. As a result, in the April 2022 NOPR, DOE proposed to continue to use dew point throughout the test procedure. *Id.*

In response to the April 2022 NOPR, HTPG commented that it disagrees with the midpoint approach and suggested maintaining the dew point approach. (HTPG, No. 32 at p. 7) DOE is adopting the proposal from the April 2022 NOPR and continuing to specify refrigerant conditions using dew point.

10. Refrigerant Temperature and Pressure Instrumentation Locations

As discussed in the April 2022 NOPR, the specified superheat in AHRI 1250–2020 differs from the current DOE test procedure for dedicated condensing unit efficiency calculations, but there is no effective difference in where the required pressure and temperature measurements should be taken on the equipment under test. 87 FR 23920, 23971. However, Figure C2 in AHRI 1250–2020 suggests that the use of a suction line mass flow meter for these measurements is not allowed. In the April 2022 NOPR, DOE proposed to clarify that a second mass flow meter in the suction line would be allowed with the adoption of AHRI 1250–2020. *Id.* Specifically, DOE clarified that the second mass flow measurement for the DX dual instrumentation method may be in the suction line upstream of the inlet to the condensing unit, as shown in Figure C1 of AHRI 1250–2009. AHRI, HTPG, Lennox, Hussmann, and RSG agreed with the proposal. (AHRI, No. 30 at p. 10; HTPG, No. 32 at p. 7; Lennox,

[55] AHRI 1250–2020 includes an adaptive defrost challenge test in appendix E (Appendix E) and a hot gas defrost challenge test in appendix F (Appendix F) that require a frosted-coil. The tests in both of these appendices are labeled as ''informative,'' and were designed to evaluate adaptive defrost or hot gas defrost functionality, respectively, rather than to quantify defrost energy use.

No. 35 at p. 7; Hussmann, No. 38 at p. 10; RSG, No. 41 at p. 2)

AHRI also commented that DOE should only reference AHRI 1250–2020, not both AHRI 1250–2020 and AHRI 1250–2009, for the location of flow meters. (AHRI, No. 30 at p. 10) DOE is clarifying that only AHRI 1250–2020 will be referenced in appendix C1, and that AHRI 1250–2009 is mentioned in this discussion only to explain the intention of the proposal. Therefore, DOE is adopting the test procedure as proposed in the April 2022 NOPR.

11. Updates to Default Values for Unit Cooler Parameters

As discussed in section III.B.3.c, Sections 7.9.1 and 7.9.2 of AHRI 1250–2020 add new equations to calculate on-cycle evaporator fan power when testing a dedicated condensing unit alone. These equations are different from those in the current test procedure in appendix C, which calculates on-cycle evaporator fan power based on the cooling capacity of the condensing unit. The equations in AHRI 1250–2020 are based on more test data and analysis than those currently in appendix C. In the April 2022 NOPR, DOE proposed to adopt the calculations for on-cycle evaporator fan power for dedicated condensing units tested alone as prescribed in AHRI 1250–2020. 87 FR 23920, 23971–23972.

AHRI, HTPG, Lennox, and RSG agreed with the proposed on-cycle evaporator fan power calculations. (AHRI, No. 30 at p. 10; HTPG, No. 32 at p. 7; Lennox, No. 35 at p. 7; RSG, No. 41 at p. 2) DOE is adopting the test procedure as proposed in the April 2020 NOPR.

12. Calculations and Rounding

In the April 2022 NOPR, DOE proposed new rounding requirements for AWEF and capacity to ensure greater test procedure consistency. 87 FR 23920, 23972. DOE clarifies here that the rounding requirements proposed in the April 2022 NOPR should have been for AWEF2 and not AWEF, which means that any rounding requirements would become effective when appendix C1 becomes effective.

DOE recognizes that the way values are rounded can affect the resulting capacity and AWEF2 values. To ensure consistency in calculating capacity and AWEF2 values, DOE proposed in the April 2022 NOPR that raw measured data be used in all capacity and AWEF2 calculations. *Id.* DOE's current standards specify a minimum AWEF2 value in Btu/(W-h) to the hundredths place. DOE proposed rounding AWEF2 values to the nearest 0.05 Btu/(W-h). *Id.* To round capacity, DOE proposed to round to the nearest multiple as specified in Table III.7. The proposed capacity bins and multiples are consistent with other HVAC test procedures.[56]

TABLE III.7—REFRIGERATION CAPACITY RATING RANGES AND THEIR ROUNDING MULTIPLES

Refrigeration capacity ratings, 1,000 Btu/h	Multiples, Btu/h
<20	100
≥20 and <38	200
≥38 and <65	500
≥65	1,000

AHRI, HTPG, KeepRite, Lennox, and National Refrigeration recommended that AWEF2 values be rounded to the nearest 0.01 Btu/(W-h), as current standards are taken to that precision. (AHRI, No. 30 at pp. 10–11; HTPG, No. 32 at p. 8; KeepRite, No. 36 at p. 4; Lennox, No. 35 at p. 7; National Refrigeration, No. 39 at p. 2) DOE agrees that rounding to the nearest 0.05 Btu/(W-h) as proposed may cause confusion. Therefore, DOE is requiring that AWEF2 values be rounded to the nearest 0.01 Btu/(W-h).

AHRI, AHRI-Wine, and RSG agreed with the proposed capacity ranges and respective rounding requirements. (AHRI, No. 30 at p. 10; AHRI-Wine, No. 30 at p. 4; RSG, No. 41 at p. 2) DOE is adopting the capacity rounding requirements as proposed in the April 2022 NOPR and summarized in Table III.7.

H. Alternative Efficiency Determination Methods for Refrigeration Systems

Pursuant to the requirements of 10 CFR 429.70, DOE may permit use of an AEDM in lieu of testing equipment for which testing burden may be considerable and for which that equipment's energy efficiency performance may be well predicted by such alternative methods. Although specific requirements vary by product or equipment, use of an AEDM entails development of a mathematical model that estimates energy efficiency or energy consumption characteristics of the basic model, as would be measured by the applicable DOE test procedure. The AEDM must be based on engineering or statistical analysis, computer simulation or modeling, or other analytic evaluation of performance data. A manufacturer must perform validation of an AEDM by demonstrating that the performance, as predicted by the AEDM, agrees with the performance as measured by actual testing in accordance with the applicable DOE test procedure. The validation procedure and requirements, including the statistical tolerance, number of basic models, and number of units tested vary by product or equipment.

Once developed, an AEDM may be used to rate and certify the performance of untested basic models in lieu of physical testing. However, use of an AEDM for any basic model is always at the option of the manufacturer. One potential advantage of AEDM use is that it may free a manufacturer from the burden of physical testing. One potential risk is that the AEDM may not perfectly predict performance, and the manufacturer could be found responsible for having an invalid rating for the equipment in question or for having distributed a noncompliant basic model. The manufacturer, by using an AEDM, bears the responsibility and risk of the validity of the ratings. For walk-ins, DOE currently permits the use of AEDMs for refrigeration systems only. 10 CFR 429.70(f).

In a final rule published on May 13, 2014, DOE established that AEDMs can be used by walk-in refrigeration manufacturers, once certain qualifications are met, to certify compliance and report ratings. 79 FR 27388, 27389. That rule established a uniform, systematic, and fair approach to the use of these types of modeling techniques that has enabled DOE to ensure that products in the marketplace are correctly rated—irrespective of whether they are subject to actual physical testing or are rated using modeling—without unnecessarily burdening regulated entities. *Id.* A minimum of two distinct models must be tested to validate an AEDM for each validation class.

DOE is adopting new test procedures for single-packaged dedicated systems, high-temperature refrigeration systems, and CO_2 unit coolers. Application design temperature of the refrigerated environment has a significant impact on equipment performance; therefore, in the April 2022 NOPR, DOE proposed to incorporate new AEDM validation classes for all high-temperature refrigeration systems (single-packaged dedicated systems and matched-pair systems). 87 FR 23920, 23973. Additionally, single-packaged units are expected to perform differently than dedicated condensing units under the test procedure which incorporates thermal losses. Therefore, in the April

[56] A version of Table III.14 can be found in AHRI Standard 390 I–P (2021), ''Performance Rating of Single-Package Vertical Air-conditioners and Heat Pumps.''

2022 NOPR, DOE proposed to create new validation classes for low-temperature, medium-temperature, and high-temperature single-packaged dedicated systems. *Id.* To ensure that walk-in validation classes are consistent with DOE's current walk-in terminology, DOE proposed to rename the ''unit cooler connected to a multiplex condensing unit'' validation classes to ''unit cooler'' at either medium- or low-temperature; however, the AEDM requirements for these classes remain the same. *Id.* Finally, DOE proposed to remove the medium-/low-temperature indoor/outdoor condensing unit validation classes, as these are redundant with the medium-/low-temperature indoor/outdoor dedicated condensing unit validation classes. *Id.*

Implementation of appendix C1 will require that all AEDMs for single-packaged dedicated systems are amended to be consistent with the test procedure proposed in appendix C1.

The AEDM validation classes for walk-in refrigeration equipment DOE proposed in the April 2022 NOPR are as follows:

- Dedicated Condensing Unit, Medium-Temperature, Indoor System
- Dedicated Condensing Unit, Medium-Temperature, Outdoor System
- Dedicated Condensing Unit, Low-Temperature, Indoor System
- Dedicated Condensing Unit, Low-Temperature, Outdoor System
- Single-packaged Dedicated System, High-Temperature, Indoor System
- Single-packaged Dedicated System, High-Temperature, Outdoor System
- Single-packaged Dedicated System, Medium-Temperature, Indoor System
- Single-packaged Dedicated System, Medium-Temperature, Outdoor System
- Single-packaged Dedicated System, Low-Temperature, Indoor System
- Single-packaged Dedicated System, Low-Temperature, Outdoor System
- Matched Pair, High-Temperature, Indoor Condensing Unit
- Matched Pair, High-Temperature, Outdoor Condensing Unit
- Matched Pair, Medium-Temperature, Indoor Condensing Unit
- Matched Pair, Medium-Temperature, Outdoor Condensing Unit
- Matched Pair, Low-Temperature, Indoor Condensing Unit
- Matched Pair, Low-Temperature, Outdoor Condensing Unit
- Unit Cooler, High-Temperature
- Unit Cooler, Medium-Temperature
- Unit Cooler, Low-Temperature

Additionally, DOE proposed in the April 2022 NOPR to maintain the provision that outdoor models within a given validation class may be used to determine represented values for the corresponding indoor class, and additional validation testing is not required. 87 FR 23920, 23973. For example, two medium-temperature outdoor dedicated condensing units may be used to validate an AEDM for both the ''Dedicated Condensing Unit, Medium-Temperature, Outdoor System'' class and the ''Dedicated Condensing Units, Medium-Temperature, Indoor System'' class. If indoor models that fall within a given validation class are tested and used to validate an indoor AEDM, however, that test data may not be used to validate the equivalent outdoor validation class.

In the April 2022 NOPR, DOE proposed no additional modifications to the walk-in specific AEDM provisions within 10 CFR 429.70(f). *Id.* In the April 2022 NOPR, DOE requested comment on its proposal to modify and extend its AEDM validation classes. *Id.*

AHRI, Lennox, National Refrigeration, and RSG agreed with the proposed AEDM validation classes. (AHRI, No. 30 at p. 11; Lennox, No. 35 at p. 8; National Refrigeration, No. 39 at p. 2; RSG, No. 41 at p. 3) HTPG agreed with DOE's proposals to (1) add single-packaged dedicated system validation classes, (2) to rename ''unit cooler connected to a multiplex condensing unit'' validation classes to ''unit cooler,'' and (3) to remove medium-/low-temperature indoor/outdoor condensing unit validation classes to eliminate redundancy. (HTPG, No. 32 at p. 8) AHRI-Wine agreed with the proposed validation classes. (AHRI-Wine, No. 30 at p. 4)

AHRI-Wine requested clarification on whether there are AEDM validation classes for high-temperature dedicated condensing units. *Id.* DOE is clarifying that there are no AEDM validation classes for high-temperature dedicated condensing units. As discussed in section III.F.7, DOE has found that the wine cellar industry seems to use general-purpose dedicated condensing units, which must meet the medium-temperature dedicated condensing unit energy conservation standard and should be certified as such. These general-purpose dedicated condensing units would fall into the ''Dedicated Condensing Unit, Medium-Temperature Outdoor System'' or ''Dedicated Condensing Unit, Medium-Temperature Indoor System'' AEDM validation class.

DOE is adopting the AEDM validation classes for refrigeration systems as proposed in the April 2022 NOPR.

I. Sampling Plan for Enforcement Testing

As discussed in the April 2022 NOPR, DOE uses appendix B to subpart C of 10 CFR part 429 to assess compliance for walk-in refrigeration systems, which is specifically intended for use for covered equipment and certain low-volume covered products. 87 FR 23920, 23973. DOE does not specifically reference which appendix in subpart C of 10 CFR part 429 it uses for determination of compliance for walk-in doors or walk-in panels. In an Enforcement NOPR published on August 31, 2020 (''August 2020 Enforcement NOPR''), DOE proposed to add walk-in cooler and freezer doors and walk-in panels to the list of equipment subject to the low-volume enforcement sampling procedures in appendix B to subpart C of 10 CFR part 429. 85 FR 53691, 53696. DOE noted that this equipment is not currently included within DOE's list because when the current regulations were drafted, walk-in doors and walk-in panels did not have applicable performance standards, only design standards, and therefore sampling provisions were not necessary at the time. In the April 2022 NOPR, DOE proposed to include walk-in doors and walk-in panels in the list of covered equipment and certain low-volume products at 10 CFR 429.110(e)(2). 87 FR 23920, 23973.

AHRI, Hussmann, Bally, and RSG all requested clarification on the definition of ''low-volume.'' (AHRI, No. 30 at p. 11; Hussmann, No. 34 at p. 4; Bally, No. 40 at p. 5; RSG, No. 41 at p. 3)

DOE does not define a numerical threshold for ''low-volume'' or ''high-volume'' products and equipment, and for some products and equipment the Department may consider volume on a case-by-case basis. DOE created the ''low-volume'' designation to separate built-to-order equipment from pre-manufactured, off the shelf products, providing built-to-order equipment a longer time period to ship a basic model. 76 FR 12421, 12435. In the context of enforcement, 10 CFR 429.110(e)(1) states that DOE will use a sample size of not more than 21 units and follow the sampling plans in appendix A to subpart C of 10 CFR part 429 to determine compliance with the applicable DOE standards for high-volume equipment, while DOE will use a sample size of not more than 4 units and follow the sampling plans in appendix B to subpart C of 10 CFR part 429 to determine compliance with the applicable DOE standards for low-volume equipment. As specified in 10 CFR 429.110(b), units selected for enforcement evaluation are provided by the manufacturer. DOE notes that walk-in refrigeration systems are currently included in the list of covered equipment and certain low-volume products at 10 CFR 429.110(e)(2). Including walk-in door and panels ensures all walk-in components are similarly evaluated. DOE is including walk-in doors and panels in the list of covered equipment and certain low-volume covered products at 10 CFR 429.110(e)(2) and thus will use the sampling plan in appendix B to subpart C of 10 CFR part 429.

DOE is adopting the enforcement sampling plan as proposed in the April 2022 NOPR.

Bally also asked for clarification regarding how the low-volume sampling procedures work when coupled with new section 5.4.3 of appendix B to subpart R of 10 CFR part 431. (Bally, No. 40 at p. 5) Bally asked whether appendix B to subpart C of 10 CFR part 429 is a restatement of 10 CFR 429.53(a)(3)(ii)(B)(*2*). *Id.* DOE notes that the sampling plan provisions in appendix B to subpart C of 10 CFR part 429 are strictly for the Department's evaluation of compliance when conducting enforcement testing. The provisions at 10 CFR 429.53(a)(3)(ii)(B)(*2*) are the requirements that manufacturers are required to follow when determining the represented value certified to DOE. DOE did not propose to make changes to the certification language in the April 2022 NOPR. The provisions in the new section 5.4.3 of appendix B to subpart R of 10 CFR part 431 are intended to allow manufacturers to use K-factor test results from a set of test samples to determine R-value of envelope components with varying foam thicknesses as long as the foam throughout the panel is of the same final chemical form and the test was completed at the same test conditions as other envelope components. In other words, if a manufacturer offers 4-inch and 5-inch cooler panels, the manufacturer may use the K-factor results of a single series of tests to determine the R-value for both the 4-inch and 5-inch cooler panels.

J. Organizational Changes

In the April 2020 NOPR, DOE proposed a number of non-substantive organizational changes. 87 FR 23920, 23977. As discussed previously, DOE proposed to reorganize appendices A and B so that they are easier for stakeholders to follow as a step-by-step test procedure. Additionally, DOE proposed to remove the specifications at 10 CFR 429.53(a)(2)(i) regarding specific test procedure provisions and instead include these provisions in the uniform test method section at 10 CFR 431.304. The intent of this proposed change was to move provisions of the applicable test procedure to the appropriate place in subpart R, rather than keeping them under the provisions for determining represented values for certification. However, DOE proposed to keep the additional detail regarding the represented values of various configurations of refrigeration systems (*e.g.,* outdoor and indoor dedicated condensing units, matched refrigeration systems, etc.) at 10 CFR 429.53(a)(2)(i).

DOE received no comment on these proposals regarding organizational changes and therefore is adopting them as proposed in the April 2022 NOPR.

K. Test Procedure Costs and Impact

EPCA requires that test procedures proposed by DOE be reasonably designed to produce test results which reflect energy efficiency and energy use of a type of industrial equipment during a representative average use cycle and not be unduly burdensome to conduct. (42 U.S.C. 6314(a)(2)) The following sections discuss DOE's evaluation of the estimated costs and savings associated with the amendments in this final rule.

1. Doors

In this document, DOE is adopting the following amendments to the test procedures in appendix A for walk-in cooler and freezer doors:

- Referencing NFRC 102–2020 for the determination of U-factor;
- Including AEDM provisions for manufacturers to alternately determine the total energy consumption of display and non-display doors;
- Providing additional detail for determining the area used to convert U-factor into conduction load, A_s, to differentiate it from the area used to determine compliance with the standards, A_{dd} or A_{nd};
- Specifying a PTO value of 97 percent for door motors.

The first and third amendments, referencing NFRC 102–2020 and additional detail on the area used to convert U-factor into a conduction load, improve the consistency, reproducibility, and representativeness of test procedure results. The second amendment, including AEDM provisions, intends to provide manufacturers with the flexibility to use an alternative method to testing that provides good agreement for their doors. The fourth amendment, including a PTO value of 97 percent, intends to provide a more representative and consistent means for comparison of walk-in door performance for doors with motors.

DOE has determined that these proposed amendments would improve the representativeness, accuracy, and reproducibility of the test results, and would not be unduly burdensome for door manufacturers to conduct. DOE has also determined that these proposed amendments would not increase testing costs per basic model relative to the current DOE test procedure in appendix A, which DOE estimates to be $10,000 for third-party labs to determine energy consumption of a walk-in door, including physical U-factor testing per NFRC 102–2020.[57] Finally, DOE has determined that manufacturers would not be required to redesign any of the covered equipment or change how the equipment is manufactured solely as a result of these amendments.

The cost impact to manufacturers as a result of the reference to NFRC 102–2020 and inclusion of AEDM provisions is dependent on the agreement between tested and simulated values as specified in section 4.7.1 of NFRC 100–2010[58] and as referenced in the current test procedure. For manufacturers of doors that have been able to achieve the specified agreement between U-factors simulated using the method in NFRC 100–2010 and U-factors tested using NFRC 102–2020, after physically conducting testing to validate the AEDM, manufacturers would be able to continue using the simulation method in NFRC 100–2010 provided it meets the basic requirements proposed for an AEDM in 10 CFR 429.53 and 429.70(f).

For manufacturers of doors that have not been able to achieve the specified agreement between U-factors simulated using the method in NFRC 100–2010 and U-factors tested using NFRC 102–2020, DOE estimates that the test burden would decrease. Under the current requirements, manufacturers may be required to determine U-factor through physical testing of every basic model. With the new test procedure,

[57] DOE estimates the cost of one test to determine energy consumption of a walk-in door, including one physical U-factor test per NFRC 102–2020, to be $5,000. Per the sampling requirements specified at 10 CFR 429.53(a)(3)(ii) and 429.11(b), manufacturers are required to test at least two units to determine the rating for a basic model, except where only one unit of the basic model is produced.

[58] Section 4.7.1 of NFRC 100–2010 requires that the accepted difference between the tested U-factor and the simulated U-factor be (a) 0.03 Btu/(h-ft^2-°F) for simulated U-factors that are 0.3 Btu/(h-ft^2-°F) or less, or (b) 10 percent of the simulated U-factor for simulated U-factors greater than 0.3 Btu/(h-ft^2-°F). This agreement must match for the baseline product in a product line. Per NFRC 100–2010, the baseline product is the individual product selected for validation; it is not synonymous with ''basic model'' as defined in 10 CFR 431.302.

manufacturers who would have otherwise been required to physically test every walk-in door basic model could develop an AEDM for rating their basic models of walk-in doors consistent with the proposed provisions in 10 CFR 429.53 and 429.70(f). DOE estimates the per-manufacturer cost to develop and validate an AEDM for a single validation class of walk-in doors to be $11,100. DOE estimates an additional cost to determine energy consumption of a walk-in door using an AEDM to be $46 per basic model.[59]

DOE expects that the additional detail provided for determining the area used to convert U-factor into conduction load, A_s, would either result in reduced energy consumption or have no impact. To the extent that this change to the test procedure would amend the energy consumption attributable to a door, such changes would either not change the calculated energy consumption or result in a lower energy consumption value as compared to how manufacturers may currently be rating, given that the current test procedure does not provide specific details on measurement of A_{dd} and A_{nd}. As such, DOE expects that manufacturers would be able to rely on data generated under the current test procedure. While manufacturers must submit a report annually to certify a basic model's represented values, basic models do not need to be retested annually. The initial test results used to generate a certified rating for a basic model remain valid if the basic model has not been modified from the tested design in a way that makes it less efficient or more consumptive, which would require a change to the certified rating. If a manufacturer has modified a basic model in a way that makes it more efficient or less consumptive, new testing is only required if the manufacturer wishes to make claims using the new, more efficient rating.[60]

For doors without motors, DOE has concluded that the proposed test procedure would not change energy consumption ratings, which would not require rerating solely as result of DOE's adoption of this amendment to the test procedure. Therefore, DOE has determined all proposed amendments either decrease or result in no additional testing costs to manufacturers of walk-in doors.

To the extent that changes to the test procedure would amend the energy consumption attributable to a door motor, such changes would either not change the calculated energy consumption or result in a lower energy consumption value as compared to the currently granted waivers addressing door motors. As such, DOE expects that manufacturers would be able to rely on data generated under the current test procedure and current waivers. While manufacturers must submit a report annually to certify a basic model's represented values, basic models do not need to be retested annually. The initial test results used to generate a certified rating for a basic model remain valid if the basic model has not been modified from the tested design in a way that makes it less efficient or more consumptive, which would require a change to the certified rating. If a manufacturer has modified a basic model in a way that makes it more efficient or less consumptive, new testing is only required if the manufacturer wishes to make claims using the new, more efficient rating.

In the April 2022 NOPR, DOE requested comment on its understanding of the impact of the test procedure proposals for appendix A. 87 FR 23920, 23979.

AHRI stated that it is unable to determine or comment on impact until it understands the AEDM for doors. (AHRI, No. 30 at p. 11) DOE has provided additional detail regarding AEDMs in section III.C.1 of this document and estimates that the test burden would decrease for the industry as a whole.

Bally commented that the $11,000 estimated cost for U-factor testing doesn't consider the cost of materials. (Bally, No. 40 at p. 5) DOE has determined that the DOE test procedure for walk-in doors is non-destructive and that units can therefore be recovered after testing. For this reason, DOE does not include the cost of the unit under test.

While stakeholders did not specifically recommend including freight costs in the test cost estimates for walk-in doors, they did recommend including freight costs in the test cost estimates for walk-in refrigeration systems (discussed in section III.K.3 of this document). DOE acknowledges that freight costs are an additional expense associated with third-party testing. Therefore, to be consistent with the estimates provided for refrigeration system testing, DOE has estimated the cost of round-trip freight. DOE estimates that the shipping cost for a walk-in box from a manufacturing facility to a test lab can range from $800 to $2,500 depending on the relative locations of the two facilities, the weight and size of the unit being shipped, and the discounts associated with shipping multiple units at one time. Thus, DOE estimates the round-trip freight costs as ranging from $1,600 to $5,000.

2. Panels

In this final rule, DOE is amending the existing test procedure in appendix B for measuring the R-value of insulation of panels by:

- Incorporating by reference the updated version of the applicable industry test method, ASTM C518–17;
- Including provisions specific to measurement of test specimen and total insulation thickness; and
- Providing a method for determining the parallelism and flatness of the test specimen.

The first amendment incorporates by reference the most up-to-date version of the industry standards currently referenced in the DOE test procedure. The second and third amendments include additional instructions intended to improve consistency and reproducibility of test procedure results.

DOE has determined that these proposed amendments would improve the accuracy and reproducibility of the test results and would not be unduly burdensome for manufacturers to conduct, nor would they be expected to increase the testing burden.

DOE expects that the proposed test procedure in appendix B for measuring the R-value of insulation would not increase testing costs per basic model relative to the current DOE test procedure, which DOE estimates to be $1,200 for third-party laboratory testing.[61] Additionally, DOE has determined that the test procedure in appendix B would not result in manufacturers having to redesign any of the covered equipment or change how the equipment is manufactured.

In the April 2022 NOPR, DOE requested comment on its understanding of the impact of the test procedure proposals for appendix B. 87 FR 23920, 23975.

AHRI agreed with DOE's understanding of the impact of the test

[59] DOE estimated initial costs to validate an AEDM assuming 24 hours of general time to develop and validate an AEDM based on existing simulation tools. DOE estimated the cost of an engineering calibration technician fully burdened wage of $46 per hour plus the cost of third-party physical testing of two basic models per proposed validation class. DOE estimated the additional per basic model cost to determine efficiency using an AEDM assuming 1 hour per basic model at the cost of an engineering calibration technician wage of $46 per hour.

[60] *See* guidance issued by DOE at *www1.eere.energy.gov/buildings/appliance_standards/pdfs/cert_faq_2012-04-17.pdf.*

[61] DOE estimates the cost of one test to determine R-value to be $600. Per the sampling requirements specified at 10 CFR 429.53(a)(3)(ii) and 429.11(b), manufacturers are required to test at least two units to determine the rating for a basic model, except where only one unit of the basic model is produced.

procedure. (AHRI, No. 30 at p. 12) Bally commented that the increased measurement and complex calculations involving least squares regression for parallelism and flatness are overly burdensome and that it anticipates difficulty finding laboratories capable of doing the calculations. (Bally, No. 40 at p. 6) In response to Bally's comment, DOE reiterates that the measurement and calculations for parallelism and flatness are necessary to improve the accuracy and reproducibility of the test results. Additionally, what Bally has identified as increased measurement are generally measurements that are already being taken by third party laboratories, but which have not been specified in the DOE test procedure. With respect to the complexity of the calculations, DOE notes that third party laboratories typically use templates to run calculations which would be repeated for multiple tests conducted and that, while a laboratory may need to initially update the template they use, the calculations would not be overly complex and burdensome on an ongoing basis for testing. DOE was also able to find laboratories capable of doing the additional measurements and calculations. Thus, DOE has determined that the procedure is not overly burdensome.

Because the test procedure for walk-in panels is destructive and that units cannot be recovered after testing, DOE is including in its evaluation the cost of the unit under test. DOE estimates the cost of a walk-in panel to range from $90 to $300, depending on size and materials used, and when testing a minimum of two units of a basic model as required by 10 CFR 429.53(a)(1), a total cost of $180 to $600 per basic model.

DOE acknowledges that freight costs are an additional expense associated with third-party testing. Therefore, DOE has estimated the cost of freight to the test facility. DOE estimates that the shipping cost for one walk-in box from a manufacturing facility to a test laboratory can range from $800 to $2,500 depending on the relative locations of the two facilities, the weight and size of the unit being shipped, and the discounts associated with shipping multiple units at one time.

3. Refrigeration Systems

DOE is adopting certain changes to appendix C that DOE has determined will improve the accuracy and reproducibility of the test results and would not be unduly burdensome for manufacturers to conduct. DOE has further determined that these changes will not impact testing cost. Additionally, the amended, appendix C measures AWEF per AHRI 1250–2009, and therefore does not contain any changes that will require retesting or rerating. The current testing costs which DOE have determined will be equivalent to the amended appendix C testing costs are summarized in this section. DOE's assessment of the impacts of the amendments of appendix C to include new test procedures for high-temperature refrigeration systems and CO_2 unit coolers are discussed in more detail in this section.

In response to the April 2022 NOPR, HTPG agreed that proposals to appendix C will not be unduly burdensome or impact cost. (HTPG, No. 32 at p. 8)

DOE is also adopting certain changes in the new appendix C1 that will amend the existing test procedure for walk-in coolers and freezers by:

• Expanding the off-cycle refrigeration system power measurements;
• Adding methods of test for single-packaged dedicated systems; and
• Including a method for testing ducted systems.

DOE has determined that these amendments will improve the representativeness, accuracy, and reproducibility of the test results, and will not be unduly burdensome for manufacturers to conduct. DOE has also determined that these amendments will impact testing costs by equipment type. DOE does not anticipate that the remainder of the amendments adopted in this final rule would impact test costs or test burden. DOE estimates third-party costs for testing to the current DOE test procedure to be:

• $10,000 for outdoor low-temperature and medium-temperature dedicated condensing units tested alone;
• $6,500 for indoor low-temperature and medium-temperature dedicated condensing units tested alone;
• $6,500 for low-temperature unit coolers tested alone;
• $6,000 for medium-temperature unit coolers tested alone;
• $10,000 for single-packaged dedicated systems; and
• $10,000 for high-temperature matched pairs.

As discussed previously in section III.G.1 of this document, DOE is adopting off-cycle test provisions in AHRI 1250–2020 for walk-in cooler and freezer refrigeration systems. The current test procedure requires off-cycle power to be measured at a single ambient condition (*i.e.,* 90 °F). The new test procedure requires off-cycle to be measured at three different ambient conditions (*i.e.,* 95 °F, 59 °F, and 35 °F) for outdoor dedicated condensing units, outdoor matched pair systems, and outdoor dedicated systems. The matched-pair and single-packaged dedicated systems include high-temperature refrigeration systems. When the waivers for these high-temperature refrigeration systems were granted, only one off-cycle test was required; therefore, manufacturers with waivers would be required to conduct additional testing compared to the alternate test procedure currently required. DOE estimates that measuring off-cycle power at these additional ambient conditions may increase third-party lab test cost by $1,000 per unit to a total cost of $11,000 per unit for outdoor dedicated condensing units, outdoor matched-pair systems, and outdoor single-packaged dedicated systems.

Manufacturers are not required to perform laboratory testing on all basic models. In accordance with 10 CFR 429.53, WICF refrigeration system manufacturers may elect to use AEDMs. DOE estimates the per-manufacturer cost to develop and validate an AEDM for outdoor dedicated condensing units and outdoor matched-pair systems to be $24,600.[62] DOE estimates an additional cost of approximately $46 per basic model[63] for determining energy efficiency of a given basic model using the validated AEDM.

As discussed previously in section III.G.2, DOE is adopting the single-packaged dedicated system test procedure for walk-ins in AHRI 1250–2020. The procedure requires air enthalpy tests to be used as the primary test method. In the current test procedure, single-packaged dedicated systems use refrigerant enthalpy as the primary test method. DOE does not estimate a difference in physical testing costs between air and refrigerant enthalpy testing of single-packaged units. DOE estimates the per-unit third-party lab test cost to be $11,000 for outdoor single-packaged dedicated

[62] Outdoor single-packaged systems are also impacted by the proposed adoption of the AHRI 1250–2020 single-packaged test procedure for walk-in cooler and freezer refrigeration systems. The combined potential cost increase for outdoor single-packaged systems is presented in the next paragraph.

[63] DOE estimated initial costs to validate an AEDM assuming 40 hours of general time to develop an AEDM based on existing simulation tools and 16 hours to validate two basic models within that AEDM at the cost of an engineering calibration technician fully burdened wage of $46 per hour plus the cost of third-party physical testing of two units per validation class (as required in 10 CFR 429.70(c)(2)(iv)). DOE estimated the additional per basic model cost to determine efficiency using an AEDM assuming 1 hour per basic model at the cost of an engineering calibration technician wage of $46 per hour.

systems and $6,500 for indoor single-packaged dedicated systems. However, should a manufacturer choose to use an AEDM, it may incur additional costs regarding the development and validation of new AEDMs for single-packaged dedicated systems. DOE estimates the per-manufacturer cost to develop and validate an AEDM to be $24,600 for outdoor single-packaged units and $15,600 for indoor single-packaged units. DOE estimates an additional cost of approximately $46 per basic model [64] for determining energy efficiency using the validated AEDM.

As discussed in sections III.F.6 and III.G.6, DOE is adopting test procedures for CO_2 unit coolers and high-temperature refrigeration systems. DOE estimates that the average third-party lab per unit test cost would be $11,000 for a high-temperature matched-pair or single-packaged dedicated system, $6,000 for a high-temperature unit cooler tested alone, $6,500 for a low-temperature CO_2 unit cooler, and $6,000 for a medium-temperature CO_2 unit cooler. As discussed previously, DOE has granted waivers to certain manufacturers for both high-temperature refrigeration systems and CO_2 unit coolers. The test procedures being adopted are consistent with the alternate test procedures included in the granted waivers. For those manufacturers who have been granted a test procedure waiver for this equipment, DOE expects that there would be no additional test burden. However, DOE expects that there would be additional testing costs for any manufacturers of these products who have not submitted or been granted a test procedure waiver at the time this test procedure is finalized. Such companies may incur an additional per unit test cost of:

- $11,000 for a high-temperature matched-pair or single-packaged system;
- $6,000 for a high-temperature unit cooler tested alone;
- $6,500 for a low-temperature CO_2 unit cooler tested alone; and
- $6,000 for a medium-temperature CO_2 unit cooler tested alone.

In the April 2022 NOPR, DOE requested comment on its understanding of the impact of the test procedure proposals for refrigeration systems. 87 FR 23920, 23976.

AHRI commented that a third-party lab test of a low-temperature unit cooler would be two to three times more expensive than DOE's $6,500 estimate. (AHRI, No. 30 at p. 12) Lennox stated that, in general, DOE's amendments increase work content of the test and therefore increase test costs. (Lennox, No. 35 at p. 8) Lennox also stated that the costs of their third-party lab tests have been at least double DOE's estimates. *Id.* RSG commented that it considers DOE's estimates to be very low and stated that there are few outside labs capable of testing to the degree that DOE requires. (RSG, No. 41 at p. 3) AHRI-Wine stated that they believe the estimated testing burden is reasonable and consistent. (AHRI-Wine, No. 30 at p. 4) DOE notes that the estimated test costs were based on actual lab quotes, which DOE has determined are representative of the pricing available to the industry as a whole. Additionally, DOE is aware of third-party labs that have the capability to test to the current DOE test procedure.

HTPG disagreed with DOE's test cost estimates for AEDMs and stated that 40 hours of labor per refrigerant is more accurate and therefore test costs would be multiplied by the number of refrigerants. (HTPG, No. 32 at p. 8) HTPG also stated that more validation would be done by manufacturers than what was estimated to ensure an AEDM applies across a basic model family. *Id.*

DOE notes that the estimated AEDM cost is per AEDM and does not make assumptions about the number of AEDMs needed based on the refrigerants used by a given manufacturer. DOE used the minimum number of tests (two) needed to validate an AEDM. While manufacturers may choose to test more units to validate an AEDM, testing more than two is not required.

AHRI stated that small original equipment manufacturers ("OEMs") represent a significant amount of the market and will be negatively impacted by added complexity and costs. (AHRI, No. 30 at p. 12) NAFEM encouraged DOE to consider the limitation of lab capacity and the financial impacts on small businesses. (NAFEM, No. 33 at p. 2) DOE specifically discusses the test procedure burden imposed on small businesses in section IV.B of this document.

AHRI stated that EPA and DOE regulations will impact small refrigeration OEMs in a relatively immediate time frame. (AHRI, No. 30 at p. 12) NAFEM also commented that DOE should evaluate how various EPA rulemakings may impact energy efficiency improvements in the WICF manufacturing process and available products. (NAFEM, No. 33 at p. 2) DOE acknowledges that while there are other regulations that impact walk-in equipment, DOE will take cumulative regulatory burden into account in the ongoing energy conservation standards rulemaking as part of its manufacturer impact analysis.

AHRI and Lennox commented that the test cost estimates should include freight cost, unit cost, and cost of a unit to run the test. (AHRI, No. 30 at p. 12; Lennox, No. 35 at p. 8) DOE acknowledges that freight costs are an additional expense associated with third-party testing. DOE has determined that the DOE test procedure is non-destructive and that units can therefore be recovered after testing. For this reason, DOE has estimated the cost of round-trip freight, but does not include the cost of the unit under test. Additionally, DOE notes that the test procedure does not specifically require use of the unit matched to the unit under test (*i.e.,* a dedicated condensing unit matched to a unit cooler under test, or a unit cooler matched to a dedicated condensing unit under test).

DOE estimates that the shipping cost for one walk-in unit from a manufacturing facility to a test laboratory can range from $250 to $1,000 depending on the relative locations of the two facilities, the weight and size of the unit being shipped, and the discounts associated with shipping multiple units at one time. Thus, DOE estimates the round-trip freight costs as ranging from $500 to $2,000.

DOE additionally notes that it has used third-party laboratory test costs for its estimate of test costs. DOE understands that most walk-in refrigeration system manufacturers have their own test chambers. In these cases, DOE expects that its estimate for test and freight costs is conservative.

L. Effective and Compliance Dates

The effective date for the adopted test procedure amendment will be 30 days after publication of this final rule in the **Federal Register**. EPCA prescribes that all representations of energy efficiency and energy use, including those made on marketing materials and product labels, must be made in accordance with an amended test procedure, beginning 180 days after publication of the final rule in the **Federal Register**. (42 U.S.C. 6314(d)(1)) EPCA provides an allowance for individual manufacturers to petition DOE for an extension of the 180-day period if the manufacturer may experience undue hardship in meeting

[64] DOE estimated initial costs to validate an AEDM assuming 40 hours of general time to develop an AEDM based on existing simulation tools and 16 hours to validate two basic models within that AEDM at the cost of an engineering calibration technician fully burdened wage of $46 per hour plus the cost of third-party physical testing of two units per validation class (as required in 10 CFR 429.70(c)(2)(iv)). DOE estimated the additional per basic model cost to determine efficiency using an AEDM assuming 1 hour per basic model at the cost of an engineering calibration technician wage of $46 per hour.

the deadline. (42 U.S.C. 6314(d)(2)) To receive such an extension, petitions must be filed with DOE no later than 60 days before the end of the 180-day period and must detail how the manufacturer will experience undue hardship. *Id.* To the extent the modified test procedure adopted in this final rule is required only for the evaluation and issuance of updated efficiency standards, compliance with the amended test procedure does not require use of such modified test procedure provisions until the compliance date of updated standards.

Upon the compliance date of test procedure provisions in this final rule, any waivers that had been previously issued and are in effect that pertain to issues addressed by such provisions are terminated. 10 CFR 431.404(h)(3). Recipients of any such waivers are required to test the products subject to the waiver according to the amended test procedure as of the compliance date of the amended test procedure. The amendments adopted in this document pertain to issues addressed by waivers granted to the manufacturers listed in Table III.8.

TABLE III.8—MANUFACTURERS GRANTED WAIVERS AND INTERIM WAIVERS

Manufacturer	Subject	Case No.	Relevant test procedure	Proposed test procedure compliance date
Jamison Door Company	PTO for Door Motors	2017–009	Appendix A	10/31/2023.
HH Technologies	PTO for Door Motors	2018–001	Appendix A	10/31/2023.
Senneca Holdings	PTO for Door Motors	2020–002	Appendix A	10/31/2023.
Hercules	PTO for Door Motors	2020–013	Appendix A	10/31/2023.
HTPG	CO_2 Unit Coolers	2020–009	Appendix C	10/31/2023.
Hussmann	CO_2 Unit Coolers	2020–010	Appendix C	10/31/2023.
KeepRite	CO_2 Unit Coolers	2020–014	Appendix C	10/31/2023.
RefPlus, Inc	CO_2 Unit Coolers	2021–006	Appendix C	10/31/2023.
RSG	Multi-Circuit Single-Package Dedicated Systems.	2022–004	Appendix C	10/31/2023.
LRC Coil	Wine Cellar Refrigeration Systems.	2020–024	Appendix C [65]	10/31/2023.
Store It Cold	Single-Packaged Dedicated Systems.	2018–002	Appendix C1	Compliance date of updated standards.
CellarPro	Wine Cellar Refrigeration Systems.	2019–009	Appendix C1	Compliance date of updated standards.
Air Innovations	Wine Cellar Refrigeration Systems.	2019–010	Appendix C1	Compliance date of updated standards.
Vinotheque	Wine Cellar Refrigeration Systems.	2019–011	Appendix C1	Compliance date of updated standards.
Vinotemp	Wine Cellar Refrigeration Systems.	2020–005	Appendix C1	Compliance date of updated standards.

IV. Procedural Issues and Regulatory Review

A. Review Under Executive Orders 12866 and 13563

Executive Order (''E.O.'') 12866, ''Regulatory Planning and Review,'' as supplemented and reaffirmed by E.O. 13563, ''Improving Regulation and Regulatory Review,'' 76 FR 3821 (Jan. 21, 2011), requires agencies, to the extent permitted by law, to (1) propose or adopt a regulation only upon a reasoned determination that its benefits justify its costs (recognizing that some benefits and costs are difficult to quantify); (2) tailor regulations to impose the least burden on society, consistent with obtaining regulatory objectives, taking into account, among other things, and to the extent practicable, the costs of cumulative regulations; (3) select, in choosing among alternative regulatory approaches, those approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts; and equity); (4) to the extent feasible, specify performance objectives, rather than specifying the behavior or manner of compliance that regulated entities must adopt; and (5) identify and assess available alternatives to direct regulation, including providing economic incentives to encourage the desired behavior, such as user fees or marketable permits, or providing information upon which choices can be made by the public. DOE emphasizes as well that E.O. 13563 requires agencies to use the best available techniques to quantify anticipated present and future benefits and costs as accurately as possible. In its guidance, the Office of Information and Regulatory Affairs (''OIRA'') in the Office of Management and Budget (''OMB'') has emphasized that such techniques may include identifying changing future compliance costs that might result from technological innovation or anticipated behavioral changes. For the reasons stated in the preamble, this final regulatory action is consistent with these principles.

Section 6(a) of E.O. 12866 also requires agencies to submit ''significant regulatory actions'' to OIRA for review. OIRA has determined that this final regulatory action does not constitute a ''significant regulatory action'' under section 3(f) of E.O. 12866. Accordingly, this action was not submitted to OIRA for review under E.O. 12866.

B. Review Under the Regulatory Flexibility Act

The Regulatory Flexibility Act (5 U.S.C. 601 *et seq.*) requires preparation of a final regulatory flexibility analysis (''FRFA'') for any final rule where the agency was first required by law to publish a proposed rule for public comment, unless the agency certifies that the rule, if promulgated, will not have a significant economic impact on a substantial number of small entities. As required by Executive Order 13272, ''Proper Consideration of Small Entities in Agency Rulemaking,'' 67 FR 53461 (August 16, 2002), DOE published procedures and policies on February 19, 2003, to ensure that the potential impacts of its rules on small entities are properly considered during the DOE rulemaking process. 68 FR 7990. DOE

[65] DOE notes that Table III.15 in the April 2022 NOPR should have listed appendix C instead of appendix C1 as the relevant test procedure for the LRC Coil waiver. 87 FR 23920, 23977.

has made its procedures and policies available on the Office of the General Counsel's website: *www.energy.gov/gc/office-general-counsel.* DOE reviewed this final rule under the provisions of the Regulatory Flexibility Act and the procedures and policies published on February 19, 2003.

The Energy Policy and Conservation Act, Public Law 94–163, as amended (''EPCA''),[66] authorizes DOE to regulate the energy efficiency of a number of consumer products and certain industrial equipment. (42 U.S.C. 6291–6317) Title III, Part C[67] of EPCA, added by Public Law 95–619, Title IV, section 441(a), established the Energy Conservation Program for Certain Industrial Equipment, which sets forth a variety of provisions designed to improve energy efficiency. This equipment includes walk-in coolers and walk-in freezers (collectively ''WICFs'' or ''walk-ins''), the subject of this document. (42 U.S.C. 6311(1)(G)) DOE is publishing this final rule in satisfaction of the 7-year review requirement specified in EPCA. (42 U.S.C. 6314(b)(1))

DOE has conducted a focused inquiry into small business manufacturers of the equipment covered by this rulemaking. DOE used the Small Business Administration's small business size standards to determine whether any small entities would be subject to the requirements of the rule. The size standards are listed by North American Industry Classification System (''NAICS'') code as well as by industry description and are available at *www.sba.gov/document/support-table-size-standards.* Manufacturing WICFs is classified under NAICS 333415, ''Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing.'' The SBA sets a threshold of 1,250 employees or fewer for an entity to be considered as a small business for this category.[68] DOE used publicly available information to identify potential small businesses that manufacture WICFs covered in this rulemaking. DOE reviewed its Certification Compliance Database (''CCD'')[69] and the California Energy Commission's Modernized Appliance Efficiency Database System (''MAEDbS'')[70] to identify manufacturers. DOE also used subscription-based business information tools (*e.g.,* reports from Dun & Bradstreet[71]) to determine headcount and revenue of the small businesses.

Using these data sources, DOE identified 78 original equipment manufacturers (''OEMs'') of WICFs that could be potentially affected by this rulemaking. DOE screened out companies that do not meet the definition of a ''small business'' or are foreign-owned and operated. Of these 78 OEMs, 57 are small, domestic manufacturers. DOE notes that some manufacturers may produce more than one of the principal components of WICFs: doors, panels, and refrigeration systems. Forty-one of the small, domestic OEMs manufacture doors; 35 of the small, domestic OEMs manufacture panels; and 18 of the small, domestic OEMs manufacture refrigeration systems.

In response to the Initial Regulatory Flexibility Analysis published as part of the April 2022 NOPR, AHRI noted that while they are unsure of the exact number of small OEMs of WICF panels, doors, and refrigeration systems, they acknowledge that small OEMs represent a significant portion of the WICF market. AHRI asserted that small OEMs would be negatively impacted by what AHRI characterized as the added complexity and related costs. AHRI also noted that EPA and DOE regulatory actions that are not yet fully resolved have impact in a relatively immediate timeframe. (AHRI, No. 30 at p. 12)

DOE agrees with AHRI that small businesses account for the majority of WICF component OEMs operating in the United States. Regarding AHRI's concerns about complexity, DOE evaluates test procedures for each type of covered equipment, including WICFs, to determine whether amended test procedures would more accurately or fully comply with the requirements for the test procedures to not be unduly burdensome to conduct and be reasonably designed to produce test results that reflect energy efficiency, energy use, and estimated operating costs during a representative average use cycle. (42 U.S.C. 6314(a)(1)) DOE has determined that the amendments in this final rule would improve the accuracy, reproducibility, and representativeness of test procedure results, and will not be unduly burdensome for manufacturers to conduct. DOE has determined that the amendments outlined in this final rule will not require retesting or rerating of units.

Regarding the impact of EPA refrigerant regulation and other DOE rulemaking actions on small businesses, DOE would consider the impact on manufacturers of multiple product/equipment-specific regulatory actions pursuant to section 13(g) in appendix A to subpart C of part 430, in any subsequent energy conservation standards rulemaking analysis for WICFs.

RSG commented that it considers DOE's door, panel, and refrigeration system cost estimates to be very low. For refrigeration systems, RSG further stated that there are few outside labs capable of testing to the degree that DOE requires. (RSG, No. 41 at p. 3) DOE notes that the estimated test costs were based on actual laboratory quotes, which DOE has determined are representative of the pricing available to the industry as a whole. Additionally, DOE is aware of third-party laboratories that have the capability to test to the current DOE test procedure.

Doors

DOE has determined that retesting and recertification would not be required for walk-in cooler and freezer doors as a result of this rulemaking. DOE is adopting the following amendments to appendix A for walk-in cooler and freezer doors:

1. Referencing NFRC 102–2020 for the determination of U-factor;
2. Including AEDM provisions for manufacturers to alternately determine the total energy consumption of display and non-display doors;
3. Providing additional detail for determining the area used to convert U-factor into conduction load, A_s, to differentiate it from the area used to determine compliance with the standards, A_{dd} or A_{nd}; and
4. Specifying a PTO value of 97 percent for door motors.

DOE has determined that these amendments would not increase testing costs per basic model relative to the current DOE test procedure in appendix A.[72] Items 1 and 3, referencing NFRC

[66] All references to EPCA in this document refer to the statute as amended through the Energy Act of 2020, Public Law 116–260 (Dec. 27, 2020), which reflect the last statutory amendments that impact Parts A and A–1 of EPCA.

[67] For editorial reasons, upon codification in the U.S. Code, Part C was redesignated Part A–1.

[68] The size standards are listed by NAICS code and industry description and are available at: *www.sba.gov/document/support-table-size-standards.* (Last accessed Oct. 11, 2022.)

[69] U.S. Department of Energy Compliance Certification Database, available at *www.regulations.doe.gov/certification-data/#q=Product_Group_s%3A*.* (Last accessed March 16, 2022.)

[70] California Energy Commission's Modernized Appliance Efficiency Database System, available at *cacertappliances.energy.ca.gov/Pages/Search/AdvancedSearch.aspx.* (Last accessed Nov. 1, 2021.)

[71] D&B Hoovers reports are available at *app.dnbhoovers.com.* (Last accessed Oct. 12, 2022.)

[72] DOE estimates the cost of one test to determine energy consumption of a walk-in door, including one physical U-factor test per NFRC 102–2020, to be $5,000. Per the sampling requirements specified

102–2020 and additional detail on the area used to convert U-factor into a conduction load, improves the consistency, reproducibility, and representativeness of test procedure results. Item 2, including AEDM provisions, intends to provide manufacturers with the flexibility to use an alternative method that gives the best agreement for their doors. Item 4, by including a PTO value of 97 percent, intends to provide a more representative and consistent means for comparison of walk-in door performance for doors with motors.

DOE expects certification costs for door manufacturers would either remain the same or be reduced, depending on whether manufacturers have been able to achieve the agreement between U-factors simulated using the method in NFRC 100 and U-factors tested using NFRC 102. Manufacturers of doors that have been able to achieve the specified agreement [73] between U-factors simulated using the method in NFRC 100 and U-factors tested using NFRC 102 would be able to continue using the simulation method in NFRC 100, provided that the simulation method also meets the basic requirements proposed for an AEDM in 10 CFR 429.53 and 429.70(f). For manufacturers of doors that have not been able to achieve the specified agreement between U-factors simulated using the method in NFRC 100 and U-factors tested using NFRC 102, DOE estimates that the test burden would decrease. With the new test procedure, manufacturers who would have otherwise been required to physically test every walk-in door basic model could develop an AEDM for rating their basic models of walk-in doors consistent with the proposed provisions in 10 CFR 429.53 and 429.70(f). DOE estimates the per-manufacturer cost to develop and validate an AEDM for a single validation class of walk-in doors to be $11,100, in addition to an estimated $1,600 to $5,000 in shipping costs.[74] DOE estimates an additional cost to determine energy consumption of a walk-in door using an AEDM to be $46 per basic model.[75]

DOE expects that the additional detail provided for determining the area used to convert U-factor into conduction load, A_s, would not result in changes that require manufacturers to re-certify equipment. Manufacturers would be able to rely on data generated under the current test procedure for equipment already certified.

For walk-in doors with motors, DOE has determined that the amendments described in section III of this final rule would either not change the measured energy consumption or would result in a lower measured energy consumption and therefore, would not require retesting or recertification as a result of DOE's adoption of the amendments to the test procedures. New testing is only required if the manufacturer wishes to make claims using the new, more efficient rating. Additionally, DOE has determined the amendments would not increase the cost of testing for doors with motors.

DOE concludes that manufacturers of WICF doors, including small manufacturers, will not incur retesting and recertification costs as a result of this final rule.

Panels

In this final rule, DOE is amending the existing test procedure in appendix B for measuring the R-value of insulation of panels by:

1. Incorporating by reference the updated version of the applicable industry test method, ASTM C518–17;

2. Including provisions specific to measurement of test specimen and total insulation thickness; and

3. Providing specifications for determining the parallelism and flatness of the test specimen.

The first item incorporates by reference the most up-to-date version of the industry standards currently referenced in the DOE test procedure. Items 2 and 3 include additional instructions intended to improve consistency and reproducibility of test procedure results.

DOE has concluded that the amendments will not change efficiency ratings for walk-in panels, and therefore will not require rerating as result of DOE's adoption of this amendment to the test procedure. Therefore, DOE has determined that these amendments will not add any additional testing costs to small business manufacturers of WICF panels.

Refrigeration Systems

In this final rule, DOE is adopting changes to appendix C that DOE has determined would improve the accuracy and reproducibility of the test results and would not be unduly burdensome for manufacturers to conduct. DOE has determined that these changes would not impact testing cost. Additionally, the amended appendix C, measuring AWEF per AHRI 1250–2009, does not contain any changes that would require retesting or rerating.

DOE is also adopting, through incorporations by reference, certain provisions of AHRI 1250–2020 in appendix C1 that will amend the existing test procedure for walk-in cooler and freezer refrigeration systems. DOE notes that the new appendix C1, which establishes new energy efficiency metric AWEF2, would increase testing costs for certain refrigeration system equipment types. This final rule does not require manufacturers to rate equipment using appendix C1. If DOE were to adopt a future energy conservation standard using the AWEF2 metric, that energy conversation standard will cause manufacturers to incur costs for retesting and recertification at the time when the amended standards take effect. The cost of retesting and recertification based on appendix C1 would be incorporated into the analysis of the energy conservation standard adopting the AWEF2 metric, should DOE choose to establish standard using that metric.

Although this test procedure final rule does not require the use of appendix C1 and manufacturers, including small manufacturers, will not incur retesting or recertification costs based on the AWEF2 metric at this time, DOE discusses the potential impacts of adopting certain changes in the new appendix C1 in this section.

at 10 CFR 429.53(a)(3)(ii) and 429.11(b), manufacturers are required to test at least two units to determine the rating for a basic model, except where only one unit of the basic model is produced.

[73] Section 4.7.1 of NFRC 100 requires that the accepted difference between the tested U-factor and the simulated U-factor be (a) 0.03 Btu/(h-ft2 °F) for simulated U-factors that are 0.3 Btu/(h-ft2 °F) or less, or (b) 10 percent of the simulated U-factor for simulated U-factors greater than 0.3 Btu/(h-ft2 °F). This agreement must match for the baseline product in a product line. Per NFRC 100, the baseline product is the individual product selected for validation; it is not synonymous with ''basic model'' as defined in 10 CFR 431.302.

[74] DOE estimates that the shipping cost for a walk-in box, typically made up of multiple panels and a door, from a manufacturing facility to a test lab can range from $800 to $2,500 depending on the relative locations of the two facilities, the weight and size of the unit being shipped, and the discounts associated with shipping multiple units at one time. This means that each estimated test cost would increase from $1,600 to $5,000 dollars when shipping a unit for test to and from a third-party lab.

[75] DOE estimated initial costs to validate an AEDM assuming 24 hours of general time to develop and validate an AEDM based on existing simulation tools. DOE estimated the cost of an engineering calibration technician fully burdened wage of $46 per hour plus the cost of third-party physical testing of two basic models per proposed validation class. DOE estimated the additional per basic model cost to determine efficiency using an AEDM assuming 1 hour per basic model at the cost of an engineering calibration technician wage of $46 per hour.

As discussed previously in this final rule, DOE is adopting off-cycle test provisions in AHRI 1250–2020 for walk-in refrigeration systems. The current test procedure requires off-cycle power to be measured at the 95 °F ambient condition. The new test procedure requires off-cycle to be measured at 95 °F, 59 °F, and 35 °F ambient conditions for outdoor dedicated condensing units, outdoor matched pair systems, and outdoor dedicated systems. The matched pair and single-packaged dedicated systems include high-temperature refrigeration systems. When the waivers for these high-temperature refrigeration systems were granted, only one off-cycle test was required; therefore, manufacturers with waivers would be required to conduct additional testing as compared to the alternate test procedure currently required. DOE estimates that measuring off-cycle power at these additional ambient conditions may increase third-party lab test cost by $1,000 per unit to a total cost of $11,000 per unit for outdoor dedicated condensing units, outdoor matched pair systems, and outdoor single-packaged dedicated systems. The physical testing cost would be $22,000 per basic model for outdoor dedicated condensing units, outdoor matched pair systems, and outdoor single-packaged dedicated systems, in addition to an estimated $1,000 to $4,000 in round trip shipping costs.[76]

However, manufacturers are not required to perform laboratory testing on all basic models. In accordance with 10 CFR 429.53, WICF refrigeration system manufacturers may elect to use AEDMs. DOE estimates the per-manufacturer cost to develop and validate an AEDM for outdoor dedicated condensing units and outdoor matched pair systems to be approximately $24,581,[77] in addition to an estimated $1,000 to $4,000 in round trip shipping costs.[78] DOE estimates an additional cost of approximately $46 per basic model [79] for determining energy efficiency of a given basic model using the validated AEDM.

DOE estimated the range of potential costs for the five small OEMs that manufacture outdoor dedicated condensing units, outdoor matched pair systems, and outdoor single-packaged dedicated systems. When developing cost estimates for the small OEMs, DOE considers the cost to update the existing AEDM simulation tool, the costs to validate the AEDM through physical testing (including shipping costs to and from the third-party laboratory), and the cost to rate basic models using the AEDM. DOE assumes a high-cost scenario where manufacturers would be required to develop AEDMs for six validation classes.

DOE estimates the impacts based on basic model counts and company revenue. Table IV.1 summarizes DOE's estimates for the five identified small businesses. On average, testing costs represent less than 1 percent of annual revenue for a typical small business.

As previously discussed, the procedure in appendix C1 would only require retesting or recertification when and if a future energy conservation standard takes effect.

TABLE IV.1—POTENTIAL SMALL BUSINESS RE-RATING COSTS (2022$) AS A RESULT OF OFF-CYCLE REFRIGERATION SYSTEM POWER REQUIREMENTS

Small domestic OEM	Re-rating estimate *($MM)*	Estimated annual revenue *($MM)*	Percent of annual revenue
Manufacturer 1	0.16	12.0	1.4
Manufacturer 2	0.16	110.3	0.1
Manufacturer 3	0.23	88.7	0.3
Manufacturer 4	0.16	116.2	0.1
Manufacturer 5	0.16	156.3	0.1

As also discussed in the final rule, DOE is adopting the single-packaged dedicated system test procedure for walk-ins in AHRI 1250–2020. The procedure requires air enthalpy tests to be used as the primary test method. In the current test procedure, single-packaged dedicated systems use refrigerant enthalpy as the primary test method. DOE does not estimate a difference in physical testing costs between air and refrigerant enthalpy testing of single-packaged dedicated systems. DOE estimates the per-unit third party lab test cost to be $11,000 for outdoor single-packaged units and $6,500 for indoor single-packaged units. The physical testing cost would be $22,000 per basic model for outdoor single-packaged dedicated systems and $13,000 per basic model for indoor package systems, in addition to an estimated $1,000 to $4,000 in round trip shipping costs for each class.[80]

However, should a manufacturer choose to use an AEDM, it may incur additional costs regarding the development and validation of new AEDMs for single-packaged dedicated systems. DOE estimates the per manufacturer cost to develop and validate an AEDM to be $24,580 for outdoor single-packaged units and $15,580 for indoor single-packaged units, in addition to an estimated $1,000 to $4,000 in round trip shipping costs.[81] DOE estimates an additional cost of

[76] The cost to test one unit is $11,000, plus an estimated $500 to $2,000 for shipping the refrigeration system to and from the third-party lab. Per the sampling requirements specified at 10 CFR 429.53(a)(2)(ii) and 429.11(b), manufacturers are required to test at least two units to determine the rating for a basic model, except where only one unit of the basic model is produced.

[77] Outdoor single-packaged systems are also impacted by the proposed adoption of AHRI 1250–2020 single-packaged test procedure for walk-in cooler and freezer refrigeration systems. The combined potential cost increase for outdoor single-packaged systems is presented in the next paragraph.

[78] Shipping costs associated with third-party physical testing of two units per validation class (as required in 10 CFR 429.70(c)(2)(iv)).

[79] DOE estimated initial costs to validate a AEDM assuming 40 hours of general time to develop an AEDM based on existing simulation tools and 16 hours to validate two basic models within that AEDM at the cost of an engineering calibration technician fully burdened wage of $46 per hour plus the cost of third-party physical testing of two units per validation class (as required in 10 CFR 429.70(c)(2)(iv)). DOE estimated the additional per basic model cost to determine efficiency using an AEDM assuming 1 hour per basic model at the cost of an engineering calibration technician wage of $46 per hour.

[80] Per the sampling requirements specified at 10 CFR 429.53(a)(2)(ii) and 429.11(b), manufacturers are required to test at least two units to determine the rating for a basic model, except where only one unit of the basic model is produced.

[81] Shipping costs associated with third-party physical testing of two units per validation class (as required in 10 CFR 429.70(c)(2)(iv)).

approximately $46 per basic model [82] for determining energy efficiency using the validated AEDM.

DOE estimated the range of potential costs for the two domestic, small OEMs that manufacture single-packaged dedicated systems. When developing cost estimates for the small OEMs, DOE considered the cost to update the existing AEDM simulation tool, the costs to validate the AEDM through physical testing (including shipping costs to and from the third-party laboratory), and the cost to rate basic models using the AEDM.

Both small businesses manufacture indoor and outdoor, low- and medium-temperature, single-packaged dedicated systems. One small business manufactures 28 basic models of single-packaged dedicated systems with an estimated annual revenue of $110 million. Therefore, DOE estimates the associated re-rating costs for this manufacturer to be approximately $91,250 when making use of AEDMs. The cost for this manufacturer represents less than 1 percent of annual revenue.

The second small business manufactures 38 basic models of single-packaged dedicated systems with an estimated annual revenue of $156 million. Therefore, DOE estimates the associated re-rating costs for this manufacturer to be approximately $91,700 when making use of AEDMs. The cost for this manufacturer represents less than 1 percent of annual revenue.

As previously discussed, the procedure in appendix C1 would only require retesting or recertification when and if a future energy conservation standard takes effect.

As also discussed in this final rule, DOE is adopting test procedures for CO_2 unit coolers and high-temperature refrigeration systems. DOE estimates that the average third-party lab per unit test cost would be $11,000 for a high-temperature matched pair or single-packaged dedicated system, $6,000 for a high-temperature unit cooler tested alone, $6,500 for a low-temperature CO_2 unit cooler, and $6,000 for a medium-temperature CO_2 unit cooler. As discussed previously, DOE has granted waivers to certain manufacturers for both high-temperature refrigeration systems and CO_2 unit coolers. The test procedures being adopted are consistent with the alternate test procedures included in the granted waivers. For those manufacturers who have been granted a test procedure waiver for this equipment, DOE expects that there would be no additional test burden. However, DOE expects that there would be additional testing costs for any manufacturers of these products who have not submitted or been granted a test procedure waiver at the time this test procedure is finalized. DOE estimates these manufacturers may incur rating expenses up to the following estimates, in addition to an estimated $5,000 to $2,000 in shipping costs for each class.[83]

- $22,000 per basic model for a high-temperature matched pair or single-packaged dedicated system; [84]
- $12,000 per basic model for a high-temperature unit cooler tested alone; [85]
- $13,000 per basic model for a low-temperature CO_2 unit cooler; [86] and
- $12,000 per basic model for a medium-temperature CO_2 unit cooler.[87]

However, manufacturers are not required to perform laboratory testing on all basic models. In accordance with 10 CFR 429.53, WICF refrigeration system manufacturers may elect to use AEDMs. DOE estimates the per-manufacturer cost to develop and validate an AEDM for high-temperature systems and low- and medium-temperature CO_2 unit coolers to be $24,580 per validation class, in addition to an estimated $1,000 to $4,000 in round trip shipping costs.[88] DOE estimates an additional cost of approximately $46 per basic model [89] for determining energy efficiency using the validated AEDM.

DOE estimated the potential costs to manufacturers of high-temperature units as a result of off-cycle requirements using an AEDM. Specifically, DOE estimated the range of potential costs for the five identified domestic, small OEMs that manufacture high-temperature units. When developing cost estimates for the small OEMs, DOE considers the cost to develop the AEDM simulation tool, the costs to validate the AEDM through physical testing (including shipping costs to and from the third-party laboratory), and the cost to rate basic models using the AEDM. DOE assumes a scenario where manufacturers would be required to develop AEDMs for three validation classes.

DOE estimated the impacts based on basic model counts and company revenue. Table IV.2 summarizes DOE's estimates for the five identified small businesses. On average, testing costs represent approximately 1.3 percent of annual revenue for a typical small business.

As previously discussed, the procedure in appendix C1 would only require retesting or recertification when and if a future energy conservation standard takes effect.

[81] Shipping costs associated with third-party physical testing of two units per validation class (as required in 10 CFR 429.70(c)(2)(iv)).

[82] DOE estimated initial costs to validate an AEDM assuming 40 hours of general time to develop an AEDM based on existing simulation tools and 16 hours to validate two basic models within that AEDM at the cost of an engineering calibration technician fully burdened wage of $46 per hour plus the cost of third-party physical testing of two units per validation class (as required in 10 CFR 429.70(c)(2)(iv)). DOE estimated the additional per basic model cost to determine efficiency using an AEDM assuming 1 hour per basic model at the cost of an engineering calibration technician wage of $46 per hour.

[83] The cost to ship one unit to and from the third-party lab is approximately $500 to $2,000. Per the sampling requirements specified at 10 CFR 429.53(a)(2)(ii) and 429.11(b), manufacturers are required to test at least two units to determine the rating for a basic model, except where only one unit of the basic model is produced.

[84] Per the sampling requirements specified at 10 CFR 429.53(a)(2)(ii) and 429.11(b), manufacturers

[88] Shipping costs associated with third-party physical testing of two units per validation class (as required in 10 CFR 429.70(c)(2)(iv)).

[89] DOE estimated initial costs to validate an AEDM assuming 40 hours of general time to develop an AEDM based on existing simulation tools and 16 hours to validate two basic models within that AEDM at the cost of an engineering calibration technician fully burdened wage of $46 per hour plus the cost of third-party physical testing of two units per validation class (as required in 10 CFR 429.70(c)(2)(iv)). DOE estimated the additional per basic model cost to determine efficiency using an AEDM assuming 1 hour per basic model at the cost of an engineering calibration technician wage of $46 per hour.

TABLE IV.2—POTENTIAL SMALL BUSINESS RE-RATING COSTS (2022$) FOR HIGH-TEMPERATURE REFRIGERATION SYSTEMS

Small domestic OEM	Re-rating estimate *($MM)*	Estimated annual revenue *($MM)*	Percent of annual revenue
Manufacturer A	0.089	3.9	2.3
Manufacturer B	0.088	3.6	2.5
Manufacturer C	0.089	11.5	0.8
Manufacturer D	0.091	10.8	0.8
Manufacturer E	0.089	208.0	0.0

Manufacturers of CO_2 unit coolers may also choose to utilize an AEDM. Furthermore, AEDM unit cooler validation classes do not distinguish between CO_2 unit coolers and non-CO_2 unit coolers. Therefore, manufacturers of CO_2 unit coolers may use the same validation classes as non-CO_2 unit coolers.

On the basis that the adopted test procedure changes will not require retesting and recertification, DOE certifies that this final rule does not have a ''significant economic impact on a substantial number of small entities,'' and that the preparation of a FRFA is not warranted. DOE will transmit a certification and supporting statement of factual basis to the Chief Counsel for Advocacy of the Small Business Administration for review under 5 U.S.C. 605(b).

C. Review Under the Paperwork Reduction Act of 1995

Manufacturers of walk-ins must certify to DOE that their products comply with any applicable energy conservation standards. To certify compliance, manufacturers must first obtain test data for their products according to the DOE test procedures, including any amendments adopted for those test procedures. DOE has established regulations for the certification and recordkeeping requirements for all covered consumer products and commercial equipment, walk-ins. (*See* generally 10 CFR part 429.) The collection-of-information requirement for the certification and recordkeeping is subject to review and approval by OMB under the Paperwork Reduction Act (PRA). This requirement has been approved by OMB under OMB Control Number 1910–1400. Public reporting burden for the certification is estimated to average 35 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

DOE is not amending the certification or reporting requirements for walk-ins in this final rule. Instead, DOE may consider proposals to amend the certification requirements and reporting for walk-ins under a separate rulemaking regarding appliance and equipment certification. DOE will address changes to OMB Control Number 1910–1400 at that time, as necessary.

Notwithstanding any other provision of the law, no person is required to respond to, nor shall any person be subject to a penalty for failure to comply with, a collection of information subject to the requirements of the PRA, unless that collection of information displays a currently valid OMB Control Number.

D. Review Under the National Environmental Policy Act of 1969

In this final rule, DOE establishes test procedure amendments that it expects will be used to develop and implement future energy conservation standards for walk-ins. DOE has determined that this rule falls into a class of actions that are categorically excluded from review under the National Environmental Policy Act of 1969 (42 U.S.C. 4321 *et seq.*) and DOE's implementing regulations at 10 CFR part 1021. Specifically, DOE has determined that adopting test procedures for measuring energy efficiency of consumer products and industrial equipment is consistent with activities identified in 10 CFR part 1021, appendix A to subpart D, A5 and A6. Accordingly, neither an environmental assessment nor an environmental impact statement is required.

E. Review Under Executive Order 13132

Executive Order 13132, ''Federalism,'' 64 FR 43255 (August 4, 1999), imposes certain requirements on agencies formulating and implementing policies or regulations that preempt State law or that have federalism implications. The Executive order requires agencies to examine the constitutional and statutory authority supporting any action that would limit the policymaking discretion of the States and to carefully assess the necessity for such actions. The Executive order also requires agencies to have an accountable process to ensure meaningful and timely input by State and local officials in the development of regulatory policies that have Federalism implications. On March 14, 2000, DOE published a statement of policy describing the intergovernmental consultation process it will follow in the development of such regulations. 65 FR 13735. DOE examined this final rule and determined that it will not have a substantial direct effect on the States, on the relationship between the National Government and the States, or on the distribution of power and responsibilities among the various levels of government. EPCA governs and prescribes Federal preemption of State regulations as to energy conservation for the equipment that are the subject of this final rule. States can petition DOE for exemption from such preemption to the extent, and based on criteria, set forth in EPCA. (42 U.S.C. 6297(d)) No further action is required by Executive Order 13132.

F. Review Under Executive Order 12988

Regarding the review of existing regulations and the promulgation of new regulations, section 3(a) of Executive Order 12988, ''Civil Justice Reform,'' 61 FR 4729 (Feb. 7, 1996), imposes on Federal agencies the general duty to adhere to the following requirements: (1) eliminate drafting errors and ambiguity; (2) write regulations to minimize litigation; (3) provide a clear legal standard for affected conduct rather than a general standard; and (4) promote simplification and burden reduction. Section 3(b) of Executive Order 12988 specifically requires that Executive agencies make every reasonable effort to ensure that the regulation (1) clearly specifies the preemptive effect, if any; (2) clearly specifies any effect on existing Federal law or regulation; (3) provides a clear legal standard for affected conduct while promoting simplification and burden reduction; (4) specifies the retroactive effect, if any; (5) adequately defines key terms; and (6) addresses other important issues affecting clarity and general draftsmanship under any guidelines issued by the Attorney General. Section 3(c) of Executive Order 12988 requires Executive agencies to review regulations in light of applicable standards in sections 3(a) and 3(b) to determine whether they are met or it is unreasonable to meet one or more of them. DOE has completed the required review and determined that, to the extent permitted by law, this final rule meets the relevant standards of Executive Order 12988.

G. Review Under the Unfunded Mandates Reform Act of 1995

Title II of the Unfunded Mandates Reform Act of 1995 (''UMRA'') requires each Federal agency to assess the effects of Federal regulatory actions on State, local, and Tribal governments and the private sector. Public Law 104–4, sec. 201 (codified at 2 U.S.C. 1531). For a regulatory action resulting in a rule that may cause the expenditure by State, local, and Tribal governments, in the aggregate, or by the private sector of $100 million or more in any one year (adjusted annually for inflation), section 202 of UMRA requires a Federal agency to publish a written statement that estimates the resulting costs, benefits, and other effects on the national economy. (2 U.S.C. 1532(a), (b)) The UMRA also requires a Federal agency to develop an effective process to permit timely input by elected officers of State, local, and Tribal governments on a proposed ''significant intergovernmental mandate,'' and requires an agency plan for giving notice and opportunity for timely input to potentially affected small governments before establishing any requirements that might significantly or uniquely affect small governments. On March 18, 1997, DOE published a statement of policy on its process for intergovernmental consultation under UMRA. 62 FR 12820; also available at *www.energy.gov/gc/office-general-counsel.* DOE examined this final rule according to UMRA and its statement of policy and determined that the rule contains neither an intergovernmental mandate, nor a mandate that may result in the expenditure of $100 million or more in any year, so these requirements do not apply.

H. Review Under the Treasury and General Government Appropriations Act, 1999

Section 654 of the Treasury and General Government Appropriations Act, 1999 (Pub. L. 105–277) requires Federal agencies to issue a Family Policymaking Assessment for any rule that may affect family well-being. This final rule will not have any impact on the autonomy or integrity of the family as an institution. Accordingly, DOE has concluded that it is not necessary to prepare a Family Policymaking Assessment.

I. Review Under Executive Order 12630

DOE has determined, under Executive Order 12630, ''Governmental Actions and Interference with Constitutionally Protected Property Rights,'' 53 FR 8859 (March 18, 1988), that this regulation will not result in any takings that might require compensation under the Fifth Amendment to the U.S. Constitution.

J. Review Under Treasury and General Government Appropriations Act, 2001

Section 515 of the Treasury and General Government Appropriations Act, 2001 (44 U.S.C. 3516 note) provides for agencies to review most disseminations of information to the public under guidelines established by each agency pursuant to general guidelines issued by OMB. OMB's guidelines were published at 67 FR 8452 (Feb. 22, 2002), and DOE's guidelines were published at 67 FR 62446 (Oct. 7, 2002). Pursuant to OMB Memorandum M–19–15, Improving Implementation of the Information Quality Act (April 24, 2019), DOE published updated guidelines which are available at *www.energy.gov/sites/prod/files/2019/12/f70/DOE%20Final%20Updated%20IQA%20Guidelines%20Dec%202019.pdf.* DOE has reviewed this final rule under the OMB and DOE guidelines and has concluded that it is consistent with applicable policies in those guidelines.

K. Review Under Executive Order 13211

Executive Order 13211, ''Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use,'' 66 FR 28355 (May 22, 2001), requires Federal agencies to prepare and submit to OMB, a Statement of Energy Effects for any significant energy action. A ''significant energy action'' is defined as any action by an agency that promulgated or is expected to lead to promulgation of a final rule, and that (1) is a significant regulatory action under Executive Order 12866, or any successor order; and (2) is likely to have a significant adverse effect on the supply, distribution, or use of energy; or (3) is designated by the Administrator of OIRA as a significant energy action. For any significant energy action, the agency must give a detailed statement of any adverse effects on energy supply, distribution, or use if the regulation is implemented, and of reasonable alternatives to the action and their expected benefits on energy supply, distribution, and use.

This regulatory action is not a significant regulatory action under Executive Order 12866. Moreover, it would not have a significant adverse effect on the supply, distribution, or use of energy, nor has it been designated as a significant energy action by the Administrator of OIRA. Therefore, it is not a significant energy action, and, accordingly, DOE has not prepared a Statement of Energy Effects.

L. Review Under Section 32 of the Federal Energy Administration Act of 1974

Under section 301 of the Department of Energy Organization Act (Pub. L. 95–91; 42 U.S.C. 7101), DOE must comply with section 32 of the Federal Energy Administration Act of 1974, as amended by the Federal Energy Administration Authorization Act of 1977. (15 U.S.C. 788; ''FEAA'') Section 32 essentially provides in relevant part that, where a rule authorizes or requires use of commercial standards, the rulemaking must inform the public of the use and background of such standards. In addition, section 32(c) requires DOE to consult with the Attorney General and the Chairman of the Federal Trade Commission (''FTC'') concerning the impact of the commercial or industry standards on competition.

The modifications to the test procedure for walk-ins adopted in this final rule incorporates testing methods contained in certain sections of the following commercial standards: NFRC 102–2020, ASTM C1199–14, ASTM C518–17, AHRI 1250–2020, AHRI 1250–2020, ANSI/ASHRAE 37–2009, and ANSI/ASHRAE 16–2016. DOE has evaluated these standards and is unable to conclude whether it fully complies with the requirements of section 32(b) of the FEAA (*i.e.,* whether it was developed in a manner that fully provides for public participation, comment, and review). DOE has consulted with both the Attorney General and the Chairman of the FTC about the impact on competition of using the methods contained in these standards.

M. Congressional Notification

As required by 5 U.S.C. 801, DOE will report to Congress on the promulgation of this rule before its effective date. The report will state that it has been determined that the rule is not a ''major rule'' as defined by 5 U.S.C. 804(2).

N. Description of Materials Incorporated by Reference

AHRI Standard 1250 (I–P)-2009 is an industry-accepted test procedure for measuring the performance of walk-in cooler and walk-in freezer refrigeration systems. Specifically, the test procedure codified by this final rule references AHRI 1250–2009 for testing walk-in refrigeration units. AHRI 1250–2009 is reasonably available on AHRI's website at *www.ahrinet.org/standards/search-standards.*

AHRI Standard 1250–2020 is an industry-accepted test procedure for measuring the performance of walk-in cooler and walk-in freezer refrigeration systems. Specifically, the test procedure codified by this final rule references AHRI 1250–2020 for testing walk-in refrigeration units. AHRI 1250–2020 is reasonably available on AHRI's website at *www.ahrinet.org/standards/search-standards.*

ANSI/AHRI Standard 420–2008 is an industry-accepted test procedure for rating the performance of forced-circulation free-delivery unit coolers for refrigeration and is referenced by AHRI 1250–2009. Specifically, the test procedure codified by this final rule references AHRI 420–2008 for the information that should be recorded when testing unit coolers. AHRI 420–2008 is reasonably available on AHRI's website at *www.ahrinet.org/standards/search-standards.*

ANSI/ASHRAE Standard 16–2016 is an industry-accepted test procedure for measuring cooling and heating capacity of room air conditioners, packaged terminal air conditioners, and packaged terminal heat pumps and is referenced by AHRI 1250–2020. Specifically, the test procedure codified by this final rule references ANSI/ASHRAE 16–2016 for test provisions related the capacity measurement of single-packaged dedicated systems for the appendix C1 test procedure. ANSI/ASHRAE 16–2016 is reasonably available on ASHRAE's website at *www.ashrae.org.*

ANSI/ASHRAE Standard 23.1–2010 is an industry-accepted test procedure for rating the performance of positive displacement refrigerant compressors and condensing units that operate at refrigerant subcritical temperatures and is referenced by AHRI 1250–2009 and AHRI 1250–2020. Specifically, the test procedure codified by this final rule references ANSI/ASHRAE 23.1–2010 for test provisions related to capacity measurement of condensing units using the compressor calibration method. ANSI/ASHRAE 23.1–2010 is reasonably available on ASHRAE's website at *www.ashrae.org.*

ANSI/ASHRAE Standard 37–2009 is an industry-accepted test procedure for testing and rating air-conditioning and heat pump equipment and is referenced by AHRI 1250–2020. Specifically, the test procedure codified by this final rule references ANSI/ASHRAE 37–2009 for test provisions related to capacity measurement of single-packaged dedicated systems for the appendix C1 test procedure. ANSI/ASHRAE 37–2009 is reasonably available on ASHRAE's website at *www.ashrae.org.*

ANSI/ASHRAE Standard 41.1–2013 is an industry-accepted test procedure for measuring temperature and is referenced by AHRI 1250–2020. Specifically, the test procedure codified by this final rule references ANSI/ASHRAE 41.1–2013 for temperature measurements for all refrigeration unit tests. ANSI/ASHRAE 41.1–2013 is reasonably available on ASHRAE's website at *www.ashrae.org.*

ANSI/ASHRAE Standard 41.3–2014 is an industry-accepted test procedure for measuring pressure and is referenced by AHRI 1250–2020. Specifically, the test procedure codified by this final rule references ANSI/ASHRAE 41.3–2014 for pressure measurements for all refrigeration unit tests. ANSI/ASHRAE 41.3–12014 is reasonably available on ASHRAE's website at *www.ashrae.org.*

ANSI/ASHRAE Standard 41.6–2014 is an industry-accepted test procedure for measuring humidity and is referenced by AHRI 1250–2020. Specifically, the test procedure codified by this final rule references ANSI/ASHRAE 41.6–2014 for test provisions related to capacity measurement of single-packaged dedicated systems for the appendix C1 test procedure. ANSI/ASHRAE 41.6–2014 is reasonably available on ASHRAE's website at *www.ashrae.org.*

ANSI/ASHRAE Standard 41.10–2013 is an industry-accepted test procedure for measuring the mass flow of volatile refrigerants with flowmeter test methods and is referenced by AHRI 1250–2020. Specifically, the test procedure codified by this final rule references ANSI/ASHRAE 41.10–2013 for measuring the flow rates of volatile refrigerants with flow meters for all refrigeration unit tests. ANSI/ASHRAE 41.10–2013 is reasonably available on ASHRAE's website at *www.ashrae.org.*

ASTM C518–17 is an industry-accepted test procedure for measuring thermal transmission properties using a heat flow meter apparatus. Specifically, the test procedure codified by this final rule references ASTM C518–17 for testing walk-in envelope components. ASTM C518–17 is reasonably available on ASTM's website at *www.astm.org.*

ASTM C1199–14 is an industry-accepted test procedure for measuring the steady state thermal transmittance of fenestration systems and is referenced by NFRC 102–2020. Specifically, the test procedure codified by this final rule references ASTM C1199–14 for testing walk-in envelope components. ASTM C1199–14 is reasonably available on ASTM's website at *www.astm.org.*

NFRC 102–2020 [E0A0], is an industry-accepted test procedure for measuring the steady state thermal transmittance of fenestration systems. Specifically, the test procedure codified by this final rule references NFRC 102–2020 for testing walk-in envelope components. NFRC 102–2020 is reasonably available on NFRC's website at *www.nfrc.org.*

V. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of this final rule.

List of Subjects

10 CFR Part 429

Administrative practice and procedure, Confidential business information, Energy conservation, Household appliances, Imports, Intergovernmental relations, Reporting and recordkeeping requirements, Small businesses.

10 CFR Part 431

Administrative practice and procedure, Confidential business information, Energy conservation test procedures, Incorporation by reference, Reporting and recordkeeping requirements.

Signing Authority

This document of the Department of Energy was signed on April 12, 2023, by Francisco Alejandro Moreno, Acting Assistant Secretary for Energy Efficiency and Renewable Energy, pursuant to delegated authority from the Secretary of Energy. That document with the original signature and date is maintained by DOE. For administrative purposes only, and in compliance with requirements of the Office of the Federal Register, the undersigned DOE Federal Register Liaison Officer has been authorized to sign and submit the document in electronic format for publication, as an official document of the Department of Energy. This administrative process in no way alters the legal effect of this document upon publication in the **Federal Register**.

Signed in Washington, DC, on April 12, 2023.

Treena V. Garrett,

Federal Register Liaison Officer, U.S. Department of Energy.

For the reasons stated in the preamble, DOE is amending parts 429 and 431 of chapter II of title 10, Code of Federal Regulations as set forth below:

PART 429—CERTIFICATION, COMPLIANCE, AND ENFORCEMENT FOR CONSUMER PRODUCTS AND COMMERCIAL AND INDUSTRIAL EQUIPMENT

■ 1. The authority citation for part 429 continues to read as follows:

Authority: 42 U.S.C. 6291–6317; 28 U.S.C. 2461 note.

■ 2. Amend § 429.53 by revising paragraphs (a)(2)(i) and (a)(3) and adding paragraph (a)(4) to read as follows:

§ 429.53 Walk-in coolers and walk-in freezers.

(a) * * *

(2) * * *

(i) *Applicable test procedure.* If AWEF or AWEF2 is determined by testing, test according to the applicable provisions of § 431.304(b) of this chapter with the following equipment-specific provisions.

(A) *Dedicated condensing units.* Outdoor dedicated condensing refrigeration systems that are also designated for use in indoor applications must be tested and rated as both an outdoor dedicated condensing refrigeration system and an indoor dedicated refrigeration system.

(B) *Matched refrigeration systems.* A matched refrigeration system is not required to be rated if the constituent unit cooler(s) and dedicated condensing unit have been tested as specified in § 431.304(b)(4) of this chapter. However, if a manufacturer wishes to represent the efficiency of the matched refrigeration system as distinct from the efficiency of either constituent component, or if the manufacturer cannot rate one or both of the constituent components using the specified method, the manufacturer must test and rate the matched refrigeration system as specified in § 431.304(b)(4) of this chapter.

(C) *Detachable single-packaged dedicated systems.* Detachable single-packaged dedicated systems must be tested and rated as a single-packaged dedicated systems using the test procedure in § 431.304(b)(4) of this chapter.

(D) *Attached split systems.* Attached split systems must be tested and rated as dedicated condensing units and unit coolers using the test procedure in § 431.304(b)(4) of this chapter.

* * * * *

(3) For each basic model of walk-in cooler and walk-in freezer display and non-display door, the daily energy consumption must be determined by testing, in accordance with § 431.304 of this chapter and the provisions of this section, or by application of an AEDM that meets the requirements of § 429.70 and the provisions of this section.

(i) *Applicable test procedure.* Prior to October 31, 2023 use the test procedure for walk-ins in 10 CFR part 431, subpart R, appendix A, revised as of January 1, 2022, to determine daily energy consumption. Beginning October 31, 2023, use the test procedure in part 431, subpart R, appendix A of this chapter to determine daily energy consumption.

(ii) *Units to be tested.* For each basic model, a sample of sufficient size shall be randomly selected and tested to ensure that any represented value of daily energy consumption of a basic model or other measure of energy use for which consumers would favor lower values shall be greater than or equal to the higher of:

(A) The mean of the sample, where:

Equation 3 to Paragraph (a)(3)(ii)(A)

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

And $\bar{x}$ is the sample mean, n is the number of samples, and $\bar{x}_i$ is the ith sample; or,

(B) The upper 95 percent confidence limit (UCL) of the true mean divided by 1.05, where:

Equation 4 to Paragraph (a)(3)(ii)(B)

$$UCL = \bar{x} + t_{0.95}\frac{s}{\sqrt{n}}$$

And $\bar{x}$ is the sample mean, s is the sample standard deviation; n is the number of samples, and $t_{-0.95}$ is the statistic for a 95 percent one-tailed confidence interval with n-1 degrees of freedom (from appendix A to this subpart).

(4) For each basic model of walk-in cooler and walk-in freezer panel and non-display door, the R-value must be determined by testing, in accordance with § 431.304 of this chapter and the provisions of this section.

(i) *Applicable test procedure.* Prior to October 31, 2023, use the test procedure for walk-ins in 10 CFR part 431, subpart R, appendix B, revised as of January 1, 2022, to determine R-value. Beginning October 31, 2023, use the test procedure in appendix B to subpart R of part 431 of this chapter to determine R-value.

(ii) *Units to be tested.* For each basic model, a sample of sufficient size shall be randomly selected and tested to ensure that any represented value of R-value or other measure of efficiency of a basic model for which consumers would favor higher values shall be less than or equal to the lower of:

(A) The mean of the sample, where:

Equation 5 to Paragraph (a)(4)(ii)(A)

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

And $\bar{x}$ is the sample mean, n is the number of samples, and $\bar{x}_i$ is the i^{th} sample; or,

(B) The lower 95 percent confidence limit (LCL) of the true mean divided by 0.95, where:

Equation 6 to Paragraph (a)(4)(ii)(B)

$$LCL = \bar{x} - t_{0.95}\frac{s}{\sqrt{n}}$$

And $\bar{x}$ is the sample mean, s is the sample standard deviation; n is the number of samples, and $t_{-0.95}$ is the statistic for a 95 percent one-tailed confidence interval with n–1 degree of freedom (from appendix A to this subpart).

* * * * *

■ 3. Amend § 429.70 by:

■ a. Adding a heading for the table in paragraph (c)(5)(viii)(A);

■ b. Renumbering tables 7 and 8 in paragraphs (m)(5)(vi) and (m)(5)(viii)(A), respectively, as tables 9 and 10;

■ c. Revising the heading to paragraph (f) and paragraphs (f)(2)(ii)(A) and (B);

■ d. Adding paragraphs (f)(2)(ii)(C) and (f)(2)(iii)(E);

■ e. Revising paragraphs (f)(2)(iv) and (f)(5)(vi); and

■ f. Adding a heading for the table in paragraph (h)(2)(iv).

The revisions and additions read as follows:

§ 429.70 Alternative methods for determining energy efficiency and energy use.

* * * * *

(c) * * *

(5) * * *

(viii) * * *

(A) * * *

Table 3 to Paragraph (c)(5)(viii)(A)

* * * * *

(f) *Alternative efficiency determination method (AEDM) for walk-*

in refrigeration systems and doors—

* * *

(2) * * *

(ii) * * *

(A) For refrigeration systems, which are subject to an energy efficiency metric, the predicted efficiency for each model calculated by applying the AEDM may not be more than five percent greater than the efficiency determined from the corresponding test of the model.

(B) For doors, which are subject to an energy consumption metric the predicted daily energy consumption for each model calculated by applying the AEDM may not be more than five percent less than the daily energy consumption determined from the corresponding test of the model.

(C) The predicted energy efficiency or energy consumption for each model calculated by applying the AEDM must meet or exceed the applicable federal energy conservation standard.

(iii) * * *

(E) For rating doors, an AEDM may not simulate or model components of the door that are not required to be tested by the DOE test procedure. That is, if the test results used to validate the AEDM are for the U-factor test of the door, the AEDM must estimate the daily energy consumption, specifically the conduction thermal load, and the direct and indirect electrical energy consumption, using the nominal values and calculation procedure specified in the DOE test procedure.

(iv) *WICF validation classes*—(A) *Doors.*

TABLE 4 TO PARAGRAPH (f)(2)(iv)(A)

Validation class	Minimum number of distinct models that must be tested
Display Doors, Medium Temperature	2 Basic Models.
Display Doors, Low Temperature	2 Basic Models.
Non-display Doors, Medium Temperature	2 Basic Models.
Non-display Doors, Low Temperature	2 Basic Models.

(B) *Refrigeration systems.* (*1*) For representations made prior to the compliance date of revised energy conservation standards for walk-in cooler and walk-in freezer refrigeration systems, use the following validation classes.

TABLE 5 TO PARAGRAPH (f)(2)(iv)(B)(*1*)

Validation class	Minimum number of distinct models that must be tested
Dedicated Condensing, Medium Temperature, Matched Pair Indoor System	2 Basic Models.
Dedicated Condensing, Medium Temperature, Matched Pair Outdoor System [1]	2 Basic Models.
Dedicated Condensing, Low Temperature, Matched Pair Indoor System	2 Basic Models.
Dedicated Condensing, Low Temperature, Matched Pair Outdoor System [1]	2 Basic Models.
Unit Cooler, High-temperature	2 Basic Models.
Unit Cooler, Medium Temperature	2 Basic Models.
Unit Cooler, Low Temperature	2 Basic Models.
Medium Temperature, Indoor Condensing Unit	2 Basic Models.
Medium Temperature, Outdoor Condensing Unit [1]	2 Basic Models.
Low Temperature, Indoor Condensing Unit	2 Basic Models.
Low Temperature, Outdoor Condensing Unit [1]	2 Basic Models.

[1] AEDMs validated for an outdoor class by testing only outdoor models of that class may be used to determine representative values for the corresponding indoor class, and additional validation testing is not required. AEDMs validated only for a given indoor class by testing indoor models or a mix of indoor and outdoor models may not be used to determine representative values for the corresponding outdoor class.

(*2*) For representations made on or after the compliance date of revised energy conservation standards for walk-in cooler and walk-in freezer refrigeration systems, use the following validation classes.

TABLE 6 TO PARAGRAPH (f)(2)(iv)(B)(*2*)

Validation class	Minimum number of distinct models that must be tested
Dedicated Condensing Unit, Medium Temperature, Indoor System	2 Basic Models.
Dedicated Condensing Unit, Medium Temperature, Outdoor System [1]	2 Basic Models.
Dedicated Condensing Unit, Low Temperature, Indoor System	2 Basic Models.
Dedicated Condensing Unit, Low Temperature, Outdoor System [1]	2 Basic Models.
Single-packaged Dedicated Condensing, High-temperature, Indoor System	2 Basic Models.
Single-packaged Dedicated Condensing, High-temperature, Outdoor System [1]	2 Basic Models.
Single-packaged Dedicated Condensing, Medium Temperature, Indoor System	2 Basic Models.
Single-packaged Dedicated Condensing, Medium Temperature, Outdoor System [1]	2 Basic Models.
Single-packaged Dedicated Condensing, Low Temperature, Indoor System	2 Basic Models.
Single-packaged Dedicated Condensing, Low Temperature, Indoor System [1]	2 Basic Models.
Matched Pair, High-temperature, Indoor Condensing Unit	2 Basic Models.
Matched Pair, High-temperature, Outdoor Condensing Unit [1]	2 Basic Models.
Matched Pair, Medium Temperature, Indoor Condensing Unit	2 Basic Models.
Matched Pair, Medium Temperature, Outdoor Condensing Unit [1]	2 Basic Models.

TABLE 6 TO PARAGRAPH (f)(2)(iv)(B)(*2*)—Continued

Validation class	Minimum number of distinct models that must be tested
Matched Pair, Low Temperature, Indoor Condensing Unit	2 Basic Models.
Matched Pair, Low Temperature, Outdoor Condensing Unit [1]	2 Basic Models.
Unit Cooler, High-temperature	2 Basic Models.
Unit Cooler, Medium Temperature	2 Basic Models.
Unit Cooler, Low Temperature	2 Basic Models.

[1] AEDMs validated for an outdoor class by testing only outdoor models of that class may be used to determine representative values for the corresponding indoor class, and additional validation testing is not required. AEDMs validated only for a given indoor class by testing indoor models or a mix of indoor and outdoor models may not be used to determine representative values for the corresponding outdoor class.

* * * * *

(5) * * *

(vi) *Tolerances.* For efficiency metrics, the result from a DOE verification test must be greater than or equal to the certified rating × (1 − the applicable tolerance). For energy consumption metrics, the result from a DOE verification test must be less than or equal to the certified rating × (1 + the applicable tolerance).

TABLE 7 TO PARAGRAPH (f)(5)(iv)

Equipment	Metric	Applicable tolerance (%)
Refrigeration systems (including components)	AWEF/AWEF2	5
Doors	Daily Energy Consumption	5

* * * * *

(h) * * *

(2) * * *

(iv) * * *

Table 8 to Paragraph (h)(2)(iv)

* * * * *

■ 4. Amend § 429.110 by revising paragraph (e)(2) to read as follows:

§ 429.110 Enforcement testing.

* * * * *

(e) * * *

(2) For automatic commercial ice makers; commercial refrigerators, freezers, and refrigerator-freezers; refrigerated bottled or canned vending machines; commercial air conditioners and heat pumps; commercial packaged boilers; commercial warm air furnaces; commercial water heating equipment; and walk-in cooler and walk-in freezer doors, panels, and refrigeration systems, DOE will use an initial sample size of not more than four units and follow the sampling plans in appendix B to this subpart.

* * * * *

■ 5. Amend § 429.134 by adding introductory text to paragraph (q) and revising paragraphs (q)(2) and (4) to read as follows:

§ 429.134 Product-specific enforcement provisions.

* * * * *

(q) * * * Prior to October 31, 2023, the provisions in 10 CFR 429.134, revised as of January 1, 2022, are applicable. On and after October 31, 2023, the following provisions apply.

* * * * *

(2) *Verification of refrigeration system net capacity.* The net capacity of the refrigeration system basic model will be measured pursuant to the test requirements of part 431, subpart R, appendix C of this chapter for each unit tested on and after October 31, 2023, but before the compliance date of revised energy conservation standards for walk-in cooler and walk-in freezer refrigeration systems. The net capacity of the refrigeration system basic model will be measured pursuant to the test requirements of part 431, subpart R, appendix C1 of this chapter for each unit tested on and after the compliance date of revised energy conservation standards for walk-in cooler and walk-in freezer refrigeration systems. The results of the measurement(s) will be averaged and compared to the value of net capacity certified by the manufacturer. The certified net capacity will be considered valid only if the average measured net capacity is within plus or minus five percent of the certified net capacity.

* * * * *

(4) *Verification of door electricity-consuming device power.* For each basic model of walk-in cooler and walk-in freezer door, DOE will calculate the door's energy consumption using the input power listed on the nameplate of each electricity-consuming device shipped with the door. If an electricity-consuming device shipped with a walk-in door does not have a nameplate or the nameplate does not list the device's input power, then DOE will use the device's rated input power included in the door's certification report. If the door is not certified or if the certification does not include a rated input power for an electricity-consuming device shipped with a walk-in door, DOE will use the measured input power. DOE also may validate the power listed on the nameplate or the rated input power by measuring it when energized using a power supply that provides power within the allowable voltage range listed on the component nameplate or the door nameplate, whichever is available. If the measured input power is more than 10 percent higher than the input power listed on the nameplate or the rated input power, as appropriate, then the measured input power shall be used in the door's energy consumption calculation.

(i) For electricity-consuming devices with controls, the maximum input wattage observed while energizing the device and activating the control shall be considered the measured input power. For anti-sweat heaters that are controlled based on humidity levels, the control may be activated by increasing relative humidity in the region of the controls without damaging the sensor. For lighting fixtures that are controlled with motion sensors, the control may be activated by simulating motion in the vicinity of the sensor. Other kinds of controls may be activated based on the functions of their sensor.

(ii) [Reserved]

* * * * *

PART 431—ENERGY EFFICIENCY PROGRAM FOR CERTAIN COMMERCIAL AND INDUSTRIAL EQUIPMENT

■ 6. The authority citation for part 431 continues to read as follows:

Authority: 42 U.S.C. 6291–6317; 28 U.S.C. 2461 note.

■ 7. Amend § 431.302 by:
■ a. Adding, in alphabetical order, definitions for ''Attached split system,'' ''CO_2 unit cooler,'' and ''Detachable single-packaged dedicated system'';
■ b. Revising the definition for ''Door'';
■ c. Adding, in alphabetical order, definitions for ''Door leaf,'' ''Door surface area,'' ''Ducted fan coil unit,'' ''Ducted multi-circuit single-packaged dedicated system,'' ''Ducted single-packaged dedicated system,'' ''High-temperature refrigeration system,'' ''Multi-circuit single-packaged dedicated system,'' and ''Non-display door''; and
■ d. Revising the definition of ''Walk-in cooler and walk-in freezer''.

The additions and revisions read as follows:

§ 431.302 Definitions concerning walk-in coolers and walk-in freezers.

* * * * *

Attached split system means a matched pair refrigeration system which is designed to be installed with the evaporator entirely inside the walk-in enclosure and the condenser entirely outside the walk-in enclosure, and the evaporator and condenser are permanently connected with structural members extending through the walk-in wall.

* * * * *

CO_2 *unit cooler* means a unit cooler that includes a nameplate listing only CO_2 as an approved refrigerant.

* * * * *

* * * * *

Detachable single-packaged dedicated system means a system consisting of a dedicated condensing unit and an insulated evaporator section in which the evaporator section is designed to be installed external to the walk-in enclosure and circulating air through the enclosure wall, and the condensing unit is designed to be installed either attached to the evaporator section or mounted remotely with a set of refrigerant lines connecting the two components.

* * * * *

Door means an assembly installed in an opening on an interior or exterior wall that is used to allow access or close off the opening and that is movable in a sliding, pivoting, hinged, or revolving manner of movement. For walk-in coolers and walk-in freezers, a door includes the frame (including mullions), the door leaf or multiple leaves (including glass) within the frame, and any other elements that form the assembly or part of its connection to the wall.

Door leaf means the pivoting, rolling, sliding, or swinging portion of a door.

Door surface area means the product of the height and width of a walk-in door measured external to the walk-in. The height and width dimensions shall be perpendicular to each other and parallel to the wall or panel of the walk-in to which the door is affixed. The height and width measurements shall extend to the edge of the frame and frame flange (as applicable) to which the door is affixed. For sliding doors, the height and width measurements shall include the track; however, the width (for horizontal sliding doors) or the height (for vertical sliding doors) shall be truncated to the external width or height of the door leaf or leaves and its frame or casings. The surface area of a display door is represented as A_{dd} and the surface area of a non-display door is represented as A_{nd}.

Ducted fan coil unit means an assembly, including means for forced air circulation capable of moving air against both internal and non-zero external flow resistance, and elements by which heat is transferred from air to refrigerant to cool the air, with provision for ducted installation.

Ducted multi-circuit single-packaged dedicated system means a ducted single-packaged dedicated system or a ducted single-packaged dedicated system (as defined in this section) that contains two or more refrigeration circuits that refrigerate a single stream of circulated air.

Ducted single-packaged dedicated system means a refrigeration system (as defined in this section) that is a single-packaged assembly designed for use with ducts, that includes one or more compressors, a condenser, a means for forced circulation of refrigerated air, and elements by which heat is transferred from air to refrigerant.

* * * * *

High-temperature refrigeration system means a refrigeration system which is not designed to operate below 45 °F.

* * * * *

Multi-circuit single-packaged dedicated system means a single-packaged dedicated system or a ducted single-packaged dedicated system (as defined in this section) that contains two or more refrigeration circuits that refrigerate a single stream of circulated air.

Non-display door means a door that is not a display door.

* * * * *

Walk-in cooler and walk-in freezer means an enclosed storage space including, but not limited to, panels, doors, and refrigeration system, 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; however, the terms do not include products designed and marketed exclusively for medical, scientific, or research purposes.

* * * * *

■ 8. Revise § 431.303 as follows:

§ 431.303 Materials incorporated by reference.

(a) Certain material is incorporated by reference into this subpart with the approval of the Director of the Federal Register in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. To enforce any edition other than that specified in this section, the U.S. Department of Energy (DOE) must publish a document in the **Federal Register** and the material must be available to the public. All approved incorporation by reference (IBR) material is available for inspection at DOE, and at the National Archives and Records Administration (NARA). Contact DOE at: the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Program, Sixth Floor, 950 L'Enfant Plaza SW, Washington, DC 20024, (202) 586–9127, *Buildings@ee.doe.gov, www.energy.gov/eere/buildings/building-technologies-office.* For information on the availability of this material at NARA, email: *fr.inspection@nara.gov,* or go to: *www.archives.gov/federal-register/cfr/ibr-locations.html.* The material may be obtained from the sources in the following paragraphs of this section.

(b) *AHRI.* Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201; (703) 600–0366; *www.ahrinet.org.*

(1) ANSI/AHRI Standard 420–2008 (''AHRI 420–2008''), *Performance Rating of Forced-Circulation Free-Delivery Unit Coolers for Refrigeration,* Copyright 2008; IBR approved for appendix C to subpart R.

(2) AHRI Standard 1250P (I–P)–2009 (''AHRI 1250–2009''), *Standard for Performance Rating of Walk-in Coolers*

and Freezers, (including Errata sheet dated December 2015), copyright 2009, except Table 15 and Table 16; IBR approved for appendix C to subpart R.

(3) AHRI Standard 1250 (''AHRI 1250–2020''), *Standard for Performance Rating of Walk-in Coolers and Freezers,* copyright 2020; IBR approved for appendix C1 to subpart R.

(c) *ASHRAE.* American Society of Heating, Refrigerating and Air-Conditioning Engineers, 180 Technology Parkway, Peachtree Corners, GA 30092; (404) 636–8400; *www.ashrae.org.*

(1) ANSI/ASHRAE Standard 16–2016 (''ANSI/ASHRAE 16''), *Method of Testing for Rating Room Air Conditioners, Packaged Terminal Air Conditioners, and Packaged Terminal Heat Pumps for Cooling and Heating Capacity,* ANSI-approved November 1, 2016; IBR approved for appendix C1 to subpart R.

(2) ANSI/ASHRAE Standard 23.1–2010 (''ASHRAE 23.1–2010''), *Methods of Testing for Rating the Performance of Positive Displacement Refrigerant Compressors and Condensing Units that Operate at Subcritical Temperatures of the Refrigerant,* ANSI-approved January 28, 2010; IBR approved for appendices C and C1 to subpart R.

(3) ANSI/ASHRAE Standard 37–2009 (''ANSI/ASHRAE 37''), *Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment,* ASHRAE-approved June 24, 2009; IBR approved for appendices C and C1 to subpart R.

(4) ANSI/ASHRAE Standard 41.1–2013 (''ANSI/ASHRAE 41.1''), *Standard Method for Temperature Measurement,* ANSI-approved January 30, 2013; IBR approved for appendix C1 to subpart R.

(5) ANSI/ASHRAE Standard 41.3–2014 (''ANSI/ASHRAE 41.3''), *Standard Methods for Pressure Measurement,* ANSI-approved July 3, 2014; IBR approved for appendix C1 to subpart R.

(6) ANSI/ASHRAE Standard 41.6–2014 (''ANSI/ASHRAE 41.6''), *Standard Method for Humidity Measurement,* ANSI-approved July 3, 2014; IBR approved for appendix C1 to subpart R.

(7) ANSI/ASHRAE Standard 41.10–2013 (''ANSI/ASHRAE 41.10''), *Standard Methods for Refrigerant Mass Flow Measurement Using Flowmeters,* ANSI-approved June 27, 2013; IBR approved for appendix C1 to subpart R.

(d) *ASTM.* ASTM, International, 100 Barr Harbor Drive, West Conshohocken, PA 19428–2959; (610) 832–9500; *www.astm.org.*

(1) ASTM C518–17, *Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus,* approved May 1, 2017; IBR approved for appendix B to subpart R.

(2) ASTM C1199–14, *Standard Test Method for Measuring the Steady-State Thermal Transmittance of Fenestration Systems Using Hot Box Methods,* approved February 1, 2014; IBR approved for appendix A to subpart R.

(e) *NFRC.* National Fenestration Rating Council, 6305 Ivy Lane, Ste. 140, Greenbelt, MD 20770; (301) 589–1776; *www.nfrc.org/.*

(1) NFRC 102–2020 [E0A0] (''NFRC 102–2020''), *Procedure for Measuring the Steady-State Thermal Transmittance of Fenestration Systems,* copyright 2013; IBR approved for appendix A to subpart R.

(2) [Reserved]

■ 9. Amend § 431.304 by revising paragraph (b) to read as follows:

§ 431.304 Uniform test method for the measurement of energy consumption of walk-in coolers and walk-in freezers.

* * * * *

(b) *Testing and calculations.* Determine the energy efficiency and/or energy consumption of the specified walk-in cooler and walk-in freezer components by conducting the appropriate test procedure as follows:

(1) *Display panels.* Determine the energy use of walk-in cooler and walk-in freezer display panels by conducting the test procedure set forth in appendix A to this subpart.

(2) *Display doors and non-display doors.* Determine the energy use of walk-in cooler and walk-in freezer display doors and non-display doors by conducting the test procedure set forth in appendix A to this subpart.

(3) *Non-display panels and non-display doors.* Determine the R-value of insulation of walk-in cooler and walk-in freezer non-display panels and non-display doors by conducting the test procedure set forth in appendix B to this subpart.

(4) *Refrigeration systems.* Determine the AWEF and net capacity of walk-in cooler and walk-in freezer refrigeration systems by conducting the test procedures set forth in appendix C or C1 to this subpart, as applicable. Refer to the notes at the beginning of those appendices to determine the applicable appendix to use for testing.

(i) *For unit coolers:* follow the general testing provisions in sections 3.1 and 3.2, and the equipment-specific provisions in section 3.3 of appendix C or sections 4.5 through 4.8 of appendix C1.

(ii) *For dedicated condensing units:* follow the general testing provisions in sections 3.1 and 3.2, and the product-specific provisions in section 3.4 of appendix C or sections 4.5 through 4.8 of appendix C1.

(iii) *For single-packaged dedicated systems:* follow the general testing provisions in sections 3.1 and 3.2, and the product-specific provisions in section 3.3 of appendix C or sections 4.5 through 4.8 of appendix C1.

■ 10. Revise appendix A to subpart R of part 431 to read as follows:

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

Note: Prior to October 31, 2023, representations with respect to the energy use of envelope components of walk-in coolers and walk-in freezers, including compliance certifications, must be based on testing conducted in accordance with the applicable provisions of 10 CFR part 431, subpart R, appendix A, revised as of January 1, 2022. Beginning October 31, 2023, representations with respect to energy use of envelope components of walk-in coolers and walk-in freezers, including compliance certifications, must be based on testing conducted in accordance with this appendix.

0. Incorporation by Reference

DOE incorporated by reference in § 431.303 the entire standard for ASTM C1199–14 and NFRC 102–2020. However, certain enumerated provisions of these standards, as set forth in sections 0.1 and 0.2 of this appendix are inapplicable. To the extent that there is a conflict between the terms or provisions of a referenced industry standard and the CFR, the CFR provisions control.

0.1 ASTM C1199–14

(a) Section 1 Scope, is inapplicable,
(b) Section 4 Significance and Use is inapplicable,
(c) Section 7.3 Test Conditions, is inapplicable,
(d) Section 10 Report, is inapplicable, and
(e) Section 11 Precision and Bias, is inapplicable.

0.2 NFRC 102–2020

(a) Section 1 Scope, is inapplicable,
(b) Section 4 Significance and Use, is inapplicable,
(c) Section 7.3 Test Conditions, is inapplicable,
(d) Section 10 Report, is inapplicable,
(e) Section 11 Precision and Bias, is inapplicable,
(f) Annex A3 Standard Test Method for Determining the Thermal Transmittance of Tubular Daylighting Devices, is inapplicable, and
(g) Annex A5 Tables and Figures, is inapplicable.

1. *General.* The following sections of this appendix provide additional instructions for testing. In cases where there is a conflict, the language of this appendix takes highest precedence, followed by NFRC 102–2020, followed by ASTM C1199–14. Any subsequent amendment to a referenced

document by the standard-setting organization will not affect the test procedure in this appendix, unless and until the test procedure is amended by DOE. Material is incorporated as it exists on the date of the approval, and a notification of any change in the incorporation will be published in the **Federal Register**.

2. 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.

3. Definitions

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

4. Additional Definitions

4.1 *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.

4.2 *Percent time off (PTO)* means the percent of time that an electrical device is assumed to be off.4.3 *Rated power* means the input power of an electricity-consuming device as specified on the device's nameplate. If the device does not have a nameplate or such nameplate does not list the device's input power, then the rated power must be determined from the device's product data sheet, literature, or installation instructions that come with the device or are available online.

4.4 *Rating conditions* means, unless explicitly stated otherwise, all conditions shown in table A.1 of this appendix.

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

5. Test Methods and Measurements

5.1 U-Factor Test of Doors and Display Panels

Determine the U-factor of the entire door or display panel, including the frame, in accordance with the specified sections of NFRC 102–2020 and ASTM C1199–14 at the temperature conditions listed in table A.1 of this appendix.

5.2 Required Test Measurements

2.1 For display doors and display panels, thermal transmittance, U_{dd} or U_{dp}, respectively, shall be the standardized thermal transmittance, U_{ST}, determined per section 5.1.1 of this appendix.

5.2.2 For non-display doors, thermal transmittance, U_{nd}, shall be the standardized thermal transmittance, U_{ST}, determined per section 5.1 of this appendix.

5.2.3 Projected area of the test specimen, A_s, in ft², as referenced in ASTM C1199–14.

6. Calculations

6.1 Display Panels

6.1.1 Determine the U-factor of the display panel in accordance with section 5.1 of this appendix, in units of Btu/(h-ft²-°F).

6.1.2 Calculate the temperature differential, ΔT_{dp}, °F, for the display panel, as follows:

$$\Delta T_{dp} = \left| T_{DB,ext,dp} - T_{DB,int,dp} \right| \quad \text{(A-1)}$$

Where:

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

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

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

$$Q_{cond,dp} = A_s \times \Delta T_{dp} \times U_{dp} \quad \text{(A-2)}$$

Where:

A_s = projected area of the test specimen (same as the test specimen aperture in the surround panel) or the area used to determine the U-factor in section 5.1 of this appendix, 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 5.1 of this appendix, Btu/(h-ft²-°F).

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

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

Where:

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

EER = Energy Efficiency Ratio of walk-in (cooler or freezer), Btu/W-h. For coolers, use EER = 12.4 Btu/W-h. For freezers, use EER = 6.3 Btu/W-h.

6.2 Display Doors

6.2.1 Conduction Through Display Doors

6.2.1.1 Determine the U-factor of the display door in accordance with section 5.1 of this appendix, in units of Btu/(h-ft²-°F).

6.2.1.2 Calculate the temperature differential, ΔT_{dd}, °F, for the display door as follows:

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

Where:

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

$T_{DB,int,dd}$ = dry-bulb air temperature internal to the display door, °F, as prescribed in table A.1 of this appendix.

6.2.1.3 Calculate the conduction load through the display doors, $Q_{cond,dd}$, Btu/h, as follows:

$$Q_{cond,dd} = A_s \times \Delta T_{dd} \times U_{dd} \quad \text{(A-5)}$$

Where:

A_s = projected area of the test specimen (same as the test specimen aperture in the surround panel) or the area used to determine the U-factor in section 5.1 of this appendix, ft^2;

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

U_{dd} = thermal transmittance, U-factor of the door, in accordance with section 5.1 of this appendix, Btu/(h-ft^2-°F).

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

$$E_{dd,thermal} = \frac{Q_{cond,dd}}{EER} \times \frac{24\ h \times 1\ kW}{1\ day \times 1000\ W} \quad \text{(A-6)}$$

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. For coolers, use EER = 12.4 Btu/(W-h). For freezers, use EER = 6.3 Btu/(W-h).

6.2.2 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; door motors; control system units; and sensors.

6.2.2.1 Select the required value for percent time off (PTO) for each type of electricity-consuming device per table A.2 of this appendix, PTO_t (%).

TABLE A.2—PERCENT TIME OFF VALUES

Device	Temperature condition	Controls, timer, or other auto-shut-off system	Percent time off value (%)
Lights	All	Without	25
		With	50
Anti-sweat heaters	All	Without	0
	Coolers	With	75
	Freezers	With	50
Door motors	All		97
All other electricity-consuming devices	All	Without	0
		With	25

6.2.2.2 Calculate the power usage for each type of electricity-consuming device, $P_{dd,comp,u,t}$, kWh/day, as follows:

$$P_{dd,comp,u,t} = P_{rated,u,t} \times (1 - PTO_{u,t}) \times n_{u,t} \times \frac{24\ h}{day} \quad \text{(A-7)}$$

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 use 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 input 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 input power of type t, unitless. 6.2.2.3 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:

$$P_{dd,tot,int} = \sum_1^t P_{dd,comp,int,t} \quad \text{(A-8)}$$

$$P_{dd,tot,ext} = \sum_1^t P_{dd,comp,ext,t} \quad \text{(A-9)}$$

Where:

t = index for each type of electricity-consuming device with identical rated input 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. 6.2.2.4 Calculate the total electrical energy consumption, $P_{dd,tot}$, (kWh/day), as follows:

$$P_{dd,tot} = P_{dd,tot,int} + P_{dd,tot,ext} \quad \text{(A-10)}$$

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.

6.2.3 Total Indirect Electricity Consumption Due to Electrical Devices

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:

$$C_{dd,load} = P_{dd,tot,int} \times \frac{3.412\ Btu/(Wh)}{EER} \quad \text{(A-11)}$$

Where:

$P_{dd,tot,int}$ = The total internal electrical energy consumption due for the display door, kWh/day; and
EER = EER of walk-in cooler or walk-in freezer, Btu/W-h. For coolers, use EER = 12.4 Btu/(W-h). For freezers, use EER = 6.3 Btu/(W-h).

6.2.4 Total Display Door Energy Consumption

Calculate the total energy, $E_{dd,tot}$, kWh/day,

$$E_{dd,tot} = E_{dd,thermal} + P_{dd,tot} + C_{dd,load} \quad \text{(A-12)}$$

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.

6.3 Non-Display Doors

6.3.1 Conduction Through Non-Display Doors

6.3.1.1 Determine the U-factor of the non-display door in accordance with section 5.1 of this appendix, in units of Btu/(h-ft²-°F).

6.3.1.2 Calculate the temperature differential of the non-display door, ΔT_{nd}, °F, as follows:

$$\Delta T_{nd} = \left|T_{DB,ext,nd} - T_{DB,int,nd}\right| \quad \text{(A-13)}$$

Where:

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

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

$$Q_{cond,nd} = A_s \times \Delta T_{nd} \times U_{nd} \quad \text{(A-14)}$$

Where:

A_s = projected area of the test specimen (same as the test specimen aperture in the surround panel) or the area used to determine the U-factor in section 5.1 of this appendix, ft²;
ΔT_{nd} = temperature differential across the non-display door, °F; and
U_{nd} = thermal transmittance, U-factor of the door, in accordance with section 5.1 of this appendix, Btu/(h-ft²-°F).

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

$$E_{nd,thermal} = \frac{Q_{cond,nd}}{EER} \times \frac{24\ h \times 1\ kW}{1\ day \times 1000\ W} \quad \text{(A-15)}$$

Where:

$Q_{cond,nd}$ = the conduction load through the non-display door, Btu/h; and
EER = EER of walk-in (cooler or freezer), Btu/W-h. For coolers, use EER = 12.4 Btu/(W-h). For freezers, use EER = 6.3 Btu/(W-h).

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

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

6.3.2.1 Select the required value for percent time off for each type of electricity-consuming device per table A.2 of this appendix, PTO_t (%).

6.3.2.2 Calculate the power usage for each type of electricity-consuming device, $P_{nd,comp,u,t}$, kWh/day, as follows:

$$P_{nd,comp,u,t} = P_{rated,u,t} \times (1 - PTO_{u,t}) \times n_{u,t} \times \frac{24\ h}{day} \quad \text{(A-16)}$$

Where:

u = the index for each of type of electricity-consuming device located on either (1) the interior facing side of the non-display door or within the inside portion of the non-display door, (2) the exterior facing side of the non-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 non-display door then use u = int. For anti-sweat heaters sited anywhere in the non-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 input power;

$P_{rated,u,t}$ = rated input 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 input power of type t, unitless.

6.3.2.3 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:

$$P_{nd,tot,int} = \sum_1^t P_{nd,comp,int,t} \quad \text{(A-17)}$$

$$P_{nd,tot,ext} = \sum_1^t P_{nd,comp,ext,t} \quad \text{(A-18)}$$

Where:

t = index for each type of electricity-consuming device with identical rated input 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,

6.3.2.4 Calculate the total electrical energy consumption, $P_{nd,tot}$, kWh/day, as follows:

$$P_{nd,tot} = P_{nd,tot,int} + P_{nd,tot,ext} \quad \text{(A-19)}$$

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.

6.3.3 Total Indirect Electricity Consumption Due to Electrical Devices

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:

$$C_{nd,load} = P_{nd,tot,int} \times \frac{3.412\ Btu/(Wh)}{EER} \quad \text{(A-20)}$$

Where:

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

EER = EER of walk-in cooler or freezer, Btu/W-h. For coolers, use EER = 12.4 Btu/(W-h). For freezers, use EER = 6.3 Btu/(W-h).

6.3.4 Total Non-Display Door Energy Consumption

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

$$E_{nd,tot} = E_{nd,thermal} + P_{nd,tot} + C_{nd,load} \quad \text{(A-21)}$$

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.

■ 11. Revise appendix B to subpart R of part 431 to read as follows:

Appendix B to Subpart R of Part 431—Uniform Test Method for the Measurement of R-Value of Insulation for Envelope Components of Walk-In Coolers and Walk-In Freezers

Note: Prior to October 31, 2023, representations with respect to the R-value for insulation of envelope components of walk-in coolers and walk-in freezers, including compliance certifications, must be based on testing conducted in accordance with the applicable provisions of 10 CFR part 431, subpart R, appendix B, revised as of January 1, 2022. Beginning October 31, 2023, representations with respect to R-value for insulation of envelope components of walk-in coolers and walk-in freezers, including compliance certifications, must be based on testing conducted in accordance with this appendix.

0. Incorporation by Reference

DOE incorporated by reference in § 431.303 the entire standard for ASTM C518–17. However, certain enumerated provisions of ASTM C518–17, as set forth in paragraph 0.1 of this appendix, are inapplicable. To the extent there is a conflict between the terms or provisions of a referenced industry standard and the CFR, the CFR provisions control.

0.1 ASTM C518–17

(a) Section 1 Scope, is inapplicable,

(b) Section 4 Significance and Use, is inapplicable,

(c) Section 7.3 Specimen Conditioning, is inapplicable,

(d) Section 9 Report, is inapplicable,

(e) Section 10 Precision and Bias, is inapplicable,

(f) Section 11 Keywords, is inapplicable,

(g) Annex A2 Equipment Error Analysis, is inapplicable,

(h) Appendix X1 is inapplicable,

(i) Appendix X2 Response of Heat Flux Transducers, is inapplicable, and

(j) Appendix X3 Proven Performance of a Heat Flow Apparatus, is inapplicable.

0.2 [Reserved]

1. General

The following sections of this appendix provide additional instructions for testing. In cases where there is a conflict, the language of this appendix takes highest precedence, followed by ASTM C518–17. Any subsequent amendment to a referenced document by the standard-setting organization will not affect the test procedure in this appendix, unless and until the test procedure is amended by DOE. Material is incorporated as it exists on the date of the approval, and a notification of any change in the incorporation will be published in the **Federal Register**.

2. Scope

This appendix covers the test requirements used to measure the R-value of non-display panels and non-display doors of a walk-in cooler or walk-in freezer.

3. Definitions

The definitions contained in § 431.302 apply to this appendix.

4. Additional Definitions

4.1 *Edge region* means a region of the envelope component that is wide enough to encompass any framing members. If the envelope component contains framing members (*e.g.,* a wood frame) then the width of the edge region must be as wide as any framing member plus an additional 2 in. ± 0.25 in.

5. Test Methods, Measurements, and Calculations

5.1 *General.* Foam shall be tested after it is produced in its final chemical form. For foam produced inside of an envelope component (''foam-in-place''), ''final chemical form'' means the foam is cured as intended and ready for use as a finished envelope component. For foam produced as board stock (*e.g.,* polystyrene), ''final chemical form'' means after extrusion and ready for assembly into an envelope component or after assembly into an envelope component. Foam must not include any structural members or non-foam materials during testing in accordance with ASTM C518–17. When preparing the specimen for test, a high-speed bandsaw or a meat slicer are two types of recommended cutting tools. Hot wire cutters or other heated tools shall not be used for cutting foam test specimens.

5.2 Specimen Preparation

5.2.1 *Determining the thickness around the perimeter of the envelope component, t_p.* The full thickness of an envelope component around the perimeter, which may include facers on one or both sides, shall be determined as follows:

5.2.1.1 At least 8 thickness measurements shall be taken around the perimeter of the envelope component, at least 2 inches from the edge region, and avoiding any regions with hardware or fixtures.

5.2.1.2 The average of the thickness measurements taken around the perimeter of the envelope component shall be the thickness around the perimeter of the envelope component, t_p.

5.2.1.3 Measure and record the width, w_p, and height, h_p, of the envelope component. The surface area of the envelope component, A_p, shall be determined as follows:

$$A_p = w_p \times h_p \qquad \text{(B-1)}$$

Where:

w_p = width of the envelope component, in.; and

h_p = height of the envelope component, in.

5.2.2. *Removing the sample from the envelope component.*

5.2.2.1. Determine the center of the envelope component relative to its height and its width.

5.2.2.2. Cut a sample from the envelope component that is at least the length and width dimensions of the heat flow meter, and where the marked center of the sample is at least 3 inches from any cut edge.

5.2.2.3. If the center of the envelope component contains any non-foam components (excluding facers), additional samples may be cut adjacent to the previous cut that is at least the length and width dimensions of the heat flow meter and is greater than 12 inches from the edge region.

5.2.3. *Determining the thickness at the center of the envelope component, t_c.* The full thickness of an envelope component at the center, which may include facers on one or both sides, shall be determined as follows:

5.2.3.1. At least 2 thickness measurements shall be taken in each quadrant of the cut sample removed from the envelope component per section 5.2.2 of this appendix, for a total of at least 8 measurements.

5.2.3.2. The average of the thickness measurements of the cut sample removed from the envelope component shall be the overall thickness of the cut sample, t_c.

5.2.3.3. Measure and record the width and height of the cut sample removed from the envelope component. The surface area of the cut sample removed from the envelope component, A_c., shall be determined as follows:

$$A_c = w_c \times h_c \qquad \text{(B-2)}$$

Where:

w_c = width of the cut sample removed from the envelope component, in.; and

h_c = height of the cut sample removed from the envelope component, in.

5.2.4. *Determining the total thickness of the foam within the envelope component, t_{foam}.* The average total thickness of the foam sample, without facers, shall be determined as follows:

5.2.4.1. Remove the facers on the envelope component sample, while minimally disturbing the foam.

5.2.4.2. Measure the thickness of each facer in 4 locations for a total of 4 measurements if 1 facer is removed, and a total of 8 measurements if 2 facers are removed. The average of all facer measurements shall be the thickness of the facers, t_{facers}, in.

5.2.4.3. The average total thickness of the foam, t_{foam}, in., shall be determined as follows:

$$t_{foam} = \frac{t_c A_c + t_p (A_p - A_c)}{A_p} - t_{facers} \qquad \text{(B-3)}$$

Where:

t_c = the average thickness of the center of the envelope component, in., as determined per sections 5.2.3.1 and 5.2.3.2 of this appendix;

A_c = the surface area of the center of the envelope component, in^2., as determined per section 5.2.3.3 of this appendix;

t_p = the average thickness of the perimeter of the envelope component, in., as determined per sections 5.2.1.1 and 5.2.1.2 of this appendix;

A_p = the average thickness of the center of the envelope component, in^2, as determined per section 5.2.1.3 of this appendix;

t_{facers} = the average thickness of the facers of the envelope component, in., as determined per section 5.2.4.2 of this appendix.

5.2.5. *Cutting, measuring, and determining parallelism and flatness of a 1-inch-thick specimen for test from the center of the cut envelope component sample.*

5.2.5.1. Cut a 1 ± 0.1-inch-thick specimen from the center of the cut envelope sample. The 1-inch-thick test specimen shall be cut from the point that is equidistant from both edges of the sample (*i.e.,* shall be cut from the center point that would be directly between the interior and exterior space of the walk-in).

5.2.5.2. Document through measurement or photographs with measurement indicators that the specimen was taken from the center of the sample.

5.2.5.3 After the 1-inch specimen has been cut, and prior to testing, place the specimen on a flat surface and allow gravity to determine the specimen's position on the surface. This will be side 1.

5.2.5.4 To determine the flatness of side 1, take at least nine height measurements at equidistant positions on the specimen (*i.e.,* the specimen would be divided into 9 regions and height measurements taken at the center of each of these nine regions). Contact with the measurement indicator shall not indent the foam surface. From the height measurements taken, determine the least squares plane for side 1. For each measurement location, calculate the theoretical height from the least squares plane for side 1. Then, calculate the difference between the measured height and the theoretical least squares plane height at each location. The maximum difference minus the minimum difference out of the nine measurement locations is the flatness of side 1. For side 1 of the specimen to be considered flat, this shall be less than or equal to 0.03 inches.

5.2.5.5 To determine the flatness of side 2, turn the specimen over and allow gravity to determine the specimen's position on the surface. Repeat section 5.2.5.4 to determine the flatness of side 2.

5.2.5.6 To determine the parallelism of the specimen for side 1, calculate the theoretical height of the least squares plane at the furthest corners (*i.e.,* at points (0,0), (0,12), (12,0), and (12,12)) of the 12-inch by 12-inch test specimen. The difference between the maximum theoretical height and the minimum theoretical height shall be less than or equal to 0.03 inches for each side in order for side 1 to be considered parallel.

5.2.5.7 To determine the parallelism of the specimen for side 2, repeat section

5.2.5.8 The average thickness of the test specimen, *L,* shall be 1 ± 0.1-inches determined using a minimum of 18 thickness measurements (*i.e.,* a minimum of 9 measurements on side 1 of the specimen and a minimum of 9 on side 2 of the specimen). This average thickness shall be used to determine the thermal conductivity, or K-factor.

5.3 *K-factor Test.* Determine the thermal conductivity, or K-factor, of the 1-inch-thick specimen in accordance with the specified sections of ASTM C518–17.

5.3.1 *Test Conditions.*

5.3.1.1 For freezer envelope components, the K-factor of the specimen shall be determined at an average specimen temperature of 20 ± 1 degrees Fahrenheit.

5.3.1.2 For cooler envelope components, the K-factor of the specimen shall be determined at an average specimen temperature of 55 ± 1 degrees Fahrenheit.

5.4 R-value Calculation.

5.4.1 For envelope components consisting of one homogeneous layer of insulation, calculate the R-value, h-ft²-°F/Btu, as follows:

$$R = \frac{t_{foam}}{\lambda} \quad \text{(B-4)}$$

Where:

t_{foam} = the total thickness of the foam, in., as determined in section 5.2.4 of this appendix; and

λ = K-factor, Btu-in/(h-ft²-°F), as determined in section 5.3 of this appendix.

5.4.2 For envelope components consisting of two or more layers of dissimilar insulating materials (excluding facers or protective skins), determine the K-factor of each material as described in sections 5.1 through 5.3 of this appendix. For an envelope component with N layers of insulating material, the overall R-value shall be calculated as follows:

$$R = \sum_{i=1}^{N} \frac{t_i}{\lambda_i} \quad \text{(B-5)}$$

Where:

t_i is the thickness of the ith material that appears in the envelope component, inches, as determined in section 5.2.4 of this appendix;

λ_i is the k-factor of the ith material, Btu-in/(h-ft²-°F), as determined in section 5.3 of this appendix; and

N is the total number of material layers that appears in the envelope component.

5.4.3 K-factor test results from a test sample 1 ± 0.1-inches in thickness may be used to determine the R-value of envelope components with various foam thicknesses as long as the foam throughout the panel depth is of the same final chemical form and the test was completed at the same test conditions that the other envelope components would be used at. For example, a K-factor test result conducted at cooler conditions cannot be used to determine R-value of a freezer envelope component.

■ 12. Amend appendix C to subpart R of part 431 by:

■ a. Adding an introductory note;

■ b. Revising sections 2.0 and 3.1.1;

■ c. Adding sections 3.1.6 and 3.1.7;

■ d. Revising sections 3.2.1 and 3.2.3;

■ e. Adding sections 3.2.6, 3.2.6.1, 3.2.6.1.1, 3.2.6.1.2, 3.2.6.2, 3.2.6.3, 3.2.6.4, 3.2.7, 3.2.7.1, 3.2.7.2, and 3.2.8;

■ f. Revising sections 3.3.1 and 3.3.3;

■ g. Adding sections 3.3.3.1, 3.3.3.2, 3.3.3.3, 3.3.3.3.1, and 3.3.3.3.2;

■ h. Revising sections 3.3.7, 3.3.7.1, and 3.3.7.2;

■ i. Adding sections 3.3.7.3, 3.3.7.3.1, and 3.3.7.3.2; and

■ j. Revising section 3.4.2.1.

The additions and revisions read as follows:

Appendix C to Subpart R of Part 431—Uniform Test Method for the Measurement of Net Capacity and AWEF of Walk-In Cooler and Walk-In Freezer Refrigeration Systems

Note: Prior to October 31, 2023, representations with respect to the energy use of refrigeration components of walk-in coolers and walk-in freezers, including compliance certifications, must be based on testing conducted in accordance with the applicable provisions of 10 CFR part 431, subpart R, appendix C, revised as of January 1, 2022. Beginning October 31, 2023, representations with respect to energy use of refrigeration components of walk-in coolers and walk-in freezers, including compliance certifications, must be based on testing conducted in accordance with this appendix.

For any amended standards for walk-in coolers and freezers published after January 1, 2022, manufacturers must use the results of testing under appendix C1 to this subpart to determine compliance. Representations related to energy consumption must be made in accordance with appendix C1 when determining compliance with the relevant standard. Manufacturers may also use appendix C1 to certify compliance with any amended standards prior to the applicable compliance date for those standards.

* * * * *

2.0 Definitions

The definitions contained in § 431.302 and AHRI 1250–2009 (incorporated by reference; see § 431.303) apply to this appendix. When definitions contained in the standards DOE has incorporated by reference are in conflict or when they conflict with this section, the hierarchy of precedence shall be in the following order: § 431.302, AHRI 1250–2009, and then either AHRI 420–2008 (incorporated by reference; see § 431.303) for unit coolers or ASHRAE 23.1–2010 (incorporated by reference; see § 431.303) for dedicated condensing units.

The term ''unit cooler'' used in AHRI 1250–2009, AHRI 420–2008, and this subpart shall be considered to address both ''unit coolers'' and ''ducted fan coil units,'' as appropriate.

3.0 * * *

3.1. * * *

3.1.1. In Table 1, Instrumentation Accuracy, refrigerant temperature measurements shall have an accuracy of +/−0.5 °F for unit cooler in/out. When testing high-temperature refrigeration systems, measurements used to determine temperature or water vapor content of the air (*i.e.,* wet-bulb or dew point) shall be accurate to within +/−0.25 °F; all other temperature measurements shall be accurate to within +/−1.0 °F.

* * * * *

3.1.6. Test Operating Conditions for CO_2 Unit Coolers

For medium-temperature CO_2 unit coolers, conduct tests using the test conditions specified in table 17 of this appendix. For low-temperature CO_2 unit coolers, conduct tests using the test conditions specified in table 18 of this appendix.

TABLE 17—TEST OPERATING CONDITIONS FOR MEDIUM-TEMPERATURE CO_2 UNIT COOLERS

Test description	Unit cooler air entering dry-bulb, °F	Unit cooler air entering relative humidity, %	Suction dew point temp, °F	Liquid inlet bubble point temperature °F	Liquid inlet subcooling, °F	Compressor capacity	Test objective
Off-Cycle Power	35	<50				Compressor On	Measure fan input power during compressor off-cycle.
Refrigeration Capacity, Ambient Condition A.	35	<50	25	38	5	Compressor Off	Determine Net Refrigeration Capacity of Unit Cooler.

Notes:
1. Superheat shall be set as indicated in the installation instructions. If no superheat specification is given a default superheat value of 6.5 °F shall be used.

TABLE 18—TEST OPERATING CONDITIONS FOR LOW-TEMPERATURE CO_2 UNIT COOLERS

Test description	Unit cooler air entering dry-bulb, °F	Unit cooler air entering relative humidity, %	Suction dew point temp, °F	Liquid inlet bubble point temperature °F	Liquid inlet subcooling, °F	Compressor capacity	Test objective
Off-Cycle Power	−10	<50				Compressor Off	Measure fan input power during compressor off cycle.
Refrigeration Capacity, Ambient Condition A.	−10	<50	−20	38	5	Compressor On	Determine Net Refrigeration Capacity of Unit Cooler.
Defrost	−10	<50				Compressor Off	Test according to Appendix C Section C11 of AHRI 1250–2009.

1. Superheat shall be set as indicated in the installation instructions. If no superheat specification is given a default superheat value of 6.5 °F shall be used.

3.1.7. Test Operating Conditions for High-Temperature Unit Coolers

For high-temperature cooler unit coolers, conduct tests using the test conditions specified in table 19 of this appendix.

TABLE 19—TEST OPERATING CONDITIONS FOR HIGH-TEMPERATURE UNIT COOLERS

Test description	Unit cooler air entering dry-bulb, °F	Unit cooler air entering relative humidity, % [1]	Suction dew point temp, °F [2 3]	Liquid inlet bubble point temperature °F	Liquid inlet subcooling, °F	Compressor capacity	Test objective
Off-Cycle	55	55		105	9	Compressor Off	Measure fan input power.
Refrigeration Capacity Suction A	55	55	38	105	9	Compressor On	Determine Net Refrigeration Capacity of Unit Cooler.

Notes:
[1] The test condition tolerance (maximum permissible variation of the average value of the measurement from the specified test condition) for relative humidity is 3%.
[2] Superheat shall be set as indicated in the installation instructions. If no superheat specification is given a default superheat value of 6.5 °F shall be used.
[3] Suction Dew Point shall be measured at the Unit Cooler Exit.

3.2. * * *

3.2.1. Refrigerant Temperature Measurements

In AHRI 1250–2009 appendix C, section C3.1.6, any refrigerant temperature measurements entering and leaving the unit cooler may use sheathed sensors immersed in the flowing refrigerant instead of thermometer wells. When testing a condensing unit alone, measure refrigerant liquid temperature leaving the condensing unit using thermometer wells as described in AHRI 1250–2009 appendix C, section C3.1.6 or sheathed sensors immersed in the flowing refrigerant. For all of these cases, if the refrigerant tube outer diameter is less than ½ inch, the refrigerant temperature may be measured using the average of two temperature measuring instruments with a minimum accuracy of ±0.5 °F placed on opposite sides of the refrigerant tube surface—resulting in a total of up to 8 temperature measurement devices used for the DX Dual Instrumentation method. In this case, the refrigerant tube shall be insulated with 1-inch thick insulation from a point 6 inches upstream of the measurement location to a point 6 inches downstream of the measurement location. Also, to comply with this requirement, the unit cooler entering measurement location may be moved to a location 6 inches upstream of the expansion device and, when testing a condensing unit alone, the entering and leaving measurement locations may be moved to locations 6 inches from the respective service valves.

* * * * *

3.2.3. Subcooling at Refrigerant Mass Flow Meter

In appendix C, section C3.4.5 of AHRI 1250–2009 (incorporated by reference; see § 431.303), and in section 7.1.2 of ASHRAE 23.1–2010 (incorporated by reference; see § 431.303) when verifying subcooling at the mass flow meters, only the sight glass and a temperature sensor located on the tube surface under the insulation are required. Subcooling shall be verified to be within the 3 °F requirement downstream of flow meters located in the same chamber as a condensing unit under test and upstream of flow meters located in the same chamber as a unit cooler under test, rather than always downstream as indicated in AHRI 1250–2009, section C3.4.5 or always upstream as indicated in section 7.1.2 of ASHRAE 23.1–2010. If the subcooling is less than 3 °F, cool the line between the condensing unit outlet and this location to achieve the required subcooling. When providing such cooling while testing a matched pair, (a) set up the line-cooling system and also set up apparatus to heat the liquid line between the mass flow meters and the unit cooler, (b) when the system has achieved steady state without activation of the heating and cooling systems, measure the liquid temperature entering the expansion valve for a period of at least 30 minutes, (c) activate the cooling system to provide the required subcooling at the mass flow meters, (d) if necessary, apply heat such that the temperature entering the expansion valve is within 0.5 ºF of the temperature measured during step (b), and (e) proceed with measurements once condition (d) has been verified.

* * * * *

3.2.6. Installation Instructions

Manufacturer installation instructions refer to the instructions that are applied to the unit (*i.e.,* as a label) or that come packaged with the unit. Online installation instructions are acceptable only if the version number or date of publication is referenced on the unit label or in the documents that are packaged with the unit.

3.2.6.1 *Installation Instruction Hierarchy when available installation instructions are in conflict*

3.2.6.1.1 If a manufacturer installation instruction provided on the label(s) applied to the unit conflicts with the manufacturer installation instructions that are shipped with the unit, the instructions on the unit's label take precedence.

3.2.6.1.2 Manufacturer installation instructions provided in any documents that are packaged with the unit take precedence over any manufacturer installation instructions provided online.

3.2.6.2 For testing of attached split systems, the manufacturer installation instructions for the dedicated condensing unit shall take precedence over the manufacturer installation instructions for the unit cooler.

3.2.6.3 Unit setup shall be in accordance with the manufacturer installation instructions (laboratory installation instructions shall not be used).

3.2.6.4 Achieving test conditions shall always take precedence over installation instructions.

3.2.7. *Refrigerant Charging and Adjustment of Superheat and Subcooling.*

All dedicated condensing systems (dedicated condensing units tested alone, matched pairs, and single packaged dedicated systems) that use flooding of the condenser for head pressure control during low-ambient-temperature conditions shall be charged, and superheat and/or subcooling shall be set, at Refrigeration C test conditions unless otherwise specified in the installation instructions.

If after being charged at Refrigeration C condition the unit under test does not operate at the Refrigeration A condition due to high pressure cut out, refrigerant shall be removed in increments of 4 ounces or 5 percent of the test unit's receiver capacity, whichever quantity is larger, until the unit operates at the Refrigeration A condition. All tests shall be run at this final refrigerant charge. If less than 0 °F of subcooling is measured for the refrigerant leaving the condensing unit when testing at B or C condition, calculate the refrigerant-enthalpy-based capacity (*i.e.,* when using the DX dual instrumentation, the DX calibrated box, or single-packaged unit refrigerant enthalpy method) assuming that the refrigerant is at saturated liquid conditions at the condensing unit exit.

All dedicated condensing systems that do not use a flooded condenser design shall be charged at Refrigeration A test conditions unless otherwise specified in the installation instructions.

If the installation instructions give a specified range for superheat, sub-cooling, or refrigerant pressure, the average of the range shall be used as the refrigerant charging parameter target and the test condition tolerance shall be ±50 percent of the range. Perform charging of near-azeotropic and zeotropic refrigerants only with refrigerant in the liquid state. Once the correct refrigerant charge is determined, all tests shall run until completion without further modification.

3.2.7.1. When charging or adjusting superheat/subcooling, use all pertinent instructions contained in the installation instructions to achieve charging parameters within the tolerances. However, in the event of conflicting charging information between installation instructions, follow the installation instruction hierarchy listed in section 3.2.6. of this appendix. Conflicting information is defined as multiple conditions given for charge adjustment where all conditions specified cannot be met. In the event of conflicting information within the same set of charging instructions (*e.g.,* the installation instructions shipped with the dedicated condensing unit), follow the hierarchy in table 1 of this section for priority. Unless the installation instructions specify a different charging tolerance, the tolerances identified in table 1 of this section shall be used.

TABLE 1—TEST CONDITION TOLERANCES AND HIERARCHY FOR REFRIGERANT CHARGING AND SETTING OF REFRIGERANT CONDITIONS

Priority	Fixed orifice		Expansion valve	
	Parameter with installation instruction target	Tolerance	Parameter with installation instruction target	Tolerance
1	Superheat	±2.0 °F	Subcooling	10% of the Target Value; No less than ±0.5 °F, No more than ±2.0 °F.
2	High Side Pressure or Saturation Temperature.	±4.0 psi or ±1.0 °F	High Side Pressure or Saturation Temperature.	±4.0 psi or ±1.0 °F.
3	Low Side Pressure or Saturation Temperature.	±2.0 psi or ±0.8 °F	Superheat	±2.0 °F.
4	Low Side Temperature	±2.0 °F	Low Side Pressure or Saturation Temperature.	±2.0 psi or ±0.8 °F.
5	High Side Temperature	±2.0 °F	Approach Temperature	±1.0 °F.

TABLE 1—TEST CONDITION TOLERANCES AND HIERARCHY FOR REFRIGERANT CHARGING AND SETTING OF REFRIGERANT CONDITIONS—Continued

Priority	Fixed orifice		Expansion valve	
	Parameter with installation instruction target	Tolerance	Parameter with installation instruction target	Tolerance
6	Charge Weight	±2.0 oz	Charge Weight	0.5% or 1.0 oz, whichever is greater.

3.2.7.2. *Dedicated Condensing Unit.* If the Dedicated Condensing Unit includes a receiver and the subcooling target leaving the condensing unit provided in installation instructions cannot be met without fully filling the receiver, the subcooling target shall be ignored. Likewise, if the Dedicated Condensing unit does not include a receiver and the subcooling target leaving the condensing unit cannot be met without the unit cycling off on high pressure, the subcooling target can be ignored. Also, if no instructions for charging or for setting subcooling leaving the condensing unit are provided in the installation instructions, the refrigeration system shall be set up with a charge quantity and/or exit subcooling such that the unit operates during testing without shutdown (*e.g.,* on a high-pressure switch) and operation of the unit is otherwise consistent with the requirements of the test procedure of this appendix and the installation instructions.

3.2.8. *Chamber Conditioning using the Unit Under Test.*

In appendix C, section C6.2 of AHRI 1250–2009, for applicable system configurations (matched pairs, single-packaged refrigeration systems, and standalone unit coolers), the unit under test may be used to aid in achieving the required test chamber conditions prior to beginning any steady state test. However, the unit under test must be inspected and confirmed to be free from frost before initiating steady state testing.

* * * * *

3.3. * * *

3.3.1. For unit coolers tested alone, use test procedures described in AHRI 1250–2009 for testing unit coolers for use in mix-match system ratings, except that for the test conditions in tables 15 and 16 of this appendix, use the Suction A saturation condition test points only. Also, for unit coolers tested alone, other than high-temperature unit coolers, use the calculations in section 7.9 of AHRI 1250–2009 to determine AWEF and net capacity described in AHRI 1250–2009 for unit coolers matched to parallel rack systems.

* * * * *

3.3.3. *Evaporator Fan Power.*

3.3.3.1. *Ducted Evaporator Air.*

For ducted fan coil units with ducted evaporator air, or that can be installed with or without ducted evaporator air: Connect ductwork on both the inlet and outlet connections and determine external static pressure as described in ASHRAE 37 (incorporated by reference; see § 431.303), sections 6.4 and 6.5. Use pressure measurement instrumentation as described in ASHRAE 37, section 5.3.2. Test at the fan speed specified in manufacturer installation instructions—if there is more than one fan speed setting and the installation instructions do not specify which speed to use, test at the highest speed. Conduct tests with the external static pressure equal to 50 percent of the maximum external static pressure allowed by the manufacturer for system installation within a tolerance of −0.00/+0.05 in. wc. Set the external static pressure by symmetrically restricting the outlet of the test duct. Alternatively, if using the indoor air enthalpy method to measure capacity, set external static pressure by adjusting the fan of the airflow measurement apparatus. In case of conflict, these requirements for setting evaporator airflow take precedence over airflow values specified in manufacturer installation instructions or product literature.

3.3.3.2. *Unit Coolers or Single-Packaged Systems that are not High-Temperature Refrigeration Systems.*

Use appendix C, section C10 of AHRI 1250–2009 for off-cycle evaporator fan testing, with the exception that evaporator fan controls using periodic stir cycles shall be adjusted so that the greater of a 50 percent duty cycle (rather than a 25 percent duty cycle) or the manufacturer default is used for measuring off-cycle fan energy. For adjustable-speed controls, the greater of 50 percent fan speed (rather than 25 percent fan speed) or the manufacturer's default fan speed shall be used for measuring off-cycle fan energy. Also, a two-speed or multi-speed fan control may be used as the qualifying evaporator fan control. For such a control, a fan speed no less than 50 percent of the speed used in the maximum capacity tests shall be used for measuring off-cycle fan energy.

3.3.3.3. *High-Temperature Refrigeration Systems.*

3.3.3.3.1. The evaporator fan power consumption shall be measured in accordance with the requirements in section C3.5 of AHRI 1250–2009. This measurement shall be made with the fan operating at full speed, either measuring unit cooler or total system power input upon the completion of the steady state test when the compressor and the condenser fan of the walk-in system are turned off, or by submetered measurement of the evaporator fan power during the steady state test.

Section C3.5 of AHRI 1250–2009 is revised to read:

Evaporator Fan Power Measurement.

The following shall be measured and recorded during a fan power test.

$EF_{comp,on}$ Total electrical power input to fan motor(s) of Unit Cooler, W

FS Fan speed(s), rpm

N Number of motors

P_b Barometric pressure, in. Hg

T_{db} Dry-bulb temperature of air at inlet, °F

T_{wb} Wet-bulb temperature of air at inlet, °F

V Voltage of each phase

For a given motor winding configuration, the total power input shall be measured at the highest nameplate voltage. For three-phase power, voltage imbalance shall be no more than 2%.

3.3.3.3.2. Evaporator fan power for the off-cycle is equal to the on-cycle evaporator fan power with a run time of 10 percent of the off-cycle time.

$$EF_{comp,off} = 0.1 \times EF_{comp,on}$$

* * * * *

3.3.7. *Calculations for Unit Coolers Tested Alone.*

3.3.7.1. *Unit Coolers that are not High-Temperature Unit Coolers.*

Calculate the AWEF and net capacity using the calculations in AHRI 1250–2009, section 7.9.

3.3.7.2 *High-Temperature Unit Coolers.*

Calculate AWEF on the basis that walk-in box load is equal to half of the system net capacity, without variation according to high and low load periods, and with EER set according to tested evaporator capacity, as follows:

The net capacity, $\dot{q}_{mix,evap}$, is determined from the test data for the unit cooler at the 38 °F suction dewpoint.

$$\dot{BL} = 0.5 \times \dot{q}_{mix,evap}$$

$$\dot{E}_{mix,rack} = \frac{\left(\dot{q}_{mix,evap} + 3.412 \times \dot{EF}_{comp,on}\right)}{EER} + \dot{EF}_{comp,on}$$

Where:

$$EER = \begin{cases} 11 & if\ \dot{q}_{mix,evap} < 10{,}000\ Btu/h \\ 0.0007 \times \dot{q}_{mix,evap} + 4 & if\ 10{,}000 \leq \dot{q}_{mix,evap} < 20{,}000\ Btu/h \\ 18 & if\ 20{,}000 \leq \dot{q}_{mix,evap} < 36{,}000\ Btu/h \end{cases}$$

$$LF = \frac{\dot{BL} + 3.412 \times \dot{EF}_{comp,off}}{\dot{q}_{mix,evap} + 3.412 \times \dot{EF}_{comp,off}}$$

$$AWEF = \frac{\dot{BL}}{\dot{E}_{mix,rack} \times LF + \dot{EF}_{comp,off} \times (1 - LF)}$$

Where:

$\dot{BL}$ is the non-equipment-related box load;
LF is the load factor; and
Other symbols are as defined in section 8 of AHRI 1250–2009.

3.3.7.3. If the unit cooler has variable-speed evaporator fans that vary fan speed in response to load, then:

3.3.7.3.1. When testing to certify compliance with the energy conservation standards in § 431.306, fans shall operate at full speed during on-cycle operation. Do not conduct the calculations in AHRI 1250–2009, section 7.9.3. Instead, use AHRI 1250–2009, section 7.9.2 to determine the system's AWEF.

3.3.7.3.2. When calculating the benefit for the inclusion of variable-speed evaporator fans that modulate fan speed in response to load for the purpose of making representations of efficiency, use AHRI 1250–2009, section 7.9.3 to determine the system AWEF.

3.4. * * *

3.4.2. * * *

3.4.2.1. For calculating enthalpy leaving the unit cooler to calculate gross capacity, (a) the saturated refrigerant temperature (dew point) at the unit cooler coil exit, T_{evap}, shall be 25 °F for medium-temperature systems (coolers) and −20 °F for low-temperature systems (freezers), and (b) the refrigerant temperature at the unit cooler exit shall be 35 °F for medium-temperature systems (coolers) and −14 °F for low-temperature systems (freezers). For calculating gross capacity, the measured enthalpy at the condensing unit exit shall be used as the enthalpy entering the unit cooler. The temperature measurement requirements of appendix C, section C3.1.6 of AHRI 1250–2009 and modified by section 3.2.1 of this appendix shall apply only to the condensing unit exit rather than to the unit cooler inlet and outlet, and they shall be applied for two measurements when using the DX Dual Instrumentation test method.

* * * * *

■ 13. Add appendix C1 to subpart R of part 431 to read as follows:

Appendix C1 to Subpart R of Part 431—Uniform Test Method for the Measurement of Net Capacity and AWEF2 of Walk-In Cooler and Walk-In Freezer Refrigeration Systems

Note: Prior to October 31, 2023, representations with respect to the energy use of refrigeration components of walk-in coolers and walk-in freezers, including compliance certifications, must be based on testing conducted in accordance with the applicable provisions for 10 CFR part 431, subpart R, appendix C, revised as of January 1, 2022. Beginning October 31, 2023, representations with respect to energy use of refrigeration components of walk-in coolers and walk-in freezers, including compliance certifications, must be based on testing conducted in accordance with appendix C to this subpart.

For any amended standards for walk-in coolers and walk-in freezers published after January 1, 2022, manufacturers must use the results of testing under this appendix to determine compliance. Representations related to energy consumption must be made in accordance with this appendix when determining compliance with the relevant standard. Manufacturers may also use this appendix to certify compliance with any amended standards prior to the applicable compliance date for those standards.

0. Incorporation by Reference

DOE incorporated by reference in § 431.303, the entire standard for AHRI 1250–2020, ANSI/ASHRAE 16, ANSI/ASHRAE 23.1–2010, ANSI/ASHRAE 37, ANSI/ASHRAE 41.1, ANSI/ASHRAE 41.3, ANSI/ASHRAE 41.6, and ANSI/ASHRAE 41.10. However, certain enumerated provisions of these standards, as set forth in sections 0.1 through 0.8 of this appendix are inapplicable. To the extent there is a conflict between the terms or provisions of a referenced industry standard and the CFR, the CFR provisions control. To the extent there is a conflict between the terms or provisions of AHRI 1250–2020, ANSI/ASHRAE 16, ANSI/ASHRAE 23.1–2010, ANSI/ASHRAE 37, ANSI/ASHRAE 41.1, ANSI/ASHRAE 41.3, ANSI/ASHRAE 41.6, and ANSI/ASHRAE 41.10, the AHRI 1250–2020 provisions control.

0.1 AHRI 1250–2020

(a) Section 1 Purpose, is inapplicable
(b) Section 2 Scope, is inapplicable
(c) Section 9 Minimum Data Requirements for Published Rating, is inapplicable
(d) Section 10 Marking and Nameplate Data, is inapplicable

(e) Section 11 Conformance Conditions, is inapplicable

0.2 ANSI/ASHRAE 16

(a) Section 1 Purpose, is inapplicable
(b) Section 2 Scope, is inapplicable
(c) Section 4 Classifications, is inapplicable
(d) Normative Appendices E–M, are inapplicable
(e) Informative Appendices N–R, are inapplicable

0.3 ANSI/ASHRAE 23.1–2010

(a) Section 1 Purpose, is inapplicable
(b) Section 2 Scope, is inapplicable
(c) Section 4 Classifications, is inapplicable

0.4 ANSI/ASHRAE 37

(a) Section 1 Purpose, is inapplicable
(b) Section 2 Scope, is inapplicable
(c) Section 4 Classifications, is inapplicable
(d) Informative Appendix A Classifications of Unitary Air-conditioners and Heat Pumps, is inapplicable.

0.5 ANSI/ASHRAE 41.1

(a) Section 1 Purpose, is inapplicable
(b) Section 2 Scope, is inapplicable
(c) Section 4 Classifications, is inapplicable
(d) Section 9 Test Report, is inapplicable
(e) Informative Appendices A–C, are inapplicable

0.6 ANSI/ASHRAE 41.3

(a) Section 1 Purpose, is inapplicable
(b) Section 2 Scope, is inapplicable
(c) Section 4 Classifications, is inapplicable
(d) Section 6 Instrument Types (informative), is inapplicable
(e) Section 8 Test Report, is inapplicable
(f) Informative Annexes A–D, are inapplicable

0.7 ANSI/ASHRAE 41.6

(a) Section 1 Purpose, is inapplicable
(b) Section 2 Scope, is inapplicable
(c) Section 4 Classifications, is inapplicable
(d) Section 9 Test Report, is inapplicable
(e) Informative Appendices A–D, are inapplicable

0.8 ANSI/ASHRAE 41.10

(a) Section 1 Purpose, is inapplicable
(b) Section 2 Scope, is inapplicable
(c) Section 4 Classifications, is inapplicable
(d) Section 10 Test Report, is inapplicable
(e) Informative Annexes A–D, are inapplicable

1. Scope

This appendix covers the test requirements used to determine the net capacity and the AWEF2 of the refrigeration system of a walk-in cooler or walk-in freezer.

2. Definitions

2.1. Applicable Definitions

The definitions contained in § 431.302, AHRI 1250–2020, ANSI/ASHRAE 37, and ANSI/ASHRAE 16 apply to this appendix. When definitions in standards incorporated by reference are in conflict or when they conflict with this section, the hierarchy of precedence shall be in the following order: § 431.302, AHRI 1250–2020, and then either ANSI/ASHRAE 37 or ANSI/ASHRAE 16.

The term ''unit cooler'' used in AHRI 1250–2020 and this subpart shall be considered to address both ''unit coolers'' and ''ducted fan coil units,'' as appropriate.

2.2. Additional Definitions

2.2.1. *Digital Compressor* means a compressor that uses mechanical means for disengaging active compression on a cyclic basis to provide a reduced average refrigerant flow rate in response to a control system input signal.

2.2.2. *Displacement Ratio,* applicable to staged positive displacement compressor systems, means the swept volume rate, *e.g.* in cubic centimeters per second, of a given stage, divided by the swept volume rate at full capacity.

2.2.3. *Duty Cycle,* applicable to digital compressors, means the fraction of time that the compressor is engaged and actively compressing refrigerant.

2.2.4. *Maximum Speed,* applicable to variable-speed compressors, means the maximum speed at which the compressor will operate under the control of the dedicated condensing system control system for extended periods of time, *i.e.* not including short-duration boost-mode operation.

2.2.5. *Minimum Speed,* applicable to variable-speed compressors, means the minimum compressor speed at which the compressor will operate under the control of the dedicated condensing system control system.

2.2.6. *Multiple-Capacity,* applicable for describing a refrigeration system, indicates that it has three or more stages (levels) of capacity.

2.2.7. *Speed Ratio,* applicable to variable-speed compressors, means the ratio of operating speed to the maximum speed.

3. Test Methods, Measurements, and Calculations

Determine the Annual Walk-in Energy Factor (AWEF2) and net capacity of walk-in cooler and walk-in freezer refrigeration systems by conducting the test procedure set forth in AHRI 1250–2020, with the modifications to that test procedure provided in this section. However, certain sections of AHRI 1250–2020, ANSI/ASHRAE 37, and ANSI/ASHRAE 16 are not applicable, as set forth in sections 0.1, 0.2, and 0.3 of this appendix. Round AWEF2 measurements to the nearest 0.01 Btu/Wh. Round net capacity measurements as indicated in table 1 of this appendix.

TABLE 1—ROUNDING OF REFRIGERATION SYSTEM NET CAPACITY

Net capacity range, Btu/h	Rounding multiple, Btu/h
<20,000	100
≥20,000 and <38,000	200
≥38,000 and <65,000	500
≥65,000	1,000

The following sections of this appendix provide additional instructions for testing. In cases where there is a conflict, the language of this appendix takes highest precedence, followed by AHRI 1250–2020, then ANSI/ASHRAE 37 or ANSI/ASHRAE 16. Any subsequent amendment to a referenced document by the standard-setting organization will not affect the test procedure in this appendix, unless and until the test procedure is amended by DOE. Material is incorporated as it exists on the date of the approval, and a notification of any change in the incorporation will be published in the **Federal Register**.

3.1. Instrumentation Accuracy and Test Tolerances

Use measuring instruments as described in section 4.1 of AHRI 1250–2020, with the following additional requirement.

3.1.1. Electrical Energy Input measured in Wh with a minimum accuracy of ±0.5% of reading (for Off-Cycle tests per footnote 5 of Table C3 in section C3.6.2 of AHRI 1250–2020).

3.2. Test Operating Conditions

Test conditions used to determine AWEF2 shall be as specified in Tables 4 through 17 of AHRI 1250–2020. Tables 7 and 11 of AHRI 1250–2020, labeled to apply to variable-speed outdoor matched-pair refrigeration systems, shall also be used for testing variable-capacity single-packaged outdoor refrigeration systems, and also for testing multiple-capacity matched-pair or single-packaged outdoor refrigeration systems. Test conditions used to determine AWEF2 for refrigeration systems not specifically identified in AHRI 1250–2020 are as enumerated in sections 3.5.1 through 3.5.6 of this appendix.

3.2.1 Test Operating Conditions for High-Temperature Refrigeration Systems

For fixed-capacity high-temperature matched-pair or single-packaged refrigeration systems with indoor condensing units, conduct tests using the test conditions specified in table 2 of this appendix. For fixed-capacity high-temperature matched-pair or single-packaged refrigeration systems with outdoor condensing units, conduct tests using the test conditions specified in table 3 of this appendix. For high-temperature unit coolers tested alone, conduct tests using the test conditions specified in table 4 of this appendix.

TABLE 2—TEST OPERATING CONDITIONS FOR FIXED-CAPACITY HIGH-TEMPERATURE INDOOR MATCHED PAIR OR SINGLE-PACKAGED REFRIGERATION SYSTEMS

Test description	Unit cooler air entering dry-bulb, °F	Unit cooler air entering relative humidity, %[1]	Condenser air entering dry-bulb, °F	Condenser air entering wet-bulb, °F	Compressor status	Test objective
Off-Cycle Power	55	55			Compressor Off	Measure total input wattage during compressor off-cycle, ($\dot{E}_{cu,off}$ + $\dot{E}F_{comp,off}$).[2]
Refrigeration Capacity A	55	55	90	[3]75, [4]65	Compressor On	Determine Net Refrigeration Capacity of Unit Cooler, input power, and EER at Test Condition.

Notes:
[1] The test condition tolerance (maximum permissible variation of the average value of the measurement from the specified test condition) for relative humidity is 3%.
[2] Measure off-cycle power as described in sections C3 and C4.2 of AHRI 1250–2020.
[3] Required only for evaporative condensing units (*e.g.,* incorporates a slinger ring).
[4] Maximum allowable value for Single-Packaged Systems that do not use evaporative Dedicated Condensing Units, where all or part of the equipment is located in the outdoor room.

TABLE 3—TEST OPERATING CONDITIONS FOR FIXED-CAPACITY HIGH-TEMPERATURE OUTDOOR MATCHED-PAIR OR SINGLE-PACKAGED REFRIGERATION SYSTEMS

Test description	Unit cooler air entering dry-bulb, °F	Unit cooler air entering relative humidity, %[1]	Condenser air entering dry-bulb, °F	Condenser air entering wet-bulb, °F	Compressor status	Test objective
Refrigeration Capacity A	55	55	95	[3]75, [4]68	Compressor On	Determine Net Refrigeration Capacity of Unit Cooler, input power, and EER at Test Condition.
Off-Cycle Power, Capacity A[5]	55	55	95	[3]75, [4]68	Compressor Off	Measure total input wattage during compressor off-cycle, ($\dot{E}_{cu,off}$ + $\dot{E}F_{comp,off}$).[2]
Refrigeration Capacity B	55	55	59	[3]54, [4]46	Compressor On	Determine Net Refrigeration Capacity of Unit Cooler and system input power at moderate condition.
Off-Cycle Power, Capacity B[5]	55	55	59	[3]54, [4]46	Compressor Off	Measure total input wattage during compressor off-cycle, ($\dot{E}_{cu,off}$ + $\dot{E}F_{comp,off}$).[2]
Refrigeration Capacity C	55	55	35	[3]34, [4]29	Compressor On	Determine Net Refrigeration Capacity of Unit Cooler and system input power at cold condition.
Off-Cycle Power, Capacity C[5]	55	55	35	[3]34, [4]29	Compressor Off	Measure total input wattage during compressor off-cycle, ($\dot{E}_{cu,off}$ + $\dot{E}F_{comp,off}$).[2]

Notes:
[1] The test condition tolerance (maximum permissible variation of the average value of the measurement from the specified test condition) for relative humidity is 3%.
[2] Measure off-cycle power as described in sections C3 and C4.2 of AHRI 1250–2020.
[3] Required only for evaporative condensing units (*e.g.,* incorporates a slinger ring).
[4] Maximum allowable value for Single-Packaged Systems that do not use evaporative Dedicated Condensing Units, where all or part of the equipment is located in the outdoor room.

TABLE 4—TEST OPERATING CONDITIONS FOR HIGH-TEMPERATURE UNIT COOLERS

Test description	Unit cooler air entering dry-bulb, °F	Unit cooler air entering relative humidity, %[1]	Suction dew point temp, °F[3 4]	Liquid inlet bubble point temperature, °F	Liquid inlet subcooling, °F	Compressor status	Test objective
Off-Cycle	55	55		105	9	Compressor Off	Measure unit cooler input wattage during compressor off-cycle, $\dot{E}F_{comp,off}$.[2]
Refrigeration Capacity	55	55	38	105	9	Compressor On	Determine Net Refrigeration Capacity of Unit Cooler, input power, and EER at Test Condition.

Notes:
[1] The test condition tolerance (maximum permissible variation of the average value of the measurement from the specified test condition) for relative humidity is 3%.
[2] Measure off-cycle power as described in sections C3 and C4.2 of AHRI 1250–2020.
[3] Superheat shall be set as indicated in the installation instructions. If no superheat specification is given a default superheat value of 6.5 °F shall be used.
[4] Suction Dew Point shall be measured at the Unit Cooler Exit.

3.2.2 Test Operating Conditions for CO_2 Unit Coolers

For medium-temperature CO_2 Unit Coolers, conduct tests using the test conditions specified in table 5 of this appendix. For low-temperature CO_2 Unit Coolers, conduct tests using the test conditions specified in table 6 of this appendix.

TABLE 5—TEST OPERATING CONDITIONS FOR MEDIUM-TEMPERATURE CO_2 UNIT COOLERS

Test title	Unit cooler air entering dry-bulb, °F	Unit cooler air entering relative humidity, %	Suction dew point temp,[3] °F	Liquid inlet bubble point temperature, °F	Liquid inlet subcooling, °F	Compressor operating mode	Test objective
Off-Cycle Power	35	<50				Compressor On	Measure unit cooler input wattage during compressor off-cycle, $\dot{E}F_{comp,off}$.[2]

TABLE 5—TEST OPERATING CONDITIONS FOR MEDIUM-TEMPERATURE CO_2 UNIT COOLERS—Continued

Test title	Unit cooler air entering dry-bulb, °F	Unit cooler air entering relative humidity, %	Suction dew point temp,[3] °F	Liquid inlet bubble point temperature, °F	Liquid inlet subcooling, °F	Compressor operating mode	Test objective
Refrigeration Capacity, Ambient Condition A.	35	<50	25	38	5	Compressor Off ...	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{mix,rack}$.

Notes:
[1] Superheat shall be set as indicated in the installation instructions. If no superheat specification is given a default superheat value of 6.5 °F shall be used.
[2] Measure off-cycle power as described in sections C3 and C4.2 of AHRI 1250–2020.
[3] Suction Dew Point shall be measured at the Unit Cooler Exit conditions.

TABLE 6—TEST OPERATING CONDITIONS FOR LOW-TEMPERATURE CO_2 UNIT COOLERS

Test title	Unit cooler air entering dry-bulb, °F	Unit cooler air entering relative humidity, %	Suction dew point temp,[2] °F	Liquid inlet bubble point temperature, °F	Liquid inlet subcooling, °F	Compressor operating mode	Test objective
Off-Cycle Power	−10	<50	....	....	....	Compressor Off ...	Measure unit cooler input wattage during compressor off-cycle, $\dot{E}F_{comp,off}$.[2]
Refrigeration Capacity, Ambient Condition A.	−10	<50	−20	38	5	Compressor On ...	Determine Net Refrigeration Capacity of Unit Cooler, $\dot{q}_{mix,rack}$.
Defrost	−10	<50	....	....	....	Compressor Off ...	Test according to Appendix C Section C10 of AHRI 1250–2020, $\dot{D}F, \dot{Q}_{DF}$.

Notes:
[1] Superheat shall be set as indicated in the installation instructions. If no superheat specification is given a default superheat value of 6.5 °F shall be used.
[2] Measure off-cycle power as described in sections C3 and C4.2 of AHRI 1250–2020.
[3] Suction Dew Point shall be measured at the Unit Cooler Exit conditions.

3.2.3 Test Operating Conditions for Two-Capacity Condensing Units Tested Alone

For two-capacity medium-temperature outdoor condensing units tested alone, conduct tests using the test conditions specified in table 7 of this appendix. For two-capacity medium-temperature indoor condensing units tested alone, conduct tests using the test conditions specified in table 8 of this appendix. For two-capacity low-temperature outdoor condensing units tested alone, conduct tests using the test conditions specified in table 9 of this appendix. For two-capacity low-temperature indoor condensing units tested alone, conduct tests using the test conditions specified in table 10 of this appendix.

TABLE 7—TEST OPERATING CONDITIONS FOR TWO-CAPACITY MEDIUM-TEMPERATURE OUTDOOR DEDICATED CONDENSING UNITS

Test description	Suction dew point, °F	Return gas, °F	Condenser air entering dry-bulb, °F	Condenser air entering wet-bulb, °F [1]	Compressor status
Capacity, Condition A, Low Capacity	24	41	95	75	Low Capacity, k=1.
Capacity, Condition A, High Capacity	23	41	95	75	High Capacity, k=2.
Off-Cycle, Condition A	....	....	95	75	Off.
Capacity, Condition B, Low Capacity	24	41	59	54	Low Capacity, k=1.
Capacity, Condition B, High Capacity	23	....	59	54	High Capacity, k=2.
Off-Cycle, Condition B	....	....	59	54	Off.
Capacity, Condition C, Low Capacity	24	41	35	34	Low Capacity, k=1.
Capacity, Condition C, High Capacity	23	41	35	34	High Capacity, k=2.
Off-Cycle, Condition C	....	....	35	34	Off.

Notes:
[1] Required only for evaporative condensing units (*e.g.,* incorporates a slinger ring).

TABLE 8—TEST OPERATING CONDITIONS FOR TWO-CAPACITY MEDIUM-TEMPERATURE INDOOR DEDICATED CONDENSING UNITS

Test description	Suction dew point, °F	Return gas, °F	Condenser air entering dry-bulb, °F	Condenser air entering wet-bulb, °F [1]	Compressor status
Capacity, Condition A, Low Capacity	24	41	90	75	Low Capacity, k=1.
Capacity, Condition A, High Capacity	23	41	90	75	High Capacity, k=2.
Off-Cycle, Condition A	....	....	90	75	Off.

Notes:
[1] Required only for evaporative condensing units (*e.g.,* incorporates a slinger ring).

TABLE 9—TEST OPERATING CONDITIONS FOR TWO-CAPACITY LOW-TEMPERATURE OUTDOOR DEDICATED CONDENSING UNITS

Test title	Suction dew point, °F	Return gas, °F	Condenser air entering dry-bulb, °F	Condenser air entering wet-bulb, °F [1]	Compressor operating mode
Capacity, Condition A, Low Capacity	−22	5	95	75	Low Capacity, k=1.
Capacity, Condition A, High Capacity	−22	5	95	75	High Capacity, k=2.
Off-Cycle, Condition A			95	75	Compressor Off.
Capacity, Condition B, Low Capacity	−22	5	59	54	Low Capacity, k=1.
Capacity, Condition B, High Capacity	−22	5	59	54	High Capacity, k=2.
Off-Cycle, Condition B			59	54	Compressor Off.
Capacity, Condition C, Low Capacity	−22	5	35	34	Low Capacity, k=1.
Capacity, Condition C, High Capacity.	−22	5	35	34	Maximum Capacity, k=2.
Off-Cycle, Condition C			35	34	Compressor Off.

Notes:
[1] Required only for evaporative condensing units (*e.g.,* incorporates a slinger ring).

TABLE 10—TEST OPERATING CONDITIONS FOR TWO-CAPACITY LOW-TEMPERATURE INDOOR DEDICATED CONDENSING UNITS

Test title	Suction dew point, °F	Return gas, °F	Condenser air entering dry-bulb, °F	Condenser air entering wet-bulb, °F [1]	Compressor operating mode
Capacity, Condition A, Low Capacity	−22	5	90	75	Low Capacity, k=1.
Capacity, Condition A, High Capacity	−22	5	90	75	High Capacity, k=2.
Off-Cycle, Condition A			90	75	Compressor Off.

Notes:
[1] Required only for evaporative condensing units (*e.g.,* incorporates a slinger ring).

3.2.4 Test Operating Conditions for Variable- or Multiple-Capacity Condensing Units Tested Alone

For variable-capacity or multiple-capacity outdoor medium-temperature condensing units tested alone, conduct tests using the test conditions specified in table 11 of this appendix. For variable-capacity or multiple-capacity indoor medium-temperature condensing units tested alone, conduct tests using the test conditions specified in table 12 of this appendix. For variable-capacity or multiple-capacity outdoor low-temperature condensing units tested alone, conduct tests using the test conditions specified in table 13 of this appendix. For variable-capacity or multiple-capacity indoor low-temperature condensing units tested alone, conduct tests using the test conditions specified in table 14 of this appendix.

TABLE 11—TEST OPERATING CONDITIONS FOR VARIABLE- OR MULTIPLE-CAPACITY MEDIUM-TEMPERATURE OUTDOOR DEDICATED CONDENSING UNITS

Test description	Suction dew point, °F	Return gas, °F	Condenser air entering dry-bulb, °F	Condenser air entering wet-bulb, °F [1]	Compressor status
Capacity, Condition A, Minimum Capacity.	24	41	95	75	Minimum Capacity, k=1.
Capacity, Condition A, Intermediate Capacity.	24	41	95	75	Intermediate Capacity, k=i.
Capacity, Condition A, Maximum Capacity.	23	41	95	75	Maximum Capacity, k=2
Off-Cycle, Condition A			95	75	Off.
Capacity, Condition B, Minimum Capacity.	24	41	59	54	Minimum Capacity, k=1.
Capacity, Condition B, Intermediate Capacity.	24	41	59	54	Intermediate Capacity, k=i.
Capacity, Condition B, Maximum Capacity.	23	41	59	54	Maximum Capacity, k=2.
Off-Cycle, Condition B			59	54	Off.
Capacity, Condition C, Minimum Capacity.	24	41	35	34	Minimum Capacity, k=1.
Capacity, Condition C, Intermediate Capacity.	24	41	35	34	Intermediate Capacity, k=i.
Capacity, Condition C, Maximum Capacity.	23	41	35	34	Maximum Capacity, k=2.
Off-Cycle, Condition C			35	34	Off.

Notes:
[1] Required only for evaporative condensing units (*e.g.,* incorporates a slinger ring).

TABLE 12—TEST OPERATING CONDITIONS FOR VARIABLE- OR MULTIPLE-CAPACITY MEDIUM-TEMPERATURE INDOOR DEDICATED CONDENSING UNITS

Test description	Suction dew point, °F	Return gas, °F	Condenser air entering dry-bulb, °F	Condenser air entering wet-bulb, °F [1]	Compressor status
Capacity, Condition A, Minimum Capacity.	24	41	90	75	Minimum Capacity, k=1.
Capacity, Condition A, Intermediate Capacity.	24	41	90	75	Intermediate Capacity, k=i.
Capacity, Condition A, Maximum Capacity.	23	41	90	75	Maximum Capacity, k=2.
Off-Cycle, Condition A			90	75	Off.

Notes:
[1] Required only for evaporative condensing units (*e.g.,* incorporates a slinger ring).

TABLE 13—TEST OPERATING CONDITIONS FOR VARIABLE- OR MULTIPLE-CAPACITY LOW-TEMPERATURE OUTDOOR DEDICATED CONDENSING UNITS

Test title	Suction dew point, °F	Return gas, °F	Condenser air entering dry-bulb, °F	Condenser air entering wet-bulb, °F [1]	Compressor operating mode
Capacity, Condition A, Minimum Capacity.	−22	5	95	75	Minimum Capacity, k=1.
Capacity, Condition A, Intermediate Capacity.	−22	5	95	75	Minimum Capacity, k=i.
Capacity, Condition A, Maximum Capacity.	−22	5	95	75	Maximum Capacity, k=2.
Off-Cycle, Condition A			95	75	Compressor Off.
Capacity, Condition B, Minimum Capacity.	−22	5	59	54	Minimum Capacity, k=1.
Capacity, Condition B, Intermediate Capacity.	−22	5	59	54	Minimum Capacity, k=i.
Capacity, Condition B, Maximum Capacity.	−22	5	59	54	Maximum Capacity, k=2.
Off-Cycle, Condition B			59	54	Compressor Off.
Capacity, Condition C, Minimum Capacity.	−22	5	35	34	Minimum Capacity, k=1.
Capacity, Condition C, Intermediate Capacity.	−22	5	35	34	Minimum Capacity, k=i.
Capacity, Condition C, Maximum Capacity.	−22	5	35	34	Maximum Capacity, k=2
Off-Cycle, Condition C			35	34	Compressor Off.

Notes:
[1] Required only for evaporative condensing units (*e.g.,* incorporates a slinger ring).

TABLE 14—TEST OPERATING CONDITIONS FOR VARIABLE- OR MULTIPLE-CAPACITY LOW-TEMPERATURE INDOOR DEDICATED CONDENSING UNITS

Test title	Suction dew point, °F	Return gas, °F	Condenser air entering dry-bulb, °F	Condenser air entering wet-bulb, °F [1]	Compressor operating mode
Capacity, Condition A, Minimum Capacity.	−22	5	90	75	Minimum Capacity, k=1.
Capacity, Condition A, Intermediate Capacity.	−22	5	90	75	Minimum Capacity, k=i.
Capacity, Condition A, Maximum Capacity.	−22	5	90	75	Maximum Capacity, k=2.
Off-Cycle, Condition A			90	75	Compressor Off.

Notes:
[1] Required only for evaporative condensing units (*e.g.,* incorporates a slinger ring).

3.2.5 Test Operating Conditions for Two-Capacity Indoor Matched-Pair or Single-Packaged Refrigeration Systems

For two-capacity indoor medium-temperature matched-pair or single-packaged refrigeration systems, conduct tests using the test conditions specified in table 15 of this appendix. For two-capacity indoor low-temperature matched-pair or single-packaged refrigeration systems, conduct tests using the test conditions specified in table 16 of this appendix.

TABLE 15—TEST OPERATING CONDITIONS FOR TWO-CAPACITY MEDIUM-TEMPERATURE INDOOR MATCHED-PAIR OR SINGLE-PACKAGED REFRIGERATION SYSTEMS

Test description	Unit cooler air entering dry-bulb, °F	Unit cooler air entering relative humidity, %	Condenser air entering dry-bulb, °F	Condenser air entering wet-bulb, °F	Compressor status
Capacity, Condition A, Low Capacity	35	<50	90	[1] 75, [2] 65	Low Capacity.
Capacity, Condition A, High Capacity	35	<50	90	[1] 75, [2] 65	High Capacity.
Off-Cycle, Condition A	35	<50	90	[1] 75, [2] 65	Off.

Notes:
[1] Required only for evaporative condensing units (*e.g.,* incorporates a slinger ring).
[2] Maximum allowable value for Single-Packaged Systems that do not use evaporative Dedicated Condensing Units, where all or part of the equipment is located in the outdoor room.

TABLE 16—TEST OPERATING CONDITIONS FOR TWO CAPACITY LOW-TEMPERATURE INDOOR MATCHED-PAIR OR SINGLE-PACKAGED REFRIGERATION SYSTEMS

Test description	Unit cooler air entering dry-bulb, °F	Unit cooler air entering relative humidity, %	Condenser air entering dry-bulb, °F	Maximum condenser air entering wet-bulb, °F	Compressor status
Capacity, Condition A, Low Capacity	−10	<50	90	[1] 75, [2] 65	Low Capacity.
Capacity, Condition A, High Capacity	−10	<50	90	[1] 75, [2] 65	High Capacity.
Off-Cycle, Condition A	−10	<50	90	[1] 75, [2] 65	Off.
Defrost	−10	<50			System Dependent.

Notes:
[1] Required only for evaporative condensing units (*e.g.,* incorporates a slinger ring).
[2] Maximum allowable value for Single-Packaged Systems that do not use evaporative Dedicated Condensing Units, where all or part of the equipment is located in the outdoor room.

3.2.6 Test Conditions for Variable- or Multiple-Capacity Indoor Matched Pair or Single-Packaged Refrigeration Systems

For variable- or multiple-capacity indoor medium-temperature matched-pair or single-packaged refrigeration systems, conduct tests using the test conditions specified in table 17 of this appendix. For variable- or multiple-capacity indoor low-temperature matched-pair or single-packaged refrigeration systems, conduct tests using the test conditions specified in table 18 of this appendix.

TABLE 17—TEST OPERATING CONDITIONS FOR VARIABLE- OR MULTIPLE-CAPACITY MEDIUM-TEMPERATURE INDOOR MATCHED-PAIR OR SINGLE-PACKAGED REFRIGERATION SYSTEMS

Test description	Unit cooler air entering dry-bulb, °F	Unit cooler air entering relative humidity, %	Condenser air entering dry-bulb, °F	Condenser air entering wet-bulb, °F	Compressor status
Capacity, Condition A, Minimum Capacity.	35	<50	90	[1] 75, [2] 65	Minimum Capacity.
Capacity, Condition A, Intermediate Capacity.	35	<50	90	[1] 75, [2] 65	Intermediate Capacity.
Capacity, Condition A, High Capacity	35	<50	90	[1] 75, [1] 65	Maximum Capacity.
Off-Cycle, Condition A	35	<50	90	[1] 75, [2] 65	Off.

Notes:
[1] Required only for evaporative condensing units (*e.g.,* incorporates a slinger ring).
[2] Maximum allowable value for Single-Packaged Systems that do not use evaporative Dedicated Condensing Units, where all or part of the equipment is located in the outdoor room.

TABLE 18—TEST OPERATING CONDITIONS FOR VARIABLE- OR MULTIPLE-CAPACITY LOW-TEMPERATURE INDOOR MATCHED-PAIR OR SINGLE-PACKAGED REFRIGERATION SYSTEMS

Test description	Unit cooler air entering dry-bulb, °F	Unit cooler air entering relative humidity, %	Condenser air entering dry-bulb, °F	Maximum condenser air entering wet-bulb, °F	Compressor status
Capacity, Condition A, Minimum Capacity.	−10	<50	90	[1] 75, [2] 65	Minimum Capacity.
Capacity, Condition A, Intermediate Capacity.	−10	<50	90	[1] 75, [2] 65	Intermediate Capacity.
Capacity, Condition A, Maximum Capacity.	−10	<50	90	[1] 75, [2] 65	Maximum Capacity.
Off-Cycle, Condition A	−10	<50	90	[1] 75, [2] 65	Off.

TABLE 18—TEST OPERATING CONDITIONS FOR VARIABLE- OR MULTIPLE-CAPACITY LOW-TEMPERATURE INDOOR MATCHED-PAIR OR SINGLE-PACKAGED REFRIGERATION SYSTEMS—Continued

Test description	Unit cooler air entering dry-bulb, °F	Unit cooler air entering relative humidity, %	Condenser air entering dry-bulb, °F	Maximum condenser air entering wet-bulb, °F	Compressor status
Defrost	−10	<50			System Dependent.

Notes:
[1] Required only for evaporative condensing units (*e.g.,* incorporates a slinger ring).
[2] Maximum allowable value for Single-Packaged Systems that do not use evaporative Dedicated Condensing Units, where all or part of the equipment is located in the outdoor room.

3.3 Calculation for Walk-in Box Load

3.3.1 For medium- and low-temperature refrigeration systems with indoor condensing units, calculate walk-in box loads for high and low load periods as a function of net capacity as described in section 6.2.1 of AHRI 1250–2020.

3.3.2 For medium- and low-temperature refrigeration systems with outdoor condensing units, calculate walk-in box loads for high and low load periods as a function of net capacity and outdoor temperature as described in section 6.2.2 of AHRI 1250–2020.

3.3.3 For high-temperature refrigeration systems, calculate walk-in box load as follows.

$\dot{B}L = 0.5 \cdot \dot{q}_{ss,A}$

Where $\dot{q}_{ss,A}$ is the measured net capacity for Test Condition A.

3.4 Calculation for Annual Walk-in Energy Factor (AWEF2)

Calculations used to determine AWEF2 based on performance data obtained for testing shall be as specified in section 7 of AHRI 1250–2020 with modifications as indicated in sections 3.4.7 through 3.4.10 of this appendix. Calculations used to determine AWEF2 for refrigeration systems not specifically identified in sections 7.1.1 through 7.1.6 of AHRI 1250–2020 are enumerated in sections 3.4.1 through 3.4.6 and 3.4.11 through 3.4.14 of this appendix.

3.4.1 Two-Capacity Condensing Units Tested Alone, Indoor

3.4.1.1 Unit Cooler Power

Calculate maximum-capacity unit cooler power during the compressor on period $\dot{E}F_{comp,on}$, in Watts, using Equation 130 of AHRI 1250–2020 for medium-temperature refrigeration systems and using Equation 173 of AHRI 1250–2020 for low-temperature refrigeration systems.

Calculate unit cooler power during the compressor off period $\dot{E}F_{comp,off}$, in Watts, as 20 percent of the maximum-capacity unit cooler power during the compressor on period.

3.4.1.2 Defrost

For freezer refrigeration systems, calculate defrost heat contribution $\dot{Q}_{DF}$ in Btu/h and the defrost average power consumption $\dot{D}F$ in W as a function of steady-state maximum gross refrigeration capacity $\dot{Q}_{gross}^{k=2}$, as specified in section C10.2.2 of Appendix C of AHRI 1250–2020.

3.4.1.3 Net Capacity

Calculate steady-state maximum net capacity, $\dot{q}_{ss}^{k=2}$, and minimum net capacity, $\dot{q}_{ss}^{k=1}$ as follows:

$\dot{q}_{ss}^{k=2} = \dot{Q}_{gross}^{k=2} - 3412 \cdot \dot{E}F_{comp,on}$

$\dot{q}_{ss}^{k=1} = \dot{Q}_{gross}^{k=1} - 3412 \cdot 0.2 \cdot \dot{E}F_{comp,on}$

Where:

$\dot{Q}_{gross}^{k=2}$ and $\dot{Q}_{gross}^{k=1}$ represent gross refrigeration capacity at maximum and minimum capacity, respectively.

3.4.1.4 Calculate average power input during the low load period as follows.

If the low load period box load, $\dot{BL}L$, plus defrost heat contribution, $\dot{Q}_{DF}$ (only applicable for freezers), is less than the minimum net capacity $\dot{q}_{ss}^{k=1}$:

$$LFL^{k=1} = \frac{B\dot{L}L + 3.412 \cdot \dot{E}F_{comp,off} + \dot{Q}_{DF}}{\dot{q}_{ss}^{k=1} + 3.412 \cdot \dot{E}F_{comp,off}}$$

$$\dot{E}_L = \left(\dot{E}_{ss}^{k=1} + 0.2 \cdot \dot{E}F_{comp,on}\right) * LFL^{k=1} + \left(\dot{E}F_{comp,off} + \dot{E}_{cu,off}\right) * (1 - LFL^{k=1})$$

Where:

$\dot{E}_{ss}^{k=1}$ is the steady state condensing unit power input for minimum-capacity operation.

$\dot{E}_{cu,off}$ is the condensing unit off-cycle power input, measured as described in section C3.5 of AHRI 1250–2020.

If the low load period box load, $B\dot{L}L$, plus defrost heat contribution, $\dot{Q}_{DF}$, (only applicable for freezers) is greater than the minimum net capacity $\dot{q}_{ss}^{k=1}$:

$$LFL^{k=1} = \frac{\dot{q}_{ss}^{k=2} - (B\dot{L}L + \dot{Q}_{DF})}{\dot{q}_{ss}^{k=2} - \dot{q}_{ss}^{k=1}}$$

$$LFL^{k=2} = 1 - LFL^{k=1}$$

$$\dot{E}_L = \left(\dot{E}_{ss}^{k=1} + 0.2 \cdot \dot{E}F_{comp,on}\right) * LFL^{k=1} + \left(\dot{E}_{ss}^{k=2} + \dot{E}F_{comp,on}\right) * LFL^{k=2}$$

3.4.1.5 Calculate average power input during the high load period as follows.

$$LFH^{k=1} = \frac{\dot{q}_{ss}^{k=2} - (B\dot{L}H + \dot{Q}_{DF})}{\dot{q}_{ss}^{k=2} - \dot{q}_{ss}^{k=1}}$$

$$LFH^{k=2} = 1 - LFH^{k=1}$$

$$\dot{E}_H = \left(\dot{E}_{ss}^{k=1} + 0.2 \cdot E\dot{F}_{comp,on}\right) * LFH^{k=1} + \left(\dot{E}_{ss}^{k=2} + E\dot{F}_{comp,on}\right) * LFH^{k=2}$$

3.4.1.6 Calculate the AWEF2 as follows:

$$AWEF2 = \frac{0.33 \cdot B\dot{L}H + 0.67 \cdot B\dot{L}L}{0.33 \cdot \dot{E}_H + 0.67 \cdot \dot{E}_L + D\dot{F}}$$

3.4.2 Variable-Capacity or Multistage Condensing Units Tested Alone, Indoor

3.4.2.1 Unit Cooler Power

Calculate maximum-capacity unit cooler power during the compressor on period $\dot{EF}_{comp,on}$ as described in section 3.4.1.1 of this appendix.

Calculate unit cooler power during the compressor off period $\dot{EF}_{comp,off}$, in Watts, as 20 percent of the maximum-capacity unit cooler power during the compressor on period.

3.4.2.2 Defrost

Calculate Defrost parameters as described in section 4.4.1.2 of this appendix.

3.4.2.3 Net Capacity

Calculate steady-state maximum net capacity, $\dot{q}_{ss}^{k=2}$, intermediate net capacity, $\dot{q}_{ss}^{k=i}$, and minimum net capacity, $\dot{q}_{ss}^{k=1}$ as follows:

$\dot{q}_{ss}^{k=2} = \dot{Q}_{gross}^{k=2} - 3412 \cdot \dot{EF}_{comp,on}$

$\dot{q}_{ss}^{k=2} = \dot{Q}_{gross}^{k=2} - 3412 \cdot K_f \cdot \dot{EF}_{comp,on}$

$\dot{q}_{ss}^{k=1} = \dot{Q}_{gross}^{k=1} - 3412 \cdot 0.2 \cdot \dot{EF}_{comp,on}$

Where:

$\dot{Q}_{gross}^{k=2}$, $\dot{Q}_{gross}^{k=i}$, $\dot{Q}_{gross,}^{k=1}$, and represent gross refrigeration capacity at maximum, intermediate, and minimum capacity, respectively.

K_f is the unit cooler power coefficient for intermediate capacity operation, set equal to 0.2 to represent low-speed fan operation if the Duty Cycle for a Digital Compressor, the Speed Ratio for a Variable-Speed Compressor, or the Displacement Ratio for a Multi-Stage Compressor at Intermediate Capacity is 65% or less, and otherwise set equal to 1.0.

3.4.2.4 Calculate average power input during the low load period as follows.

If the low load period box load, $B\dot{L}L$, plus defrost heat contribution $\dot{Q}_{DF}$ (only applicable for freezers) is less than the minimum net capacity $\dot{q}_{ss}^{k=1}$:

$$LFL^{k=1} = \frac{B\dot{L}L + 3.412 \cdot E\dot{F}_{comp,off} + \dot{Q}_{DF}}{\dot{q}_{ss}^{k=1} + 3.412 \cdot E\dot{F}_{comp,off}}$$

$$\dot{E}_L = \left(\dot{E}_{ss}^{k=1} + 0.2 \cdot E\dot{F}_{comp,on}\right) * LFL^{k=1} + \left(E\dot{F}_{comp,off} + \dot{E}_{cu,off}\right) * (1 - LFL^{k=1})$$

Where $\dot{E}_{cu,off}$, in W, is the condensing unit off-mode power consumption, measured as described in section C3.5 of AHRI 1250–2020.

If the low load period box load $B\dot{L}L$ plus defrost heat contribution $\dot{Q}_{DF}$ (only applicable for freezers) is greater than the minimum net capacity $\dot{q}_{ss}^{k=1}$ and less than the intermediate net capacity $\dot{q}_{ss}^{k=i}$:

$$EER_L = EER^{k=1} + \left(EER^{k=i} - EER^{k=1}\right) \frac{(B\dot{L}L + \dot{Q}_{DF}) - \dot{q}_{ss}^{k=1}}{\dot{q}_{ss}^{k=i} - \dot{q}_{ss}^{k=1}}$$

$$\dot{E}_L = \frac{B\dot{L}L + \dot{Q}_{DF}}{EER_L}$$

Where:

$EER^{k=1}$ is the minimum-capacity energy efficiency ratio, equal to $\dot{q}_{ss}^{k=1}$ divided by $\dot{E}_{ss}^{k=1} + 0.2 \cdot \dot{EF}_{comp,on}$; and

$EER^{k=i}$ is the intermediate-capacity energy efficiency ratio, equal to $\dot{q}_{ss}^{k=i}$ divided by $\dot{E}_{ss}^{k=i} + K_f \cdot \dot{EF}_{comp,on}$.

3.4.2.5 Calculate average power input during the high load period as follows:

If the high load period box load, $B\dot{L}H$, plus defrost heat contribution, $\dot{Q}_{DF}$ (only applicable for freezers), is greater than the minimum net capacity $\dot{q}_{ss}^{k=1}$ and less than the intermediate net capacity $\dot{q}_{ss}^{k=i}$:

$$EER_H = EER^{k=1} + \left(EER^{k=i} - EER^{k=1}\right) \frac{(B\dot{L}H + \dot{Q}_{DF}) - \dot{q}_{ss}^{k=1}}{\dot{q}_{ss}^{k=i} - \dot{q}_{ss}^{k=1}}$$

$$\dot{E}_H = \frac{B\dot{L}H + \dot{Q}_{DF}}{EER_H}$$

If the high load period box load, $B\dot{L}H$, plus defrost heat contribution, $\dot{Q}_{DF}$ (only applicable for freezers), is greater than the intermediate net capacity, $\dot{q}_{ss}^{k=i}$, and less than the maximum net capacity, $\dot{q}_{ss}^{k=2}$:

$$EER_H = EER^{k=i} + \left(EER^{k=2} - EER^{k=i}\right) \frac{(B\dot{L}H + \dot{Q}_{DF}) - \dot{q}_{ss}^{k=i}}{\dot{q}_{ss}^{k=2} - \dot{q}_{ss}^{k=i}}$$

$$\dot{E}_H = \frac{B\dot{L}H + \dot{Q}_{DF}}{EER_H}$$

Where:

$EER^{k=2}$ is the maximum-capacity energy efficiency ratio, equal to $\dot{q}_{ss}^{k=2}$ divided by $\dot{E}_{ss}^{k=2} + \dot{E}F_{comp,on}$

3.4.2.6 Calculate the AWEF2 as follows.

$$AWEF2 = \frac{0.33 \cdot B\dot{L}H + 0.67 \cdot B\dot{L}L}{0.33 \cdot \dot{E}_H + 0.67 \cdot \dot{E}_L + D\dot{F}}$$

3.4.3 Two-Capacity Condensing Units Tested Alone, Outdoor

3.4.3.1 Unit Cooler Power

Calculate maximum-capacity unit cooler power during the compressor on period $\dot{E}F_{comp,on}$, in Watts, using Equation 153 of AHRI 1250–2020 for medium-temperature refrigeration systems and using Equation 196 of AHRI 1250–2020 for low-temperature refrigeration systems.

Calculate unit cooler power during the compressor off period $\dot{E}F_{comp,off}$, in Watts, as 20 percent of the maximum-capacity unit cooler power during the compressor on period.

3.4.3.2 Defrost

Calculate Defrost parameters as described in section 3.4.1.2 of this appendix.

3.4.3.3 Condensing Unit Off-Cycle Power

Calculate Condensing Unit Off-Cycle Power for temperature t_j as follows.

$$\dot{E}_{cu,off}(t_j) = \begin{cases} \dot{E}_{cu,off,A} & if\ t_j \geq 95\ °F \\ See\ note\ below & if\ 35\ °F < t_j < 95 °F \\ \dot{E}_{cu,off,C} & if\ t_j \leq 35 °F \end{cases}$$

Where $\dot{E}_{cu,off,A}$ and $\dot{E}_{cu,off,C}$ are the Condensing Unit off-cycle power measurements for test conditions A and C, respectively, measured as described in section C3.5 of AHRI 1250–2020. If t_j is greater than 35 °F and less than 59 °F, use Equation 157 of AHRI 1250–2020, and if t_j is greater than or equal to 59 °F and less than 95 °F, use Equation 159 of AHRI 1250–2020.

3.4.3.4 Net Capacity and Condensing Unit Power Input

Calculate steady-state maximum net capacity, $\dot{q}_{ss}^{k=2}(t_j)$, and minimum net capacity, $\dot{q}_{ss}^{k=1}(t_j)$, and corresponding condensing unit power input levels $\dot{E}_{ss}^{k=2}(t_j)$ and $\dot{E}_{ss}^{k=1}(t_j)$ as a function of outdoor temperature t_j as follows:

If $t_j \leq 59$ °F:

$$\dot{q}_{ss}^{k=2}(t_j) = \dot{Q}_{gross,C}^{k=2} + \left(\dot{Q}_{gross,B}^{k=2} - \dot{Q}_{gross,C}^{k=2}\right)\frac{t_j - 35}{59 - 35} - 3.412 \cdot \dot{E}F_{comp,on}$$

$$\dot{q}_{ss}^{k=1}(t_j) = \dot{Q}_{gross,C}^{k=1} + \left(\dot{Q}_{gross,B}^{k=1} - \dot{Q}_{gross,C}^{k=1}\right)\frac{t_j - 35}{59 - 35} - 3.412 \cdot 0.2 \cdot \dot{E}F_{comp,on}$$

$$\dot{E}_{ss}^{k}(t_j) = \dot{E}_{ss,C}^{k} + \left(\dot{E}_{ss,B}^{k} - \dot{E}_{ss,C}^{k}\right)\frac{t_j - 35}{59 - 35}$$

If 59 °F < t_j:

$$\dot{q}_{ss}^{k=2}(t_j) = \dot{Q}_{gross,B}^{k=2} + \left(\dot{Q}_{gross,A}^{k=2} - \dot{Q}_{gross,B}^{k=2}\right)\frac{t_j - 59}{95 - 59} - 3.412 \cdot \dot{EF}_{comp,on}$$

$$\dot{q}_{ss}^{k=1}(t_j) = \dot{Q}_{gross,B}^{k=1} + \left(\dot{Q}_{gross,A}^{k=1} - \dot{Q}_{gross,B}^{k=1}\right)\frac{t_j - 59}{95 - 59} - 3.412 \cdot 0.2 \cdot \dot{EF}_{comp,on}$$

$$\dot{E}_{ss}^{k}(t_j) = \dot{E}_{ss,B}^{k} + \left(\dot{E}_{ss,A}^{k} - \dot{E}_{ss,B}^{k}\right)\frac{t_j - 59}{95 - 59}$$

Where:

The capacity level k can equal 1 or 2;

$\dot{Q}_{gross,X}^{k=2}$ and $\dot{Q}_{gross,X}^{k=1}$ represent gross refrigeration capacity at maximum and minimum capacity, respectively, for test condition X, which can take on values A, B, or C;

$\dot{E}_{ss,X}^{k=2}$ and $\dot{E}_{ss,X}^{k=1}$ represent condensing unit power input at maximum and minimum capacity, respectively for test condition X.

3.4.3.5 Calculate average power input during the low load period as follows.

Calculate the temperature, t_{IL}, in the following equation which the low load period box load, $\dot{BLL}(t_j)$, plus defrost heat contribution, $\dot{Q}_{DF}$ (only applicable for freezers), is less than the minimum net capacity, $\dot{q}_{ss}^{k=1}(t_j)$, by solving the following equation for t_{IL}:

$\dot{BLL}(t_{IL}) + \dot{Q}_{DF} = \dot{q}_{ss}^{k=1}(t_{IL})$

For $t_j < t_{IL}$:

$$LFL^{k=1}(t_j) = \frac{\dot{BLL}(t_j) + 3.412 \cdot \dot{EF}_{comp,off} + \dot{Q}_{DF}}{\dot{q}_{ss}^{k=1}(t_j) + 3.412 \cdot \dot{EF}_{comp,off}}$$

$$\dot{E}_L(t_j) = \left(\dot{E}_{ss}^{k=1}(t_j) + 0.2 \cdot \dot{EF}_{comp,on}\right) * LFL^{k=1}(t_j) + \left(\dot{EF}_{comp,off} + \dot{E}_{cu,off}(t_j)\right) * \left(1 - LFL^{k=1}(t_j)\right)$$

Where $\dot{E}_{cu,off}(t_j)$, in W, is the condensing unit off-mode power consumption for temperature t_j, determined as indicated in section 3.4.3.3 of this appendix.

For $t_j \geq t_{IL}$:

$$LFL^{k=1}(t_j) = \frac{\dot{q}_{ss}^{k=2}(t_j) - (\dot{BLL}(t_j) + \dot{Q}_{DF})}{\dot{q}_{ss}^{k=2}(t_j) - \dot{q}_{ss}^{k=1}(t_j)}$$

$$LFL^{k=2}(t_j) = 1 - LFL^{k=1}(t_j)$$

$$\dot{E}_L(t_j) = \left(\dot{E}_{ss}^{k=1}(t_j) + 0.2 \cdot \dot{EF}_{comp,on}\right) * LFL^{k=1}(t_j) + \left(\dot{E}_{ss}^{k=2}(t_j) + \dot{EF}_{comp,on}\right) * LFL^{k=2}(t_j)$$

3.4.3.6 Calculate average power input during the high load period as follows.

Calculate the temperature, t_{IH}, in the following equation which the high load period box load, $\dot{BLH}(t_j)$, plus defrost heat contribution, $\dot{Q}_{DF}$ (only applicable for freezers), is less than the minimum net capacity, $\dot{q}_{ss}^{k=1}(t_j)$, by solving the following equation for t_{IH}:

$\dot{BLH}(t_{IH}) + \dot{Q}_{DF} = \dot{q}_{ss}^{k=1}(t_{IH})$

Calculate the temperature, t_{IIH}, in the following equation which the high load period box load $\dot{BLH}(t_j)$ plus defrost heat contribution $\dot{Q}_{DF}$ (only applicable for freezers) is less than the maximum net capacity $\dot{q}_{ss}^{k=2}(t_j)$, by solving the following equation for t_{IIH}:

$\dot{BLH}(t_{IIH}) + \dot{Q}_{DF} = \dot{q}_{ss}^{k=1}(t_{IIH})$

For $t_j < t_{IH}$:

$$LFH^{k=1}(t_j) = \frac{B\dot{L}H(t_j) + 3.412 \cdot \dot{EF}_{comp,off} + \dot{Q}_{DF}}{\dot{q}_{ss}^{k=1}(t_j) + 3.412 \cdot \dot{EF}_{comp,off}}$$

$$\dot{E}_H(t_j) = \left(\dot{E}_{ss}^{k=1}(t_j) + 0.2 \cdot \dot{EF}_{comp,on}\right) * LFH^{k=1}(t_j) +$$

$$\left(\dot{EF}_{comp,off} + \dot{E}_{cu,off}(t_j)\right) * \left(1 - LFH^{k=1}(t_j)\right)$$

For $t_{IH} \le t_j < t_{IIH}$:

$$LFH^{k=1}(t_j) = \frac{\dot{q}_{ss}^{k=2}(t_j) - (B\dot{L}H(t_j) + \dot{Q}_{DF})}{\dot{q}_{ss}^{k=2}(t_j) - \dot{q}_{ss}^{k=1}(t_j)}$$

$$LFH^{k=2}(t_j) = 1 - LFH^{k=1}(t_j)$$

$$\dot{E}_H(t_j) = \left(\dot{E}_{ss}^{k=1}(t_j) + 0.2 \cdot \dot{EF}_{comp,on}\right) * LFH^{k=1}(t_j) + \left(\dot{E}_{ss}^{k=2}(t_j) + \dot{EF}_{comp,on}\right) * LFH^{k=2}(t_j)$$

For $t_{IIH} \le t_j$:
$\dot{E}_H(t_j) = (\dot{E}_{ss}{}^{k=2}(t_j) + \dot{EF}_{comp,on})$

3.4.3.7 Calculate the AWEF2 as follows:

$$AWEF2 = \frac{\sum_{j=1}^{n}\left[0.33 \cdot B\dot{L}H(t_j) + 0.67 \cdot B\dot{L}L(t_j)\right] \cdot n_j}{\sum_{j=1}^{n}\left[0.33 \cdot \dot{E}_H(t_j) + 0.67 \cdot \dot{E}_L(t_j) + \dot{DF}\right] \cdot n_j}$$

3.4.4 Variable-Capacity or Multistage Condensing Units Tested Alone, Outdoor

3.4.4.1 Unit Cooler Power

Calculate maximum-capacity unit cooler power during the compressor on period $\dot{EF}_{comp,on}$ as described in section 3.4.1.1 of this appendix.

Calculate unit cooler power during the compressor off period $\dot{EF}_{comp,on}$, in Watts, as 20 percent of the maximum-capacity unit cooler power during the compressor on period.

3.4.4.2 Defrost

Calculate Defrost parameters as described in section 3.4.1.2 of this appendix.

3.4.4.3 Condensing Unit Off-Cycle Power

Calculate Condensing Unit Off-Cycle Power for temperature, t_j, as described in section 3.4.3.3 of this appendix.

3.4.4.4 Net Capacity and Condensing Unit Power Input

Calculate steady-state maximum net capacity, $\dot{q}_{ss}{}^{k=2}(t_j)$, intermediate net capacity, $\dot{q}_{ss}{}^{k=i}(t_j)$, and minimum net capacity, $\dot{q}_{ss}{}^{k=1}(t_j)$, and corresponding condensing unit power input levels $\dot{E}_{ss}{}^{k=2}(t_j)$, $\dot{E}_{ss}{}^{k=i}(t_j)$, $\dot{E}_{ss}{}^{k=1}(t_j)$ and as a function of outdoor temperature, t_j, as follows:

If $t_j \le 59$ °F:

$$\dot{q}_{ss}^{k=2}(t_j) = \dot{Q}_{gross,C}^{k=2} + \left(\dot{Q}_{gross,B}^{k=2} - \dot{Q}_{gross,C}^{k=2}\right)\frac{t_j - 35}{59 - 35} - 3.412 \cdot \dot{EF}_{comp,on}$$

$$\dot{q}_{ss}^{k=i}(t_j) = \dot{Q}_{gross,C}^{k=i} + \left(\dot{Q}_{gross,B}^{k=i} - \dot{Q}_{gross,C}^{k=i}\right)\frac{t_j - 35}{59 - 35} - 3.412 \cdot K_f.\dot{EF}_{comp,on}$$

$$\dot{q}_{ss}^{k=1}(t_j) = \dot{Q}_{gross,C}^{k=1} + \left(\dot{Q}_{gross,B}^{k=1} - \dot{Q}_{gross,C}^{k=1}\right)\frac{t_j - 35}{59 - 35} - 3.412 \cdot 0.2 \cdot \dot{EF}_{comp,on}$$

$$\dot{E}_{ss}^{k}(t_j) = \dot{E}_{ss,C}^{k} + \left(\dot{E}_{ss,B}^{k} - \dot{E}_{ss,C}^{k}\right)\frac{t_j - 35}{59 - 35}$$

If 59 °F < t_j:

$$\dot{q}_{ss}^{k=2}(t_j) = \dot{Q}_{gross,B}^{k=2} + \left(\dot{Q}_{gross,A}^{k=2} - \dot{Q}_{gross,B}^{k=2}\right)\frac{t_j - 59}{95 - 59} - 3.412 \cdot \dot{EF}_{comp,on}$$

$$\dot{q}_{ss}^{k=i}(t_j) = \dot{Q}_{gross,B}^{k=i} + \left(\dot{Q}_{gross,A}^{k=i} - \dot{Q}_{gross,B}^{k=i}\right)\frac{t_j - 59}{95 - 59} - 3.412 \cdot K_f \cdot \dot{EF}_{comp,on}$$

$$\dot{q}_{ss}^{k=1}(t_j) = \dot{Q}_{gross,B}^{k=1} + \left(\dot{Q}_{gross,A}^{k=1} - \dot{Q}_{gross,B}^{k=1}\right)\frac{t_j - 59}{95 - 59} - 3.412 \cdot 0.2 \cdot \dot{EF}_{comp,on}$$

$$\dot{E}_{ss}^{k}(t_j) = \dot{E}_{ss,B}^{k} + \left(\dot{E}_{ss,A}^{k} - \dot{E}_{ss,B}^{k}\right)\frac{t_j - 59}{95 - 59}$$

Where:

The capacity level k can equal 1, i, or 2;

$\dot{Q}_{gross,X}^{k=2}$, $\dot{Q}_{gross,X}^{k=i}$ and $\dot{Q}_{gross,X}^{k=1}$ represent gross refrigeration capacity at maximum, intermediate, and minimum capacity, respectively, for test condition X, which can take on values A, B, or C;

$\dot{E}_{ss,X}^{k=2}$ and $\dot{E}_{ss,X}^{k=1}$ represent condensing unit power input at maximum and minimum capacity, respectively for test condition X; and

K_f is the unit cooler power coefficient for intermediate capacity operation, set equal to 0.2 to represent low-speed fan operation if the Duty Cycle for a Digital Compressor, the Speed Ratio for a Variable-Speed Compressor, or the Displacement Ratio for a Multi-Stage Compressor at Intermediate Capacity is 65% or less, and otherwise set equal to 1.0.

3.4.4.5 Calculate average power input during the low load period as follows.

Calculate the temperature, t_{IL}, in the following equation which the low load period box load $\dot{BLL}(t_j)$ plus defrost heat contribution, $\dot{Q}_{DF}$ (only applicable for freezers), is less than the minimum net capacity, $\dot{q}_{ss}^{k=1}(t_j)$, by solving the following equation for t_{IL}:

$\dot{BLL}(t_{IL}) + \dot{Q}_{DF} = \dot{q}_{ss}^{k=1}(t_{IL})$

Calculate the temperature, t_{VL}, in the following equation which the low load period box load, $\dot{BLL}(t_j)$, plus defrost heat contribution, $\dot{Q}_{DF}$ (only applicable for freezers), is less than the intermediate net capacity, $\dot{q}_{ss}^{k=i}(t_j)$, by solving the following equation for t_{VL}:

$\dot{BLL}(t_{VL}) + \dot{Q}_{DF} = \dot{q}_{ss}^{k=i}(t_{VL})$

For $t_j < t_{IL}$:

$$LFL^{k=1}(t_j) = \frac{\dot{BLL}(t_j) + 3.412 \cdot \dot{EF}_{comp,off} + \dot{Q}_{DF}}{\dot{q}_{ss}^{k=1}(t_j) + 3.412 \cdot \dot{EF}_{comp,off}}$$

$$\dot{E}_L(t_j) = \left(\dot{E}_{ss}^{k=1}(t_j) + 0.2 \cdot \dot{EF}_{comp,on}\right) * LFL^{k=1}(t_j) + \left(\dot{EF}_{comp,off} + \dot{E}_{cu,off}(t_j)\right) * \left(1 - LFL^{k=1}(t_j)\right)$$

Where, $\dot{E}_{cu,off}(t_j)$ in W, is the condensing unit off-mode power consumption for temperature, t_j, determined as indicated in section 3.4.3.3 of this appendix.

For $t_{IL} \le t_j < t_{VL}$:

$$EER_L(t_j) = EER^{k=1}(t_j) + \left(EER^{k=i}(t_j) - EER^{k=1}(t_j)\right)\frac{(\dot{BLL}(t_j) + \dot{Q}_{DF}) - \dot{q}_{ss}^{k=1}(t_j)}{\dot{q}_{ss}^{k=i}(t_j) - \dot{q}_{ss}^{k=1}(t_j)}$$

$$\dot{E}_L(t_j) = \frac{\dot{BLL}(t_j) + \dot{Q}_{DF}}{EER_L(t_j)}$$

For $t_{VL} \le t_j$:

$$EER_L(t_j) = EER^{k=i}(t_j) + \left(EER^{k=2}(t_j) - EER^{k=i}(t_j)\right)\frac{(\dot{BLL}(t_j) + \dot{Q}_{DF}) - \dot{q}_{ss}^{k=i}(t_j)}{\dot{q}_{ss}^{k=2}(t_j) - \dot{q}_{ss}^{k=i}(t_j)}$$

$$\dot{E}_L(t_j) = \frac{\dot{BLL}(t_j) + \dot{Q}_{DF}}{EER_L(t_j)}$$

Where:

$EER^{k=2}(t_j)$ is the minimum-capacity energy efficiency ratio, equal to $\dot{q}_{ss}^{k=1}(t_j)$ divided by $\dot{E}_{ss}^{k=1}(t_j) + 0.2\ \dot{EF}_{comp,on}$;

$EER^{k=i}(t_j)$ is the intermediate-capacity energy efficiency ratio, equal to $\dot{q}_{ss}^{k=i}(t_j)$ divided by $\dot{E}_{ss}^{k=i}(t_j) + K_f \cdot \dot{EF}_{comp,on}$; and

$EER^{k=2}(t_j)$ is the maximum-capacity energy efficiency ratio, equal to $\dot{q}_{ss}^{k=2}(t_j)$ divided by $\dot{E}_{ss}^{k=2}(t_j) + \dot{EF}_{comp,on}$

3.4.4.6 Calculate average power input during the high load period as follows.

Calculate the temperature t_{VH} in the following equation which the high load period box load $B\dot{L}H(t_j)$ plus defrost heat contribution $\dot{Q}_{DF}$ (only applicable for freezers) is less than the intermediate net capacity $\dot{q}_{ss}^{k=i}(t_j)$, by solving the following equation for t_{VH}:

$B\dot{L}H(t_{VH}) + \dot{Q}_{DF} = \dot{q}_{ss}^{k=i}(t_{VH})$

Calculate the temperature t_{IIH} in the following equation which the high load period box load $B\dot{L}H(t_j)$ plus defrost heat contribution $\dot{Q}_{DF}$ (only applicable for freezers) is less than the maximum net capacity $\dot{q}_{ss}^{k=2}(t_j)$, by solving the following equation for t_{IIH}:

$B\dot{L}H(t_{IIH}) + \dot{Q}_{DF} = \dot{q}_{ss}^{k=2}(t_{IIH})$

For $t_j < t_{VH}$:

$$EER_H(t_j) = EER^{k=1}(t_j) + \left(EER^{k=i}(t_j) - EER^{k=1}(t_j)\right) \frac{(B\dot{L}H(t_j) + \dot{Q}_{DF}) - \dot{q}_{ss}^{k=1}(t_j)}{\dot{q}_{ss}^{k=i}(t_j) - \dot{q}_{ss}^{k=1}(t_j)}$$

$$\dot{E}_H(t_j) = \frac{B\dot{L}H(t_j) + \dot{Q}_{DF}}{EER_H(t_j)}$$

For $t_{VH} \le t_j < t_{IIH}$:

$$EER_H(t_j) = EER^{k=i}(t_j) + \left(EER^{k=2}(t_j) - EER^{k=i}(t_j)\right) \frac{(B\dot{L}H(t_j) + \dot{Q}_{DF}) - \dot{q}_{ss}^{k=i}(t_j)}{\dot{q}_{ss}^{k=2}(t_j) - \dot{q}_{ss}^{k=i}(t_j)}$$

$$\dot{E}_H(t_j) = \frac{B\dot{L}H(t_j) + \dot{Q}_{DF}}{EER_H(t_j)}$$

For $t_{IIH} \le t_j$:

$\dot{E}_H(t_j) = (\dot{E}_{ss}^{k=2}(t_j) + \dot{EF}_{comp,on})$

3.4.4.7 Calculate the AWEF2 as follows:

$$AWEF2 = \frac{\sum_{j=1}^{n}\left[0.33 \cdot B\dot{L}H(t_j) + 0.67 \cdot B\dot{L}L(t_j)\right] \cdot n_j}{\sum_{j=1}^{n}\left[0.33 \cdot \dot{E}_H(t_j) + 0.67 \cdot \dot{E}_L(t_j) + \dot{DF}\right] \cdot n_j}$$

3.4.5 Two-Capacity Indoor Matched Pairs or Single-Packaged Refrigeration Systems Other Than High-Temperature

3.4.5.1 Defrost

For freezer refrigeration systems, defrost heat contribution $\dot{Q}_{DF}$ in Btu/h and the defrost average power consumption $\dot{DF}$ in W shall be as measured in accordance with section C10.2.1 of Appendix C of AHRI 1250–2020.

3.4.5.2 Calculate average power input during the low load period as follows.

If the low load period box load $B\dot{L}L$ plus defrost heat contribution $\dot{Q}_{DF}$ (only applicable for freezers) is less than the minimum net capacity $\dot{q}_{ss}^{k=1}$:

$$LFL^{k=1} = \frac{B\dot{L}L + 3.412 \cdot \dot{EF}_{comp,off} + \dot{Q}_{DF}}{\dot{q}_{ss}^{k=1} + 3.412 \cdot \dot{EF}_{comp,off}}$$

$$\dot{E}_L = \left(\dot{E}_{ss}^{k=1}\right) * LFL^{k=1} + \left(\dot{EF}_{comp,off} + \dot{E}_{cu,off}\right) * (1 - LFL^{k=1})$$

Where:

$\dot{q}_{ss}^{k=1}$ and $\dot{E}_{ss}^{k=1}$ are the steady state refrigeration system minimum net capacity, in Btu/h, and associated refrigeration system power input, in W, respectively, for minimum-capacity operation, measured as described in AHRI 1250–2020.

$\dot{EF}_{comp,off}$ and $\dot{E}_{cu,off}$, both in W, are the unit cooler and condensing unit, respectively, off-mode power consumption, measured as described in section C3.5 of AHRI 1250–2020.

If the low load period box load $B\dot{L}L$ plus defrost heat contribution $\dot{Q}_{DF}$ (only applicable for freezers) is greater than the minimum net capacity $\dot{q}_{ss}^{k=1}$:

$$LFL^{k=1} = \frac{\dot{q}_{ss}^{k=2} - (B\dot{L}L + \dot{Q}_{DF})}{\dot{q}_{ss}^{k=2} - \dot{q}_{ss}^{k=1}}$$

$$LFL^{k=2} = 1 - LFL^{k=1}$$

$$\dot{E}_L = \left(\dot{E}_{ss}^{k=1}\right) * LFL^{k=1} + \left(\dot{E}_{ss}^{k=2}\right) * LFL^{k=2}$$

Where $\dot{q}_{ss}{}^{k=2}$ and $\dot{E}_{ss}{}^{k=2}$ are the steady state refrigeration system maximum net capacity, in Btu/h, and associated refrigeration system power input, in W, respectively, for maximum-capacity operation, measured as described in AHRI 1250–2020.

3.4.5.3 Calculate average power input during the high load period as follows.

$$LFH^{k=1} = \frac{\dot{q}_{ss}^{k=2} - (B\dot{L}H + \dot{Q}_{DF})}{\dot{q}_{ss}^{k=2} - \dot{q}_{ss}^{k=1}}$$

$$LFH^{k=2} = 1 - LFH^{k=1}$$

$$\dot{E}_H = \left(\dot{E}_{ss}^{k=1}\right) * LFH^{k=1} + \left(\dot{E}_{ss}^{k=2}\right) * LFH^{k=2}$$

3.4.5.4 Calculate the AWEF2 as follows:

$$AWEF2 = \frac{0.33 \cdot B\dot{L}H + 0.67 \cdot B\dot{L}L}{0.33 \cdot \dot{E}_H + 0.67 \cdot \dot{E}_L + \dot{DF}}$$

3.4.6 Variable-Capacity or Multistage Indoor Matched Pairs or Single-Packaged Refrigeration Systems Other Than High-Temperature

3.4.6.1 Defrost

For freezer refrigeration systems, defrost heat contribution $\dot{Q}_{DF}$ in Btu/h and the defrost average power consumption $\dot{DF}$ in W shall be as measured in accordance with section C10.2.1 of Appendix C of AHRI 1250–2020.

3.4.6.2 Calculate average power input during the low load period as follows.

If the low load period box load $B\dot{L}L$ plus defrost heat contribution $\dot{Q}_{DF}$ (only applicable for freezers) is less than the minimum net capacity $\dot{q}_{ss}{}^{k=1}$:

$$LFL^{k=1} = \frac{B\dot{L}L + 3.412 \cdot E\dot{F}_{comp,off} + \dot{Q}_{DF}}{\dot{q}_{ss}^{k=1} + 3.412 \cdot E\dot{F}_{comp,off}}$$

$$\dot{E}_L = \left(\dot{E}_{ss}^{k=1}\right) * LFL^{k=1} + \left(E\dot{F}_{comp,off} + \dot{E}_{cu,off}\right) * (1 - LFL^{k=1})$$

Where:

$\dot{q}_{ss}{}^{k=1}$ and $\dot{E}_{ss}{}^{k=1}$ are the steady state refrigeration system minimum net capacity, in Btu/h, and associated refrigeration system power input, in W, respectively, for minimum-capacity operation, measured as described in AHRI 1250–2020; and

$E\dot{F}_{comp,off}$ and $\dot{E}_{cu,off}$, both in W, are the unit cooler and condensing unit, respectively, off-mode power consumption, measured as described in section C3.5 of AHRI 1250–2020.

If the low load period box load $B\dot{L}L$ plus defrost heat contribution $\dot{Q}_{DF}$ (only applicable for freezers) is greater than the minimum net capacity and less than the intermediate net capacity $\dot{q}_{ss}{}^{k=i}$:

$$EER_L = EER^{k=1} + \left(EER^{k=i} - EER^{k=1}\right) \frac{(B\dot{L}L + \dot{Q}_{DF}) - \dot{q}_{ss}^{k=1}}{\dot{q}_{ss}^{k=i} - \dot{q}_{ss}^{k=1}}$$

$$\dot{E}_L = \frac{B\dot{L}L + \dot{Q}_{DF}}{EER_L}$$

Where:

$EER^{k=1}$ is the minimum-capacity energy efficiency ratio, equal to $\dot{q}_{ss}^{k=1}$ divided by $\dot{E}_{ss}^{k=1}$;

$\dot{q}_{ss}^{k=i}$ and $\dot{E}_{ss}^{k=i}$ are the steady state refrigeration system intermediate net capacity, in Btu/h, and associated refrigeration system power input, in W, respectively, for intermediate-capacity operation, measured as described in AHRI 1250–2020.

$EER^{k=i}$ is the intermediate-capacity energy efficiency ratio, equal to $\dot{q}_{ss}^{k=i}$ divided by $\dot{E}_{ss}^{k=i}$.

3.4.6.3 Calculate average power input during the high load period as follows.

If the high load period box load $B\dot{L}H$ plus defrost heat contribution $\dot{Q}_{DF}$ (only applicable for freezers) is greater than the minimum net capacity $\dot{q}_{ss}^{k=1}$ and less than the intermediate net capacity $\dot{q}_{ss}^{k=i}$:

$$EER_H = EER^{k=1} + \left(EER^{k=i} - EER^{k=1}\right) \frac{(B\dot{L}H + \dot{Q}_{DF}) - \dot{q}_{ss}^{k=1}}{\dot{q}_{ss}^{k=i} - \dot{q}_{ss}^{k=1}}$$

$$\dot{E}_H = \frac{B\dot{L}H + \dot{Q}_{DF}}{EER_H}$$

If the high load period box load $B\dot{L}H$ plus defrost heat contribution $\dot{Q}_{DF}$ (only applicable for freezers) is greater than the intermediate net capacity $\dot{q}_{ss}^{k=i}$ and less than the maximum net capacity $\dot{q}_{ss}^{k=2}$:

$$EER_H = EER^{k=i} + \left(EER^{k=2} - EER^{k=i}\right) \frac{(B\dot{L}H + \dot{Q}_{DF}) - \dot{q}_{ss}^{k=i}}{\dot{q}_{ss}^{k=2} - \dot{q}_{ss}^{k=i}}$$

$$\dot{E}_H = \frac{B\dot{L}H + \dot{Q}_{DF}}{EER_H}$$

Where:

$\dot{q}_{ss}^{k=2}$ and $\dot{E}_{ss}^{k=2}$ are the steady state refrigeration system maximum net capacity, in Btu/h, and associated refrigeration system power input, in W, respectively, for maximum-capacity operation, measured as described in AHRI 1250–2020; and

$EER^{k=2}$ is the maximum-capacity energy efficiency ratio, equal to $\dot{q}_{ss}^{k=2}$ divided by $\dot{E}_{ss}^{k=2}$.

3.4.6.4 Calculate the AWEF2 as follows.

$$AWEF2 = \frac{0.33 \cdot B\dot{L}H + 0.67 \cdot B\dot{L}L}{0.33 \cdot \dot{E}_H + 0.67 \cdot \dot{E}_L + \dot{DF}}$$

3.4.7 Variable-Capacity or Multistage Outdoor Matched Pairs or Single-Packaged Refrigeration Systems Other Than High-Temperature

Calculate AWEF2 as described in section 7.6 of AHRI 1250–2020, with the following revisions.

3.4.7.1 Condensing Unit Off-Cycle Power

Calculate condensing unit off-cycle power for temperature t_j as indicated in section 3.4.3.3 of this appendix. Replace the constant value $\dot{E}_{CU,off}$ in Equations 55 and 70 of AHRI 1250–2020 with the values $\dot{E}_{CU,off}(t_j)$, which vary with outdoor temperature t_j.

3.4.7.2 Unit Cooler Off-Cycle Power

Set unit cooler Off-Cycle power $\dot{E}F_{comp,off}$ equal to the average of the unit cooler off-cycle power measurements made for test conditions A, B, and C.

3.4.7.3 Average Power During the Low Load Period

Calculate average power for intermediate-capacity compressor operation during the low load period $\dot{E}_{ss,L}^{k=v}(t_j)$ as described in section 7.6 of AHRI 1250–2020, except that, instead of calculating intermediate-capacity compressor EER using Equation 77 of AHRI 1250–2020, calculate EER as follows.

For $t_j < t_{VL}$:

$$\dot{E}_{ss,L}^{k=v}(t_j) = EER^{k=1}(t_j) + \left(EER^{k=i}(t_j) - EER^{k=1}(t_j)\right) \frac{(B\dot{L}L(t_j) + \dot{Q}_{DF}) - \dot{q}_{ss}^{k=1}(t_j)}{\dot{q}_{ss}^{k=i}(t_j) - \dot{q}_{ss}^{k=1}(t_j)}$$

For $t_{VL} \le t_j$:

$$\dot{E}_{ss,L}^{k=v}(t_j) = EER^{k=i}(t_j) + \left(EER^{k=2}(t_j) - EER^{k=i}(t_j)\right) \frac{(B\dot{L}L(t_j) + \dot{Q}_{DF}) - \dot{q}_{ss}^{k=i}(t_j)}{\dot{q}_{ss}^{k=2}(t_j) - \dot{q}_{ss}^{k=i}(t_j)}$$

Where:

$EER^{k=1}(t_j)$ is the minimum-capacity energy efficiency ratio, equal to $\dot{q}_{ss}^{k=1}(t_j)$ divided by $\dot{E}_{ss}^{k=1}(t_j)$;

$EER^{k=i}(t_j)$ is the intermediate-capacity energy efficiency ratio, equal to $\dot{q}_{ss}^{k=i}(t_j)$ divided by $\dot{E}_{ss}^{k=i}(t_j)$; and

$EER^{k=2}(t_j)$ is the maximum-capacity energy efficiency ratio, equal to $\dot{q}_{ss}^{k=2}(t_j)$ divided by $\dot{E}_{ss}^{k=2}(t_j)$

3.4.7.4 Average Power During the High Load Period

Calculate average power for intermediate-capacity compressor operation during the high load period $\dot{E}_{ss,H}^{k=v}(t_j)$ as described in section 7.6 of AHRI 1250–2020, except that, instead of calculating intermediate-capacity compressor EER using Equation 61 of AHRI 1250–2020, calculate EER as follows:

For $t_j < t_{VH}$:

$$EER_{ss,H}^{k=v}(t_j) = EER^{k=1}(t_j) + \left(EER^{k=i}(t_j) - EER^{k=1}(t_j)\right) \frac{(\dot{BLH}(t_j) + \dot{Q}_{DF}) - \dot{q}_{ss}^{k=1}(t_j)}{\dot{q}_{ss}^{k=i}(t_j) - \dot{q}_{ss}^{k=1}(t_j)}$$

For $t_{VH} \leq t_j$:

$$EER_{ss,H}^{k=v}(t_j) = EER^{k=i}(t_j) + \left(EER^{k=2}(t_j) - EER^{k=i}(t_j)\right) \frac{(\dot{BLH}(t_j) + \dot{Q}_{DF}) - \dot{q}_{ss}^{k=i}(t_j)}{\dot{q}_{ss}^{k=2}(t_j) - \dot{q}_{ss}^{k=i}(t_j)}$$

3.4.8 Two-Capacity Outdoor Matched Pairs or Single-Packaged Refrigeration Systems Other Than High-Temperature

Calculate AWEF2 as described in section 7.5 of AHRI 1250–2020, with the following revisions for Condensing Unit Off-Cycle Power and Unit Cooler Off-Cycle Power. Calculate condensing unit off-cycle power for temperature t_j as indicated in section 3.4.3.3 of this appendix. Replace the constant value $\dot{E}_{CU,off}$ in Equations 13 and 29 of AHRI 1250–2020 with the values $\dot{E}_{CU,off}(t_j)$, which vary with outdoor temperature t_j. Set unit cooler Off-Cycle power $\dot{EF}_{comp,off}$ equal to the average of the unit cooler off-cycle power measurements made for test conditions A, B, and C.

3.4.9 Single-Capacity Outdoor Matched Pairs or Single-Packaged Refrigeration Systems Other Than High-Temperature

Calculate AWEF2 as described in section 7.4 of AHRI 1250–2020, with the following revision for Condensing Unit Off-Cycle Power and Unit Cooler Off-cycle Power. Calculate condensing unit off-cycle power for temperature t_j as indicated in section 3.4.3.3 of this appendix. Replace the constant value $\dot{E}_{CU,off}$ in Equations 13 of AHRI 1250–2020 with the values $\dot{E}_{CU,off}(t_j)$, which vary with outdoor temperature t_j. Set unit cooler Off-Cycle power $\dot{EF}_{comp,off}$ equal to the average of the unit cooler off-cycle power measurements made for test conditions A, B, and C.

3.4.10 Single-Capacity Condensing Units, Outdoor

Calculate AWEF2 as described in section 7.9 of AHRI 1250–2020, with the following revision for Condensing Unit Off-Cycle Power. Calculate condensing unit off-cycle power for temperature t_j as indicated in section 3.4.3.3 of this appendix rather than as indicated in Equations 157, 159, 202, and 204 of AHRI 1250–2020.

3.4.11 High-Temperature Matched Pairs or Single-Packaged Refrigeration Systems, Indoor

3.4.11.1 Calculate Load Factor LF as follows:

$$LF = \frac{\dot{BL} + 3.412 \cdot \dot{EF}_{comp,off}}{\dot{q}_{ss,A} + 3.412 \cdot \dot{EF}_{comp,off}}$$

Where:

$\dot{BL}$, in Btu/h is the non-equipment-related box load calculated as described in section 3.3.3 of this appendix;

$\dot{EF}_{comp,off}$, in W, is the unit cooler off-cycle power consumption, equal to 0.1 times the unit cooler on-cycle power consumption; and

$\dot{q}_{ss,A}$, in Btu/h is the measured net capacity for test condition A.

3.4.11.2 Calculate the AWEF2 as follows:

$$AWEF2 = \frac{\dot{BL}}{\dot{E}_{SS,A} \cdot LF + \left(\dot{EF}_{comp,off} + \dot{E}_{cu,off}\right) \cdot (1 - LF)}$$

Where:

$\dot{E}_{ss,A}$, in W, is the measured system power input for test condition A; and

$\dot{E}_{cu,off}$, in W, is the condensing unit off-cycle power consumption, measured as described in section C3.5 of AHRI 1250–2020.

3.4.12 High-Temperature Matched Pairs or Single-Packaged Refrigeration Systems, Outdoor

3.4.12.1 Calculate Load Factor $LF(t_j)$ for outdoor temperature t_j as follows:

$$LF(t_j) = \frac{\dot{BL} + 3.412 \cdot \dot{EF}_{comp,off}}{\dot{q}_{ss}(t_j) + 3.412 \cdot \dot{EF}_{comp,off}}$$

Where:

$\dot{BL}$, in Btu/h, is the non-equipment-related box load calculated as described in section 3.3.3 of this appendix;

$\dot{EF}_{comp,off}$, in W, is the unit cooler off-cycle power consumption, equal to 0.1 times the unit cooler on-cycle power consumption; and

$\dot{q}_{ss}(t_j)$, in Btu/h, is the net capacity for outdoor temperature t_j, calculated as described in section 7.4.2 of AHRI 1250–2020.

3.4.12.2 Calculate the AWEF2 as follows:

$$AWEF2 = \frac{\sum_{i=1}^{n} \dot{BL} \cdot n_j}{\sum_{j=1}^{n} \left[\dot{E}_{ss}(t_j) \cdot LF(t_j) + \left(\dot{EF}_{comp,off} + \dot{E}_{cu,off}\right) \cdot \left(1 - LF(t_j)\right)\right] \cdot n_j}$$

Where:

$\dot{E}_{ss}(t_j)$, in W, is the system power input for temperature t_j, calculated as described in section 7.4.2 of AHRI 1250–2020;

$\dot{E}_{cu,off}$, in W, is the condensing unit off-cycle power consumption, measured as described in section C3.5 of AHRI 1250–2020; and

n_j are the hours for temperature bin j.

3.4.13 High-Temperature Unit Coolers Tested Alone

3.4.13.1 Calculate Refrigeration System Power Input as follows:

$$\dot{E}_{mix,rack} = \frac{\dot{q}_{mix,evap} + 3.412 \times \dot{EF}_{comp,on}}{EER} + \dot{EF}_{comp,on}$$

Where:

$\dot{q}_{mix,evap}$, in W, is the net evaporator capacity, measured as described in AHRI 1250–2020;

$\dot{EF}_{comp,on}$, in W, is the unit cooler on-cycle power consumption; and

EER, in W, equals

$$\begin{cases} 11 & if\ \dot{q}_{mix,evap} < 10{,}000\ Btu/h \\ 0.0007 \cdot \dot{q}_{mix,evap} + 4 & if\ 10{,}000 \le \dot{q}_{mix,evap} \le 20{,}000\ Btu/h \\ 18 & if\ 20{,}000 \le \dot{q}_{mix,evap} \end{cases}$$

3.4.13.2 Calculate the load factor LF as follows:

$$LF = \frac{\dot{BL} + 3.412 \cdot \dot{EF}_{comp,off}}{\dot{q}_{mix,evap} + 3.412 \cdot \dot{EF}_{comp,off}}$$

Where:

$\dot{BL}$, in Btu/h, is the non-equipment-related box load calculated as described in section 3.3.3 of this appendix; and

$\dot{EF}_{comp,off}$, in W, is the unit cooler off-cycle power consumption, equal to 0.1 times the unit cooler on-cycle power consumption.

3.4.13.3 Calculate AWEF2 as follows:

$$AWEF2 = \frac{\dot{BL}}{\dot{E}_{mix,rack} \cdot LF + \dot{EF}_{comp,off} \cdot (1 - LF)}$$

3.4.14 CO_2 Unit Coolers Tested Alone

Calculate AWEF2 for CO_2 Unit Coolers Tested Alone using the calculations specified in in section 7.8 of AHRI 1250–2020 for calculation of AWEF2 for Unit Cooler Tested Alone.

3.5 Test Method

Test the Refrigeration System in accordance with AHRI 1250–2020 to determine refrigeration capacity and power input for the specified test conditions, with revisions and additions as described in this section.

3.5.1 Chamber Conditioning Using the Unit Under Test

In Appendix C, section C5.2.2 of AHRI 1250–2020, for applicable system configurations (matched pairs, single-packaged refrigeration systems, and standalone unit coolers), the unit under test may be used to aid in achieving the required test chamber conditions prior to beginning any steady state test. However, the unit under test must be inspected and confirmed to be free from frost before initiating steady state testing.

3.5.2 General Modification: Methods of Testing

3.5.2.1 Refrigerant Temperature Measurements

When testing a condensing unit alone, measure refrigerant liquid temperature leaving the condensing unit, and the refrigerant vapor temperature entering the condensing unit as required in section C7.5.1.1.2 of Appendix C of AHRI 1250–2020 using the same measurement approach specified for the unit cooler in section C3.1.3 of Appendix C of AHRI 1250–2020. In all cases in which thermometer wells or immersed sheathed sensors are prescribed, if the refrigerant tube outer diameter is less than ½ inch, the refrigerant temperature may be measured using the average of two temperature measuring instruments with a minimum accuracy of ±0.5 °F placed on opposite sides of the refrigerant tube surface—resulting in a total of up to 8 temperature measurement devices used for the DX Dual Instrumentation method. In this case, the refrigerant tube shall be insulated with 1-inch thick insulation from a point 6 inches upstream of the measurement location to a point 6 inches downstream of the measurement location. Also, to comply with this requirement, the unit cooler/evaporator entering measurement location may be moved to a location 6 inches upstream of the expansion device and, when testing a condensing unit alone, the entering and leaving measurement locations may be moved to locations 6 inches from the respective service valves.

3.5.2.2 Mass Flow Meter Location

When using the DX Dual Instrumentation test method of AHRI 1250–2020, applicable for unit coolers, dedicated condensing units, and matched pairs, the second mass flow meter may be installed in the suction line as shown in Figure C1 of AHRI 1250–2020.

3.5.2.3 Subcooling at Refrigerant Mass Flow Meter

In section C3.4.5 of Appendix C of AHRI 1250–2020, when verifying subcooling at the mass flow meters, only the sight glass and a temperature sensor located on the tube surface under the insulation are required. Subcooling shall be verified to be within the 3 °F requirement downstream of flow meters located in the same chamber as a condensing unit under test and upstream of flow meters located in the same chamber as a unit cooler under test, rather than always downstream as indicated in AHRI 1250–2009, section C3.4.5. If the subcooling is less than 3 °F when testing a unit cooler, dedicated condensing unit, or matched pair (not a single-packaged system), cool the line between the condensing unit outlet and this location to achieve the required subcooling. When providing such cooling while testing a matched pair (a) set up the line-cooling system and also set up apparatus to heat the liquid line between the mass flow meters and the unit cooler, (b) when the system has achieved steady state without activation of the heating and cooling systems, measure the liquid temperature entering the expansion valve for a period of at least 30 minutes, (c) activate the cooling system to provide the required subcooling at the mass flow meters, (d) if necessary, apply heat such that the temperature entering the expansion valve is within 0.5 °F of the temperature measured during step (b), and (e) proceed with measurements once condition (d) has been verified.

3.5.2.4 Installation Instructions

Manufacturer installation instructions or installation instructions described in this section refer to the instructions that come packaged with or appear on the labels applied to the unit. This does not include online manuals.

Installation Instruction Hierarchy: If a given installation instruction provided on the label(s) applied to the unit conflicts with the installation instructions that are shipped with the unit, the label takes precedence. For testing of matched pairs, the installation instructions for the dedicated condensing unit shall take precedence. Setup shall be in accordance with the field installation instructions (laboratory installation instructions shall not be used). Achieving test conditions shall always take precedence over installation instructions.

3.5.2.5. Refrigerant Charging and Adjustment of Superheat and Subcooling.

All dedicated condensing systems (dedicated condensing units tested alone, matched pairs, and single packaged dedicated systems) that use flooding of the condenser for head pressure control during low-ambient-temperature conditions shall be charged, and superheat and/or subcooling shall be set, at Refrigeration C test conditions unless otherwise specified in the installation instructions.

If after being charged at Refrigeration C condition the unit under test does not operate at the Refrigeration A condition due to high pressure cut out, refrigerant shall be removed in increments of 4 ounces or 5 percent of the test unit's receiver capacity, whichever quantity is larger, until the unit operates at the Refrigeration A condition. All tests shall be run at this final refrigerant charge. If less than 0 °F of subcooling is measured for the refrigerant leaving the condensing unit when testing at B or C condition, calculate the refrigerant-enthalpy-based capacity (*i.e.*, when using the DX dual instrumentation, the DX calibrated box, or single-packaged unit refrigerant enthalpy method) assuming that the refrigerant is at saturated liquid conditions at the condensing unit exit.

All dedicated condensing systems that do not use a flooded condenser design shall be charged at Refrigeration A test conditions unless otherwise specified in the installation instructions.

If the installation instructions give a specified range for superheat, sub-cooling, or refrigerant pressure, the average of the range shall be used as the refrigerant charging parameter target and the test condition tolerance shall be ±50 percent of the range. Perform charging of near-azeotropic and zeotropic refrigerants only with refrigerant in the liquid state. Once the correct refrigerant charge is determined, all tests shall run until completion without further modification.

3.5.2.5.1. When charging or adjusting superheat/subcooling, use all pertinent instructions contained in the installation instructions to achieve charging parameters within the tolerances. However, in the event of conflicting charging information between installation instructions, follow the installation instruction hierarchy listed in section 3.5.2.4. Conflicting information is defined as multiple conditions given for charge adjustment where all conditions specified cannot be met. In the event of conflicting information within the same set of charging instructions (*e.g.,* the installation instructions shipped with the dedicated condensing unit), follow the hierarchy in Table 19 for priority. Unless the installation instructions specify a different charging tolerance, the tolerances identified in table 19 of this appendix shall be used.

TABLE 19—TEST CONDITION TOLERANCES AND HIERARCHY FOR REFRIGERANT CHARGING AND SETTING OF REFRIGERANT CONDITIONS

Priority	Fixed orifice		Expansion Valve	
	Parameter with installation instruction target	Tolerance	Parameter with installation instruction target	Tolerance
1	Superheat	±2.0 °F	Subcooling	10% of the Target Value; No less than ±0.5 °F, No more than ±2.0 °F
2	High Side Pressure or Saturation Temperature*.	±4.0 psi or ±1.0 °F	High Side Pressure or Saturation Temperature*.	±4.0 psi or ±1.0 °F
3	Low Side Pressure or Saturation Temperature*.	±2.0 psi or ±0.8 °F	Superheat	±2.0 °F
4	Low Side Temperature	±2.0 °F	Low Side Pressure or Saturation Temperature*.	±2.0 psi or ±0.8 °F
5	High Side Temperature	±2.0 °F	Approach Temperature	±1.0 °F
6	Charge Weight	±2.0 oz	Charge Weight	0.5% or 1.0 oz, whichever is greater

*Saturation temperature can refer to either bubble or dew point calculated based on a measured pressure, or a coil temperature measurement, as specified by the installation instructions.

3.5.2.5.2. *Dedicated Condensing Unit.* If the Dedicated Condensing Unit includes a receiver and the subcooling target leaving the condensing unit provided in installation instructions cannot be met without fully filling the receiver, the subcooling target shall be ignored. Likewise, if the Dedicated Condensing unit does not include a receiver and the subcooling target leaving the condensing unit cannot be met without the unit cycling off on high pressure, the subcooling target can be ignored. Also, if no instructions for charging or for setting subcooling leaving the condensing unit are provided in the installation instructions, the refrigeration system shall be set up with a charge quantity and/or exit subcooling such that the unit operates during testing without shutdown (*e.g.,* on a high-pressure switch) and operation of the unit is otherwise consistent with the requirements of the test procedure of this appendix and the installation instructions.

3.5.2.5.3. *Unit Cooler.* Use the shipped expansion device for testing. Otherwise, use the expansion device specified in the installation instructions. If the installation instructions specify multiple options for the expansion device, any specified expansion device may be used. The supplied expansion device shall be adjusted until either the superheat target is met, or the device reaches the end of its adjustable range. In the event the device reaches the end of its adjustable range and the super heat target is not met, test with the adjustment at the end of its range providing the closest match to the superheat target, and the test condition tolerance for super heat target shall be ignored. The measured superheat is not subject to a test operating tolerance. However, if the evaporator exit condition is used to determine capacity using the DX dual instrumentation method or the refrigerant enthalpy method, individual superheat value measurements may not be equal to or less than zero. If this occurs, or if the operating tolerances of measurements affected by expansion device fluctuation are exceeded, the expansion device shall be replaced, operated at an average superheat value higher than the target, or both, in order to avoid individual superheat value measurements less than zero and/or to meet the required operating tolerances.

3.5.2.5.4. *Single-Packaged Unit.* Unless otherwise directed by the installation instructions, install one or more refrigerant line pressure gauges during the setup of the unit, located depending on the parameters used to verify or set charge, as described in this section:

3.5.2.5.4.1. Install a pressure gauge in the liquid line if charging is on the basis of subcooling, or high side pressure or corresponding saturation or dew point temperature.

3.5.2.5.4.2. Install a pressure gauge in the suction line if charging is on the basis of superheat, or low side pressure or corresponding saturation or dew point temperature. Install this gauge as close to the evaporator as allowable by the installation instructions and the physical constraints of the unit. Use methods for installing pressure gauge(s) at the required location(s) as indicated in the installation instructions if specified.

3.5.2.5.4.3. If the installation instructions indicate that refrigerant line pressure gauges should not be installed and the unit fails to operate due to high-pressure or low-pressure compressor cut off, then a charging port shall be installed, and the unit shall be evacuated of refrigerant and charged to the nameplate charge.

3.5.2.6 Ducted Units

For systems with ducted evaporator air, or that can be installed with or without ducted evaporator air: Connect ductwork on both the inlet and outlet connections and determine external static pressure (ESP) as described in sections 6.4 and 6.5 of ANSI/ASHRAE 37. Use pressure measurement instrumentation as described in section 5.3.2 of ANSI/ASHRAE 37. Test at the fan speed specified in the installation instructions—if there is more than one fan speed setting and the installation instructions do not specify which speed to use, test at the highest speed. Conduct tests with the ESP equal to 50% of the maximum ESP allowed in the installation instructions, within a tolerance of −0.00/+0.05 inches of water column. If the installation instructions do not provide the maximum ESP, the ESP shall be set for testing such that the air volume rate is ⅔ of the air volume rate measured when the ESP is 0.00 inches of water column within a tolerance of −0.00/+0.05 inches of water column.

If testing using either the indoor or outdoor air enthalpy method to measure the air volume rate, adjust the airflow measurement apparatus fan to set the external static pressure—otherwise, set the external static pressure by symmetrically restricting the outlet of the test duct. In case of conflict, these requirements for setting airflow take precedence over airflow values specified in manufacturer installation instructions or product literature.

3.5.2.7. Two-Speed or Multiple-Speed Evaporator Fans. Two-Speed or Multiple-Speed evaporator fans shall be considered to meet the qualifying control requirements of section C4.2 of Appendix C of AHRI 1250–2020 for measuring off-cycle fan energy if they use a fan speed no less than 50% of the speed used in the maximum capacity tests.

3.5.2.8. Defrost

Use section C10.2.1 of Appendix C of AHRI 1250–2020 for defrost testing. The Test Room Conditioning Equipment requirement of section C10.2.1.1 of Appendix C of AHRI 1250–2020 does not apply.

3.5.2.8.1 Adaptive Defrost

When testing to certify compliance to the energy conservation standards, use N_{DF} = 4, as instructed in section C10.2.1.7 or C10.2.2.1 of AHRI 1250–2020. When determining the represented value of the calculated benefit for the inclusion of adaptive defrost, use N_{DF} = 2.5, as instructed in section C10.2.1.7 or C10.2.2.1 of AHRI 1250–2020.

3.5.2.8.2 Hot Gas Defrost

When testing to certify compliance to the energy conservation standards, remove the hot gas defrost mechanical components and disconnect all such components from electrical power. Test the units as if they are electric defrost units, but do not conduct the defrost tests described in section C10.2.1 of AHRI 1250–2020. Use the defrost heat and power consumption values as described in section C10.2.2 of AHRI 1250–2020 for the AWEF2 calculations.

3.5.2.9 Dedicated condensing units that are not matched for testing and are not single-packaged dedicated systems.

The temperature measurement requirements of sections C3.1.3 and C4.1.3.1 appendix C of AHRI 1250–2020 shall apply only to the condensing unit exit rather than to the unit cooler inlet and outlet, and they shall be applied for two measurements when using the DX Dual Instrumentation test method.

3.5.2.10. Single-packaged dedicated systems

Use the test method in section C9 of appendix C of AHRI 1250–2020 (including the applicable provisions of ASHRAE 16–2016, ASHRAE 23.1–2010, ASHRAE 37–2009, and ASHRAE 41.6–2014, as referenced in section C9.1 of AHRI 1250–2020) as the method of test for single-packaged dedicated systems, with modifications as described in this section. Use two test methods listed in table 20 of this appendix to calculate the net capacity and power consumption. The test method listed with a lower ''Hierarchy Number'' and that has ''Primary'' as an allowable use in table 20 of this appendix shall be considered the primary measurement and used as the net capacity.

TABLE 20—SINGLE-PACKAGED METHODS OF TEST AND HIERARCHY

Hierarchy number	Method of test	Test hierarchy
1	Balanced Ambient Indoor Calorimeter	Primary.
2	Indoor Air Enthalpy	Primary or Secondary.
3	Indoor Room Calorimeter	Primary or Secondary.
4	Calibrated Box	Primary or Secondary.
5	Balanced Ambient Outdoor Calorimeter	Secondary.
6	Outdoor Air Enthalpy	Secondary.
7	Outdoor Room Calorimeter	Secondary.
8	Single-Packaged Refrigerant Enthalpy [1]	Secondary.

TABLE 20—SINGLE-PACKAGED METHODS OF TEST AND HIERARCHY—Continued

Hierarchy number	Method of test	Test hierarchy
9	Compressor Calibration	Secondary.

Notes:
[1] See description of the single-packaged refrigerant enthalpy method in section 3.5.2.10.1 of this appendix.

3.5.2.10.1 Single-Packaged Refrigerant Enthalpy Method

The single-packaged refrigerant enthalpy method shall follow the test procedure of the DX Calibrated Box method in AHRI 1250–2020, appendix C, section C8 for refrigerant-side measurements with the following modifications:

3.5.2.10.1.1 Air-side measurements shall follow the requirements of the primary single-packaged method listed in table 20 of this appendix. The air-side measurements and refrigerant-side measurements shall be collected over the same intervals.

3.5.2.10.1.2 A preliminary test at Test Rating Condition A is required using the primary method prior to any modification necessary to install the refrigerant-side measuring instruments. Install surface mount temperature sensors on the evaporator and condenser coils at locations not affected by liquid subcooling or vapor superheat (i.e., near the midpoint of the coil at a return bend), entering and leaving the compressor, and entering the expansion device. These temperature sensors shall be included in the regularly recorded data.

3.5.2.10.1.3 After the preliminary test is completed, the refrigerant shall be removed from the equipment and the refrigerant-side measuring instruments shall be installed. The equipment shall then be evacuated and recharged with refrigerant. Once the equipment is operating at Test Condition A, the refrigerant charge shall be adjusted until, as compared to the average values from the preliminary test, the following conditions are achieved:

(a) Each on-coil temperature sensor indicates a reading that is within ±1.0 °F of the measurement in the initial test,

(b) The temperatures of the refrigerant entering and leaving the compressor are within ±4 °F, and

(c) The refrigerant temperature entering the expansion device is within ±1 °F.

3.5.2.10.1.4 Once these conditions have been achieved over an interval of at least 10 minutes, refrigerant charging equipment shall be removed and the official tests shall be conducted.

3.5.2.10.1.5 The lengths of liquid line to be added shall be 5 feet maximum, not including the requisite flow meter. This maximum length applies to each circuit separately.

3.5.2.10.1.6 Use section C9.2 of appendix C of AHRI 1250–2020 for allowable refrigeration capacity heat balance. Calculate the single-packaged refrigerant enthalpy (secondary) method test net capacity $\dot{Q}_{net,secondary}$ as follows: $\dot{Q}_{net,secondary} = \dot{Q}_{ref\text{-}3.412} \cdot \dot{E}F_{comp,on} - \dot{Q}_{sploss}$

Where:

$\dot{Q}_{ref}$ is the gross capacity;

$\dot{E}F_{comp,on}$ is the evaporator compartment on-cycle power, including evaporator fan power; and

$\dot{Q}_{sploss}$ is a duct loss calculation applied to the evaporator compartment of the single-packaged systems, which is calculated as indicated in the following equation.

$$\dot{Q}_{sploss} = UA_{cond} \times (T_{evapside} - T_{condside}) + UA_{amb} \times (T_{evapside} - T_{amb})$$

Where:

UA_{cond} and UA_{amb} are, for the condenser/evaporator partition and the evaporator compartment walls exposed to ambient air, respectively, the product of the overall heat transfer coefficient and surface area of the unit as manufactured, *i.e.* without external insulation that might have been added during the test. The areas shall be calculated based on measurements, and the thermal resistance values shall be based on insulation thickness and insulation material;

$T_{evapside}$ is the air temperature in the evaporator compartment—the measured evaporator air inlet temperature may be used;

$T_{condside}$ is the air temperature in the condenser compartment—the measured chamber ambient temperature may be used, or a measurement may be made using a temperature sensor placed inside the condenser box at least 6 inches distant from any part of the refrigeration system; and

T_{amb} is the air temperature outside the single-packaged system.

3.5.2.10.1.7 For multi-circuit single-packaged systems utilizing the single-packaged refrigerant enthalpy method, apply the test method separately for each circuit and sum the separately-calculated refrigerant-side gross refrigeration capacities.

3.5.2.10.2 Calibrated Box Test Procedure

3.5.2.10.2.1 Measurements. Refer to section C3 of AHRI 1250–2020 (including the applicable provisions of ASHRAE 41.1–2013, ASHRAE 41.3–2014, and ASHRAE 41.10–2013, as referenced in section C3 of AHRI 1250–2020) for requirements of air-side and refrigerant-side measurements.

3.5.2.10.2.2 Apparatus setup for Calibrated Box Calibration and Test. Refer to section C5 of AHRI 1250–2020 and section C8 of AHRI 1250–2020 for specific test setup.

3.5.2.10.2.3 The calibrated box shall be installed in a temperature-controlled enclosure in which the temperature can be maintained at a constant level. When using the calibrated box method for Single-Packaged Dedicated Systems, the enclosure air temperature shall be maintained such that the condenser air entering conditions are as specified for the test.

3.5.2.10.2. The temperature-controlled enclosure shall be of a size that will provide clearances of not less than 18 in at all sides, top and bottom, except that clearance of any one surface may be reduced to not less than 5.5 inches.

3.5.2.10.2.5 The heat leakage of the calibrated box shall be noted in the test report.

3.5.2.10.2.6 Refrigerant lines within the calibrated box shall be well insulated to avoid appreciable heat loss or gain.

3.5.2.10.2.7 Instruments for measuring the temperature around the outside of the calibrated box to represent the enclosure temperature T_{en} shall be located at the center of each wall, ceiling, and floor. Exception: in the case where a clearance around the outside of the calibrated box, as indicated in section 3.5.2.10.2.4 of this appendix, is reduced to less than 18 inches, the number of temperature measuring devices on the outside of that surface shall be increased to six, which shall be treated as a single temperature to be averaged with the temperature of each of the other five surfaces. The six temperature measuring instruments shall be located at the center of six rectangular sections of equal area. If the refrigeration system is mounted at the location that would cover the center of the face on which it is mounted, up to four temperature measurements shall be used on that face to represent its temperature. Each sensor shall be aligned with the center of the face's nearest outer edge and centered on the distance between that edge and the single-packaged unit (this is illustrated in figure C5 of this section when using surface temperature sensors), and they shall be treated as a single temperature to be averaged with the temperature of each of the other five surfaces. However, any of these sensors shall be omitted if either (a) the distance between the outer edge and the single-packaged unit is less than one foot or (b) if the sensor location would be within two feet of any of the foot square surfaces discussed in section 3.5.2.10.2.8 of this appendix representing a warm discharge air impingement area. In this case, the remaining sensors shall be used to represent the average temperature for the surface.

3.5.2.10.2.8 One of the following two approaches shall be used for the box external temperature measurement. Box calibration and system capacity measurement shall both be done using the same one of these approaches. 1: Air temperature sensors. Each temperature sensor shall be at a distance of 6 inches from the calibrated box. If the clearance from a surface of the box (allowed for one surface only) is less than 12 inches, the temperature measuring instruments shall be located midway between the outer wall of the calibrated box and the adjacent surface. 2: Surface temperature sensors. Surface temperature sensors shall be mounted on the calibrated box surfaces to represent the enclosure temperature, T_{en}.

3.5.2.10.2.9 Additional surface temperature sensors may be used to measure external hot spots during refrigeration system testing. If this is done, two temperature sensors shall be used to measure the average temperature of the calibrated box surface covered by the condensing section—they shall be located centered on equal-area rectangles comprising the covered calibrated box surface whose common sides span the short dimension of this surface. Additional surface temperature sensors may be used to measure box surfaces on which warm condenser discharge air impinges. A pattern of square surfaces measuring one foot square shall be mapped out to represent the hot spot upon which the warm condenser air impinges. One temperature sensor shall be used to measure surface temperature at the center of each square (see figure C5 of this section). A drawing showing this pattern and identifying the surface temperature sensors shall be provided in the test report. The average surface temperature of the overall calibrated box outer surface during testing shall be calculated as follows.

$$T_{en} = \frac{\sum_{i=1}^{6} A_i T_i + \sum_{j=1}^{2} A_j \left(T'_j - T_1\right) + \sum_{k=1}^{n} A_k (T''_k - T_1)}{\sum_{i=1}^{6} A_i}$$

Where:

A_i is the surface area of the ith of the six calibrated box surfaces;

T_i is the average temperature measured for the ith surface;

A_j is half of the surface area of the calibrated box covered by the condensing section;

T'_j is the jth of the two temperature measurements underneath the condensing section;

T_I is the average temperature of the four or fewer measurements representing the temperature of the face on which the single-packaged system is mounted, prior to adjustments associated with hot spots based on measurements T_j and/or T_k;

A_k is the area of the kth of n 1-square-foot surfaces used to measure the condenser discharge impingement area hot spot; and,

T''_k is the kth of the n temperature measurements of the condenser discharge impingement area hot spot.

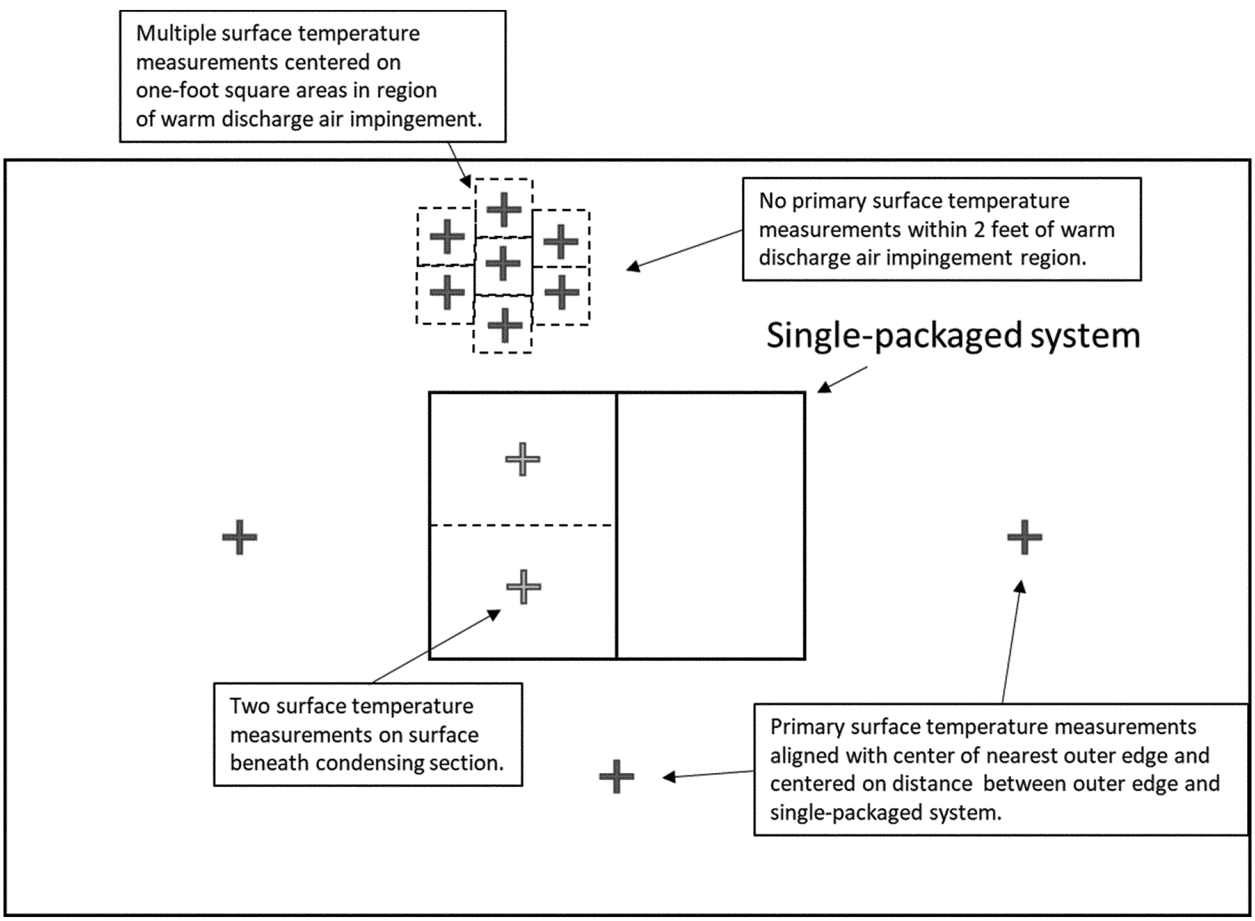

Figure C5: Illustration of Layout of Surface Temperature Sensors on Face of Calibrated Box on which Single-Packaged Dedicated System is Mounted when Using Section 3.5.2.10.2.7 of Appendix C to this Part.3.5.2.10.2.10 Heating means inside the calibrated box shall be shielded or installed in a manner to avoid radiation to the Single-Packaged Dedicated System, the temperature measuring instruments, and to the walls of the box. The heating means shall be constructed to avoid stratification of temperature, and suitable means shall be provided for distributing the temperature uniformly.

3.5.2.10.2.11 The average air dry-bulb temperature in the calibrated box during Single-Packaged Dedicated System tests and calibrated box heat leakage tests shall be the average of eight temperatures measured at the corners of the box at a distance of 2 inches to 4 inches from the walls. The instruments shall be shielded from any cold or warm surfaces except that they shall not be shielded from the adjacent walls of the box. The Single-Packaged Dedicated System under test shall be mounted such that the temperature instruments are not in the direct air stream from the discharge of the Single-Packaged Dedicated System.

3.5.2.10.2.12 Calibration of the Calibrated Box. Calibration of the Calibrated Box shall occur prior to installation of the Single-Packaged Dedicated System. This shall be done either (a) prior to cutting the opening needed to install the Single-Packaged Dedicated System, or (b) with an insulating panel with the same thickness and thermal resistance as the box wall installed in the opening intended for the Single-Packaged Dedicated System installation. Care shall be taken to avoid thermal shorts in the location of the opening either during calibration or during subsequent installation of the Single-Packaged Dedicated System. A calibration test shall be made for air movements comparable to those expected for Single-Packaged Dedicated System capacity measurement, *i.e.,* with air volume flow rate within 10 percent of the air volume flow rate of the Single-Packaged Dedicated System evaporator.

3.5.2.10.2.13 The heat input shall be adjusted to maintain an average box temperature not less than 25.0 °F above the test enclosure temperature.

3.5.2.10.2.14 The average dry-bulb temperature inside the calibrated box shall not vary more than 1.0 °F over the course of the calibration test.

3.5.2.10.2.15 A calibration test shall be the average of 11 consecutive hourly readings when the box has reached a steady-state temperature condition.

3.5.2.10.2.16 The box temperature shall be the average of all readings after a steady-state temperature condition has been reached.

3.5.2.10.2.17 The calibrated box has reached a steady-state temperature condition when: The average box temperature is not less than 25 °F above the test enclosure temperature. Temperature variations do not exceed 5.0 °F between temperature measuring stations. Temperatures do not vary by more than 2 °F at any one temperature-measuring station.

3.5.2.10.2.18 Data to be Measured and Recorded. Refer to Table C5 in section C6.2 of AHRI 1250–2020 for the required data that need to measured and recorded.

3.5.2.10.2.19 Refrigeration Capacity Calculation.

The heat leakage coefficient of the calibrated box is calculated by

$$K_{cb} = \frac{3.412 \times \dot{E}_c}{T_{en} - T_{cb}}$$

For each Dry Rating Condition, calculate the Net Capacity:

$\dot{q}_{ss} = K_{cb}\,(T_{en} - T_{cb}) + 3.412 \times \dot{E}_c$

3.5.2.10.3 Detachable single-packaged systems shall be tested as single-packaged dedicated refrigeration systems.

3.5.2.11 *Variable-Capacity and Multiple-Capacity Dedicated Condensing Refrigeration Systems*

3.5.2.11.1 Manufacturer-Provided Equipment Overrides

Where needed, the manufacturer must provide a means for overriding the controls of the test unit so that the compressor(s) operates at the specified speed or capacity and the indoor blower operates at the speed consistent with the compressor operating level as would occur without override.

3.5.2.11.2 Compressor Operating Levels

For variable-capacity and multiple-capacity compressor systems, the minimum capacity for testing shall be the minimum capacity that the system control would operate the compressor in normal operation. Likewise, the maximum capacity for testing shall be the maximum capacity that the system control would operate the compressor in normal operation. For variable-speed compressor systems, the intermediate speed for testing shall be the average of the minimum and maximum speeds. For digital compressor systems, the intermediate duty cycle shall be the average of the minimum and maximum duty cycles. For multiple-capacity compressor systems with three capacity levels, the intermediate operating level for testing shall be the middle capacity level. For multiple-capacity compressor systems with more than three capacity levels, the intermediate operating level for testing shall be the level whose displacement ratio is closest to the average of the maximum and minimum displacement ratios.

3.5.2.11.3 Refrigeration Systems with Digital Compressor(s)

Use the test methods described in section 3.5.2.10.1 of this appendix as the secondary method of test for refrigeration systems with digital compressor(s) with modifications as described in this section. The Test Operating tolerance for refrigerant mass flow rate and suction pressure in Table 2 of AHRI 1250–2020 shall be ignored. Temperature and pressure measurements used to calculate shall be recorded at a frequency of once per second or faster and based on average values measured over the 30-minute test period.

3.5.2.11.3.1 For Matched pair (not including single-packaged systems) and Dedicated Condensing Unit refrigeration systems, the preliminary test in sections 3.5.2.10.1.2 and 3.5.2.10.1.3 of this appendix is not required. The liquid line and suction line shall be 25 feet ± 3 inches, not including the requisite flow meters. Also, the term in the equation to calculate net capacity shall be set equal to zero.

3.5.2.11.3.2 For Dedicated Condensing Unit refrigeration systems, the primary capacity measurement method shall be balanced ambient outdoor calorimeter, outdoor air enthalpy, or outdoor room calorimeter.

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