DEPARTMENT OF ENERGY

10 CFR Parts 429 and 430

[EERE–2021–BT–TP–0030]

RIN 1904–AF29

Energy Conservation Program: Test Procedure for Central Air Conditioners and Heat Pumps

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 central air conditioners and heat pumps that will be required for certification of compliance with applicable energy conservation standards starting January 1, 2023, to address a limited number of specific issues, and making minor corrections to the current test procedures that are required for certification of compliance with applicable energy conservation standards prior to January 1, 2023. This rulemaking does not satisfy the 7-year lookback requirement prescribed by the Energy Policy and Conservation Act (''EPCA'').

DATES: The effective date of this rule is November 25, 2022. The final rule changes will be mandatory for product testing starting April 24, 2023. The incorporation by reference of a certain publication listed in the rule was approved by the Director of the Federal Register on February 6, 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-2021-BT-TP-0030* 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.*

FOR FURTHER INFORMATION CONTACT:

Mr. Lucas Adin, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Office, EE–5B, 1000 Independence Avenue SW, Washington, DC 20585–0121. Telephone: (202) 287–5904. Email: *ApplianceStandardsQuestions@ee.doe.gov.*

Mr. Pete Cochran, U.S. Department of Energy, Office of the General Counsel, GC–33, 1000 Independence Avenue SW, Washington, DC 20585–0121. Telephone: (202) 586–9496. Email: *peter.cochran@hq.doe.gov.*

SUPPLEMENTARY INFORMATION: DOE maintains the following previously approved incorporation by reference in part 430:

ANSI/ASHRAE Standard 37–2009, Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment, ANSI approved June 25, 2009;

Copies of ANSI/ASHRAE 37–2009, can be purchased from *www.ashrae.org/resources--publications.*

For a further discussion of this standard, see section IV.M of this document.

Table of Contents

I. Authority and Background

Central air conditioners (''CACs'') and central air conditioning heat pumps (''HPs'') (collectively, ''CAC/HPs'') are included in the list of ''covered products'' for which DOE is authorized to establish and amend energy conservation standards and test procedures (42 U.S.C. 6292(a)(3)) DOE's energy conservation standards and test procedures for CAC/HPs are currently prescribed at title 10 of the Code of Federal Regulations (''CFR''), part 430, § 430.32(c), and 10 CFR part 430, subpart B, appendices M (''appendix M'') and M1 (''appendix M1''). The following sections discuss DOE's authority to establish test procedures for CAC/HPs and relevant background information regarding DOE's consideration of test procedures for this product.

A. Authority

The Energy Policy and Conservation Act, 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 B [2] of EPCA established the Energy Conservation Program for Consumer Products Other Than Automobiles, which sets forth a variety of provisions designed to improve energy efficiency. These

[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).

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

products include CAC/HPs,[3] the subject of this document. (42 U.S.C. 6292(a)(3))

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 specifically include definitions (42 U.S.C. 6291), test procedures (42 U.S.C. 6293), labeling provisions (42 U.S.C. 6294), energy conservation standards (42 U.S.C. 6295), and the authority to require information and reports from manufacturers (42 U.S.C. 6296).

The Federal testing requirements consist of test procedures that manufacturers of covered products must use as the basis for: (1) certifying to DOE that their products comply with the applicable energy conservation standards adopted pursuant to EPCA (42 U.S.C. 6295(s)), and (2) making representations about the efficiency of those consumer products (42 U.S.C. 6293(c)). Similarly, DOE must use these test procedures to determine whether the products comply with relevant standards promulgated under EPCA. (42 U.S.C. 6295(s))

Federal energy efficiency requirements for covered products established under EPCA generally supersede State laws and regulations concerning energy conservation testing, labeling, and standards. (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. 6297(d))

Under 42 U.S.C. 6293, EPCA sets forth the criteria and procedures DOE must follow when prescribing or amending test procedures for covered products. EPCA requires that any test procedures prescribed or amended under this section be reasonably designed to produce test results which measure energy efficiency, energy use or estimated annual operating cost of a covered product during a representative average use cycle or period of use and not be unduly burdensome to conduct. (42 U.S.C. 6293(b)(3))

If the Secretary determines, on her own behalf or in response to a petition by any interested person, that a test procedure should be prescribed or amended, the Secretary shall promptly publish in the **Federal Register** proposed test procedures and afford interested persons an opportunity to present oral and written data, views, and arguments with respect to such procedures. (42 U.S.C. 6293(b)(2)) The comment period on a proposed rule to amend a test procedure shall be at least 60 days and may not exceed 270 days. *Id.* In prescribing or amending a test procedure, the Secretary shall take into account such information as the Secretary determines relevant to such procedure, including technological developments relating to energy use or energy efficiency of the type (or class) of covered products involved. *Id.*

DOE's regulations at 10 CFR 430.27 provide that any interested person may seek a waiver from the test procedure requirements if certain conditions are met. A waiver requires manufacturers to use an alternate test procedure in situations in which the DOE test procedure cannot be used to test the product or equipment, or use of the DOE test procedure would generate unrepresentative results. 10 CFR 430.27(a)(1). DOE's regulations at 10 CFR 430.27(l) require that as soon as practicable after the granting of any waiver, DOE will publish in the **Federal Register** a notice of proposed rulemaking (''NOPR'') to amend its regulations so as to eliminate any need for the continuation of such waiver. As soon thereafter as practicable, DOE will publish in the **Federal Register** a final rule. 10 CFR 430.27(l).

DOE is publishing this final rule for the limited purpose of addressing its obligations under the waiver process regulations at 10 CFR 430.27 and to incorporate additional corrections and improvements.

B. Background

As discussed, DOE's existing test procedures for CAC/HPs appear at appendices M and M1 (both titled ''Uniform Test Method for Measuring the Energy Consumption of Central Air Conditioners and Heat Pumps'').

On January 5, 2017, DOE published a final rule regarding the Federal test procedure (''TP'') for CAC/HPs. 82 FR 1426 (''January 2017 CAC TP Final Rule''). The January 2017 CAC TP Final Rule amended appendix M and established appendix M1, use of which is required beginning January 1, 2023, for any representations, including compliance certifications, made with respect to the energy use or efficiency of CAC/HPs. *Id.* Appendix M provides for the measurement of the cooling and heating performance of CAC/HPs using the seasonal energy efficiency ratio (''SEER'') metric and heating seasonal performance factor (''HSPF'') metric, respectively. Appendix M1 specifies a revised SEER metric (*i.e.,* SEER2) and a revised HSPF metric (''HSPF2'').

Since the publication of the January 2017 CAC TP Final Rule, DOE has granted various petitions for waiver and interim waiver from certain provisions of appendix M and/or M1.[4] Additionally, DOE is aware of testing conducted per both appendices M (via Compliance, Certification and Enforcement (''CCE'') testing and other verification programs) and M1 (via investigative testing to support development of the 2023 energy efficiency standards). Through these efforts, DOE has been made aware of several items for which test procedure amendments are warranted in order to improve clarity or to reduce burden. In each of these cases, DOE has determined that the amendments would have no or negligible impact on ratings and thus do not require amendment of the energy conservation standards per 42 U.S.C. 6293(e). These amendments are described in section III.D of this final rule. Further, on May 8, 2019, AHRI submitted a comment responding to the notice of proposed rulemaking to revise and adopt procedures, interpretations, and policies for consideration of new or revised energy conservation standards (2020 Process Rule NOPR, 84 FR 3910, Feb. 13, 2019) The comment included as Exhibit 2 a ''List of Errors Found in both appendix M and appendix M1'' (''AHRI Exhibit 2,'' EERE–2017–BT–STD–0062–0117 at pp. 23–24). Many of the errors pointed out by AHRI regard typographical errors in appendices M and M1. These issues are addressed in various places of this final rule, including footnotes describing amendments to correct section references, nomenclature, etc. that did not warrant standalone discussion sections.

On March 24, 2022, DOE published a notice of proposed rulemaking regarding the Federal test procedure for CAC/HPs. 87 FR 16830 (''March 2022 CAC TP NOPR''). The March 2022 CAC TP NOPR proposed changes to improve the functionality of appendix M1 to address the issues identified in test procedure waivers, improve representativeness and correct typographical issues raised by commenters. *Id.* DOE held a public meeting related to the NOPR on April

[3] This rulemaking uses the term ''CAC/HP'' to refer specifically to central air conditioners (which include heat pumps) as defined by EPCA. (42 U.S.C. 6291(21))

[4] Waivers granted to GD Midea Heating and Ventilating Equipment Co., Ltd. (83 FR 56065), Johnson Controls, Inc. (83 FR 12735 and 84 FR 52489), and TCL Air Conditioner (Zhongshan) Co., Ltd. (84 FR 11941), interim waivers granted to National Comfort Products, Inc. (83 FR 24754), Aerosys Inc. (83 FR 24762), LG Electronics U.S.A., Inc. (85 FR 40272), and Goodman Manufacturing Company, L.P. (86 FR 40534).

18, 2022 (hereafter the ''2022 CAC TP NOPR Public Meeting'').

DOE received comments in response to the March 2022 CAC TP NOPR from the interested parties listed in Table I–1.

TABLE I–1—LIST OF COMMENTERS WITH WRITTEN SUBMISSIONS IN RESPONSE TO THE MARCH 2022 CAC TP NOPR

Commenter(s)	Reference in this final rule	Comment No. in the docket	Commenter type
Air-Conditioning, Heating, & Refrigeration Institute	AHRI	25	Trade Association.
Appliance Standards Awareness Project (ASAP), American Council for an Energy-Efficient Economy (ACEEE).	Joint Advocates	18	Efficiency organizations.
Pacific Gas and Electric Company, San Diego Gas and Electric, Southern California Edison—collectively California Investor Owned Utilities.	CA IOUs	20	Efficiency organization.
Carrier Global Corporation	Carrier	15	Manufacturer.
Daikin Comfort Technologies Manufacturing Company, L.P	Daikin	24	Manufacturer.
Emerson Climate Technologies, Inc	Emerson	14	Manufacturer.
Leaders Building of America	LBA	3	Trade Association.
Lennox International Inc	Lennox	19	Manufacturer.
National Comfort Products, Inc	NCP	16	Manufacturer.
Northwest Energy Efficiency Alliance	NEEA	23	Alliance of Efficiency Organizations.
Nortek Global HVAC (NGH)	Nortek	13	Manufacturer.
New York State Energy Research and Development Authority	NYSERDA	17	Efficiency organization.
Rheem Sales Company	Rheem	21	Manufacturer.
Samsung HVAC	Samsung	22	Manufacturer.
Trane Technologies	Trane	10	Manufacturer.

A parenthetical reference at the end of a comment quotation or paraphrase provides the location of the item in the public record.[5]

The CA IOUs, Carrier, Daikin, Emerson, Joint Advocates, Lennox, NEEA, Nortek, NYSERDA, and Rheem commented that they largely supported DOE's efforts in amending the existing test procedure in appendix M1. (CA IOUs, No. 20 at p. 3, Carrier, No. 20 at p. 1, Daikin, No. 24 at p. 1, Emerson, No. 14 at p. 1, Joint Advocates, No. 18 at p. 1, Lennox, No. 19 at p. 1, NEEA, No. 23 at p. 1, Nortek, No. 13 at p. 1, NYSERDA, No. 17 at p. 1, Rheem, No. 21 at p. 1) Emerson requested that DOE publish the revised test procedure as soon as reasonably possible, so that manufacturers will have time to comply with the compliance date of January 1, 2023. (Emerson, No. 14 at p. 3) Nortek also requested that DOE publish the final rule soon, so that they can have certainty with the revised test procedure, in order to serve the CAC/HP market efficiently. (Nortek, No. 13 at p. 3)

II. Synopsis of the Final Rule

In this final rule, DOE is updating appendix M1 to subpart B of part 430, ''Uniform Test Method for Measuring the Energy Consumption of Central Air Conditioners and Heat Pumps.'' DOE has identified certain provisions of appendix M1 that may benefit from additional detail and/or instruction. The updates are as follows:

(1) Adjusting the default fan power for two-stage coil-only systems when testing at low stage with reduced air volume rate to be more representative of fan input power trends as air volume rate reduces;

(2) Defining ''variable-speed communicating coil-only central air conditioner or heat pump'' and ''variable-speed non-communicating coil-only central air conditioner or heat pump'' and establishing procedures specific for testing such systems;

(3) Allowing the adjustment of the air volume rate as a function of outdoor air temperature during testing for blower coil systems with either multiple-speed or variable-speed indoor fans and with a control system capable of adjusting air volume rate as function of outdoor air temperature;

(4) Adjusting the maximum wet bulb temperature from 3 °F to 4 °F for the H4 test condition;

(5) Specifying in section 2(B) of appendix M1, that the instructions presented in the labels attached to the unit take precedence over the installation manuals printed and shipped with a product;

(6) Specifying in sections 3.1.4.1.1, 3.1.4.1.2, and 3.1.4.4.3 of appendix M1 that the airflow measurement apparatus fan must be adjusted if necessary to maintain the same air volume rate for different test conditions for systems not including multiple-speed or variable-speed indoor fans with control system capability to adjust air volume rate as function of operating conditions such as outdoor air temperature; and

(7) Revising the equations representing full-capacity operation of variable-speed heat pumps at and above 45 °F ambient temperature to be consistent with the intent for nominal capacity operation.

Additionally, in this final rule, DOE is updating 10 CFR part 429, ''Certification, Compliance, and Enforcement for Consumer Products and Commercial and Industrial Equipment.'' DOE has identified certain provisions of part 429 that may benefit from additional detail and/or instruction. The proposed updates are as follows:

(1) Clarifying the language for required represented values for single-stage and two-stage coil-only CACs; and

(2) Providing additional direction regarding the regional standard requirements in part 429.

The adopted amendments are summarized in Table II–1 compared to the test procedure provision prior to the amendment, as well as the reason for the adopted change. Additional proposed incidental changes are summarized in Table III–4, Table III–5 and Table III–6 in section III.D.10 of this document.

[5] The parenthetical reference provides a reference for information located in the docket of DOE's rulemaking to develop test procedures for central air conditioners and heat pumps (Docket No. EERE–2021–BT–TP–0030, which is maintained at *www.regulations.gov*). The references are arranged as follows: (commenter name, comment docket ID number, page of that document).

TABLE II–1—SUMMARY OF CHANGES IN THE AMENDED TEST PROCEDURE

DOE test procedure prior to amendment	Amended test procedure	Attribution
Calculate indoor fan power of two-stage coil-only CACs and HPs using constant default fan power values that do not vary with air volume rate (441W/1000 scfm for most two-stage coil-only CACs and HPs and 406 W/1000 scfm for mobile-home and space-constrained CACs and HPs).	Calculate indoor fan power of two-stage coil-only CACs and HPs for reduced air volume rate tests using new default fan power values air volume rate (335 W/1000 scfm for most two-stage coil-only CACs and HPs and 308 W/1000 scfm for mobile-home and space-constrained CACs and HPs). Use linear interpolation to determine fan performance at intermediate airflow rates between 75 percent and 100 percent of full-load air volume rate.	Improve representativeness.
No test procedure provisions for variable-speed, coil-only CACs and HPs.	Test procedures and requirements established for variable-speed coil-only systems, include new definitions for ''variable-speed communicating coil-only central air conditioner or heat pump'' and ''variable-speed non-communicating coil-only central air conditioner or heat pump,'' for which the newly established test procedures have more flexibility.	Incorporate test procedures contained in test procedure waivers.
Appendix M1 currently does not explicitly allow for variation of air volume rate as outdoor temperature changes when testing blower coil systems.	For blower coil systems with multiple-speed or variable-speed indoor fans and the control system capability to adjust air volume rate as a function of outdoor air temperature, allow such air volume rate variation during testing.	Improve representativeness for certain models.
Appendix M1 contains provisions for conducting an optional H4 heating test at a 5 °F outdoor ambient dry-bulb temperature and, at a maximum, a 3 °F outdoor wet-bulb temperature.	Amend the wet bulb test condition for the H4 test to be 4 °F maximum instead of the current condition of 3 °F maximum.	Reduce test burden by reducing the time needed to remove sufficient moisture to achieve the wet bulb requirement.
Clarification regarding which form of installation instructions to use, if multiple forms are provided, only for variable refrigerant flow (VRF) multisplit systems.	Add direction to prioritize the instructions presented in the label attached to the unit over the installation instructions shipped with the unit for all CAC/HP products.	Improve representativeness and repeatability.
Appendix M1 currently is not clear about how to achieve the same air volume rate for different test conditions.	Add specific instruction to adjust the airflow measurement apparatus fan but not the fan of the unit under test to achieve the same air volume rate for different tests.	Improve representativeness and repeatability.
The equations for full-capacity operation for variable-speed heat pumps at and above 45 °F ambient temperature are based on operating in this range with a compressor speed the same as its operation in 17 °F ambient temperature.	Revise the equations for full-capacity operation at and above 45 °F to be more consistent with compressor speed used in normal operation for this temperature range, represented by the nominal heating test condition, $H1_N$.	Improve representativeness.
10 CFR part 429 provides requirements regarding regional CAC/HP efficiency standards.	Reinforce the language explaining regional requirements.	Improve clarity.
10 CFR 429.16(a)(1) provides requirements for represented values of single-stage and two-stage coil-only CACs that can lead to different interpretation.	Modify the instructions in that section to improve clarity without changing meaning.	Improve repeatability.
10 CFR 430.2 defines central air conditioner, excluding two commercial package air-conditioning and heating categories—packaged terminal air conditioners and packaged terminal heat pumps.	Add exclusions for additional commercial package air-conditioning and heating categories that justifiably are not central air conditioners.	Improved representativeness.

As mentioned previously, DOE is also fixing typographical errors in appendices M and M1 that were raised by AHRI. (''AHRI Exhibit 2,'' EERE–2017–BT–STD–0062–0117 at pp. 23–24) DOE is addressing these issues in this rulemaking.

Under 42 U.S.C. 6293(e)(1), DOE is required to determine whether an amended test procedure will alter the measured energy use of any covered product. If an amended test procedure does alter measured energy use, DOE is required to make a corresponding adjustment to the applicable energy conservation standard to ensure that minimally compliant covered products remain compliant. (42 U.S.C. 6293(e)(2)) DOE has determined that the amendments described in section III of this final rule would not alter the measured efficiency of CAC/HPs that are rated using the test procedure that is currently required for testing, *i.e.,* appendix M. The revisions applicable for appendix M simply fix errors within the current test procedure. With respect to appendix M1, many of the amendments clarify test procedures rather than making changes that would affect the measurements. Variable-speed coil-only systems are not addressed currently in the test procedure, so this final rule establishes a method of test for those products. For two-stage coil-only systems, DOE is amending the default fan power coefficients and default fan heat coefficients to be more representative, as further described in section III.C.1 of this document, which DOE believes will slightly improve the measured efficiency of these combinations as compared to their current representative values. Given that two-stage combinations are not representative of minimally compliant combinations, DOE has determined that this amendment would not require an adjustment to the energy conservation standard for central air conditioners and heat pumps to ensure that minimally compliant central air conditioners and heat pumps would remain compliant. Additionally, DOE has determined that the amendments would not increase the cost of testing. Discussion of DOE's actions are addressed in detail in section III of this final rule.

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 test procedures beginning 180 days after the publication of this final rule.

III. Discussion

A. Scope of Applicability

DOE is amending the test procedures at appendix M1 for CAC/HP and implementing a few minor clerical revisions to the test procedures at appendix M. A ''central air conditioner or central air conditioner heat pump'' is defined as a product, other than a packaged terminal air conditioner or packaged terminal heat pump, which is powered by single phase electric current, air cooled, rated below 65,000 British thermal units per hour (''Btu/h''), not contained within the same cabinet as a furnace, the rated capacity of which is above 225,000 Btu/h, and is a heat pump or a cooling unit only. A central air conditioner or central air conditioning heat pump may consist of: A single-package unit; an outdoor unit and one or more indoor units; an indoor unit only; or an outdoor unit with no match. In the case of an indoor unit only or an outdoor unit with no match, the unit *must* be tested and rated as a system (combination of both an indoor and an outdoor unit). 10 CFR 430.2.

Appendices M and M1 apply to the following CACs/HPs:

- Split-system air conditioners, including single-split, multi-head mini-split, multi-split (including VRF), and multi-circuit systems;
- Split-system heat pumps, including single-split, multi-head mini-split, multi-split (including VRF), and multi-circuit systems;
- Single-package air conditioners;
- Single-package heat pumps;
- Small-duct, high-velocity systems (including VRF);
- Space-constrained products—air conditioners; and
- Space-constrained products—heat pumps.

See Section 1.1 of appendices M and M1.

DOE is not proposing to change the scope of CACs/HPs covered by appendices M and M1.

B. Requests for Future Test Procedure Revisions

DOE has considered whether the current test procedures for variable-speed systems generally give manufacturers too much flexibility in specifying fixed settings of the compressor and indoor fan for testing without requiring the selected settings to be demonstrated using native control testing. DOE is aware that there is ongoing work addressing questions about whether the current DOE test procedure for variable-speed systems is fully representative of native control operation.[6] However, DOE has initiated this rulemaking not as a comprehensive revision that will satisfy the 7-year lookback requirements (*see* 42 U.S.C. 6293(b)(1)(A)), but instead as an action that will address a focused group of known issues, including those that have been raised through the test procedure waiver process. Thus, DOE limited its amendments addressing potential concerns about variable-speed systems to coil-only systems, for which there are clear differences in system controls architecture that impact the performance of these systems in the field, particularly when using non-communicating controls. However, DOE may more comprehensively address these issues for all variable-speed systems in a future rulemaking.

The CA IOUs, Joint Advocates, NEEA, and NYSERDA all encouraged DOE to review ways to improve the representativeness of the test procedures for CAC/HP in a future rulemaking under DOE's 7-year lookback authority. Specifically, the CA IOUs, Joint Advocates, and NEEA all requested that DOE explore approaches that would capture the performance of variable-speed and multi-stage systems operating under native controls rather than under fixed compressor and fan speed controls. (CA IOUs, No.20 at pp.2–3; Joint Advocates, No.18 at p.1; NEEA, No.23 at p.1)

The CA IOUs contended that the current test procedure does not fully reflect energy use during the shoulder-season hours when outdoor temperatures are typically between 55 °F and 64 °F and the equipment is likely in fan-only mode (*i.e.,* the compressor is not running). (CA IOUs, No.20 at pp.2–3) DOE acknowledges the CA IOUs' comment that shoulder-season fan energy consumption is not captured by either the SEER/SEER2 or HSPF/HSPF2 metrics, which are constructed to represent the cooling season efficiency and heating season efficiency, respectively. However, as previously mentioned, DOE is only planning to address a focused group of known issues in this rulemaking and will evaluate and addresses a broader set of changes in a future rulemaking. The CA IOUs acknowledged this point in their comment, by suggesting that DOE consider fan-only energy use during the shoulder-season in a subsequent review of the CAC/HP test procedure. *Id.* Therefore, DOE will not adopt any amendments in this rulemaking related to shoulder-season energy consumption, as suggested by the CA IOUs.

The CA IOUs also suggested that DOE consider approaches in a future rulemaking to incorporate the power consumption of auxiliary components like fans and crankcase heaters operating when the compressor is off. (CA IOUs, No.20 at pp.2–3) DOE notes that there are already test procedures and energy conservation standards governing the allowable off-mode power consumption for CACs and HPs, which encapsulates the off-mode and standby power consumed by auxiliary components such as crankcase heaters as suggested by the CA IOUs. These test procedures are enumerated in section 4.3 of appendices M and M1, and standards are enumerated at 10 CFR 430.32(c)(4).

The CA IOUs further requested that DOE amend the definition of ''variable-speed compressor systems'' to incorporate CAC/HPs with at least three compressor capacity stages that do not meet the definitions of VRF or triple-capacity northern heat pumps. Specifically, the CA IOUs suggested the following definition (additions in *italics*):

Variable-speed compressor system means ''a central air conditioner or heat pump that has a compressor that uses a variable-speed drive to vary the compressor speed to achieve variable capacities *or a compressor with at least three compressor capacity stages not including triple-capacity northern heat pumps.*'' (CA IOUs, No.20 at p.2)

Section 1.2 of appendix M1 defines ''variable-speed compressor systems'' as those CAC/HPs that have ''a compressor

[6] *E.g.,* The German energy regulatory body, Bunderstalt für Materialforschung und-Prüfung (''BAM''), has developed a dynamic load compensation method, to be used as an alternative to EN 14825:2016 ''Air conditioners, liquid chilling packages and heat pumps, with electrically driven compressors, for space heating and cooling. Testing and rating at part load conditions and calculation of seasonal performance''. Additionally, the Canadian Standards Association (''CSA'') has published the first draft edition of CSA:EXP07:19 ''Load-based and climate-specific testing and rating procedures for heat pumps and air conditioners'' (''EXP07'').

that uses a variable-speed drive to vary the compressor speed to achieve variable capacities.'' The definition for ''variable refrigerant flow (VRF) systems'' includes the language ''multi-split system with at least three compressor capacity stages, distributing refrigerant through a piping network to multiple indoor blower coil units.'' The definition for ''triple-capacity, northern heat pump'' in appendix M1 includes ''a heat pump that provides two stages of cooling and three stages of heating.'' DOE agrees with the CA IOUs' assertion that as currently structured, the definitions in appendix M1 do not explicitly clarify coverage for the specific case of CAC/HP systems having three or more stages (but without a variable-speed drive), do not include multiple indoor units (which would meet the definition for VRF), and are not heat pumps that include two cooling stages and three heating stages (which would meet the definition for triple-capacity northern heat pump). However, DOE is not aware of, nor did the CA IOUs identify, the existence of such systems. Also, as previously mentioned, DOE is only planning to address a focused group of known issues in this rulemaking and will evaluate and addresses a broader set of changes in future rulemaking. Therefore, DOE will not adopt the revised definition of ''variable-speed compressor systems,'' as suggested by the CA IOUs in this rulemaking. DOE may consider changes to the definition of ''variable-speed compressor system'' in a future rulemaking, if provided additional evidence of systems existing that meet the criteria of the hypothetical system described by the CA IOUs.

NEEA and the Joint Advocates recommended that DOE adopt a test procedure that evaluates performance under loads that respond to the heat pump's internal firmware. (NEEA, No.23 at p.1; Joint Advocates, No.18 at pp. 3–4) NEEA provided data to support their claim that seasonal efficiency performance is highly dependent on the installed firmware of the system. *Id.* at pp.3–4. NEEA compiled this information in a report[7] that was also cited by the Joint Advocates in their comment. (Joint Advocates, No.18 at p.4)

NEEA also requested that DOE adopt a load-based test procedure with the tested system operating under native controls. (NEEA, No.23 at p.2) NEEA again provided data concerning the representativeness of the existing DOE test procedure as compared to field data. NEEA cited several ongoing projects related to evaluation of load-based testing of CAC/HP and recommended that DOE leverage this work as a part of the next CAC/HP test procedure rulemaking. *Id.* at pp.5–7. NEEA additionally requested that DOE consider increasing the amount of data reported for heat pumps operating at pert-load heating conditions, specifically advocating for required reporting of COP for low-compressor-stage tests at 67 °F and 47 °F. *Id.* at p.7.

NYSERDA encouraged DOE to start immediately on foundational work needed to improve the standard and test procedure to better account for equipment performance in cold climates. NYSERDA requested that DOE make the H4, $H4_2$, or $H4_3$ heating tests mandatory in order to produce more representative ratings that account for system performance at 5 °F. NYSERDA also requested that DOE explore how to test and report relative capacity maintenance at temperatures lower than the heating mode test temperatures that are used to determine nominal capacity and suggested that DOE prescribe performance requirements of low-temperature capacity maintenance for products advertised as cold-climate heat pumps.[8] Further, NYSERDA requested that DOE evaluate how a variety of sizing approaches could be incorporated into the test procedure. NYSERDA highlighted that DOE has previously established that the sizing assumptions inherent in the DOE test procedure are based on cooling capacity and provided an example of a sizing and selection guide that emphasizes heating function.[9] NYSERDA ultimately acknowledged that DOE is addressing a more limited set of issues in this rulemaking and suggested that if their comments could not be considered now, they should be considered applicable for the next test procedure update for CACs or other HVAC equipment, as appropriate. (NYSERDA, No.17 at pp.2–3)

In summary, DOE received a variety of comments that requested changes to the CAC test procedure beyond the limited scope of proposals in the March 2022 CAC TP NOPR. DOE received comments recommending consideration of load-based testing methods, controls validation (particularly for variable-speed systems), amended metrics, amended definitions, and expansion of test methods to capture low-temperature heating performance for heat pumps. As stated, DOE will consider these comments when conducting the next rulemaking that includes a full review of the CAC test procedure.

C. Topics Arising From Test Procedure Waivers

1. Fan Power at Reduced Airflows for Coil-Only Systems

a. Background

Coil-only air conditioners are matched split-systems consisting of a condensing unit and indoor coil that are distributed in commerce without an indoor blower or separate designated air mover. Such systems installed in the field rely on a separately installed furnace or a modular blower for indoor air movement. Because coil-only CAC/HPs do not include their own indoor fan to circulate air, the DOE test procedures prescribe equations that are used to calculate the assumed (*i.e.,* ''default'') power input and heat output of an average furnace fan with which the test procedure assumes the indoor coil is pared in a field installation. In each equation, the measured airflow rate (in cubic feet per minute of standard air (''scfm'')) is multiplied by a defined coefficient (expressed in Watts (''W'') per 1,000 scfm (''W/1000 scfm'') for fan power, and British Thermal Units (''Btu'') per hour (''Btu/h'') per 1000 scfm (''Btu/h/1000 scfm'') for fan heat), hereafter referred to as the ''default fan power coefficient'' and ''default fan heat coefficient.'' The resulting fan power input value is added to the electrical power consumption measured during testing. The resulting fan heat output value is subtracted from the measured cooling capacity of the CAC/HP for cooling mode tests and added to the measured heating capacity for heating mode tests.

In appendix M1, separate fan power and fan heat equations are provided for different types of coil-only systems (*i.e.,* the equations for mobile home or space-constrained are different than for ''conventional'' non-mobile home and non-space-constrained).[10] 10 CFR part

[7] NEEA report ''Heat Pump and Air Conditioner Efficiency Ratings: Why Metrics Matter'' available online at: *https://neea.org/resources/heat-pump-and-air-conditioner-efficiency-ratings-why-metrics-matter.*

[8] NYSERDA cited the EPA's Energy Star Version 6.1 CAC/HP specification, which prescribes a heating capacity maintenance of 70% at 5 °F relative to 47 °F for cold-climate heat pumps. The Energy Star specification can be found online at: *https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20Central%20Air%20Conditioner%20and%20Heat%20Pump%20Version%206.1%20Final%20Specification.pdf.*

[9] NYSERDA identified NEEP's ASHP sizing and selection guide, available online at: *https://neep.org/sites/default/files/resources/ASHP%20Sizing%20%26%20Selecting%20-%208x11_edits.pdf.*

[10] The different default fan power and default fan heat coefficients for mobile-home and space-constrained systems as compared to conventional systems reflect the lower duct pressure drop

Continued

430, subpart B, appendix M1, *see, e.g.,* section 3.3. For coil-only units installed in mobile-homes and for space-constrained systems, appendix M1 defines a default fan power coefficient of 406 W/1000scfm and a default fan heat coefficient of 1,385 Btu/h/1000 scfm. *See, e.g.,* appendix M1, section 3.3.d. For coil-only units installed in conventional (*i.e.,* non-mobile-home and non-space-constrained) systems, appendix M1 defines a default fan power coefficient of 441 W/1000 scfm and a default fan heat coefficient of 1,505 Btu/h/1000 scfm. *See, e.g.,* appendix M1, section 3.3.e. In appendix M1, for both the default fan power coefficient and default fan heat coefficient, the same coefficient is used for both the full-load and part-load tests.

In the March 2022 CAC TP NOPR, DOE discussed a petition for waiver and interim waiver filed by Nortek on September 7, 2021, that requested an alternate test procedure that would define lower default fan power and fan heat coefficients for the part-load tests, instead of applying the same coefficients to both the full-load and part-load tests, as is done in appendix M1. 87 FR 16830, 16834–16835; *see* Nortek, EERE–2021–BT–WAV–0025, No. 1 at pp. 4–9. In response, DOE published a notice that announced its receipt of the petition for waiver and denial of Nortek's petition for an interim waiver. *Id. See* 86 FR 63357 (''Notification of Petition for Waiver''). In the Notification of Petition for Waiver, DOE noted that applying the modified default fan power coefficients and default fan heat coefficients in appendix M1 to products such as those that are the subject of Nortek's petition was determined to be representative of the systems' performance and reflected the adoption of the recommendations of a working group formed to negotiate a notice of proposed rulemaking for energy conservation standards for CAC/HPs; and that the modified coefficients were subject to public comment during the 2016 test procedure rulemaking for CAC/HPs (''2016 CAC TP Rulemaking''). *Id. See* 82 FR 1426, 1452. DOE also noted that Nortek commented in support of the modified coefficients during the 2016 CAC TP Rulemaking. *Id.*

In response to the issue raised by Nortek, DOE re-examined the furnace fan electrical power consumption data collected for the furnace fans rulemaking (*see* 79 FR 506, Jan. 3, 2014) that was used to develop the default fan power coefficients and default fan heat coefficients for coil-only products in appendix M1. DOE extended the prior analysis to examine both full-load and part-load air volume rates.[11] DOE correlated the predicted power consumption with the predicted air volume rate for each furnace fan to determine adjusted values of the default fan power coefficients that may result in a more representative estimate of fan power and fan heat at reduced airflow conditions, compared to the coefficients currently defined in appendix M1. DOE's analysis indicated that at a reduced air volume rate of 75 percent, the average indoor fan power coefficient would be 360 W/1000 scfm for coil-only CAC/HPs in a conventional (*i.e.,* non-mobile-home and non-space-constrained) installation. For mobile-home and space-constrained systems, the average indoor fan power coefficient would be 331 W/1000 scfm.[12] DOE also calculated the fan heat coefficients associated with these power input levels. The average indoor fan heat coefficients would be 1,228 Btu/hr/1000 scfm and 1,130 Btu/h/1000 scfm for conventional (*i.e.,* non-mobile-home and non-space-constrained) and mobile-home/space-constrained installations, respectively. 78 FR 16830, 16834–16835.

The analysis conducted by DOE for the March 2022 CAC TP NOPR resulted in higher default fan power coefficients and default fan heat coefficients at the reduced 75 percent air volume rate than the values presented in the Nortek waiver petition. DOE tentatively concluded that its analysis is a more appropriate representation of average furnace fan power consumption than the results presented by Nortek because (1) DOE's analysis relied on empirical test results while Nortek's analysis was theoretical, (2) DOE's analysis applied the same weighting factors[13] from the 2016 CAC TP Rulemaking to ensure consistency, and (3) DOE's analysis considered constant-torque brushless-permanent-magnet ''X13'' motors while Nortek's analysis did not. DOE proposed to amend the default fan power coefficients and default fan heat coefficients for coil-only fan power when operating at reduced air volume rates to reflect the results of its analysis. *Id.*

AHRI, Carrier, Emerson, the Joint Advocates, Lennox, Nortek, and Rheem all supported DOE's proposal to reduce the default fan power and fan heat coefficients for low-stage operation of coil-only conventional, mobile-home and space-constrained CACs. (AHRI, No.25 at p.3; Carrier, No.15 at p.2; Emerson, No.14 at p.1; Joint Advocates, No.18 at p.1; Lennox, No.19 at p.2; Nortek, No.13 at p.1; Rheem, No.21 at p.1) Carrier, the Joint Advocates, and Lennox all stated that DOE's proposal to include a lower default fan power coefficient at part-load airflows would improve the representativeness of testing for two-stage coil-only systems over the current approach in appendix M1. (Carrier, No.15 at p.1; Joint Advocates, No.18 at p.1; Lennox, No.19 at p.2) Even though there was general support for DOE's proposals, several comments were received on the specific proposed values and the assumptions made in order to calculate them. The following sections detail these specific comments.

b. BPM Market Penetration

Despite supporting DOE's proposal to establish a second default fan power coefficient representing low-stage operation, AHRI argued that DOE's proposed part-load default fan power and heat coefficients were still higher than they should be. (AHRI, No.25 at pp. 2–3) Carrier, Daikin, Emerson, Lennox, Nortek, and Rheem all agreed with the AHRI comment that the part-load default fan power and heat coefficients should be lower than the proposed values. (Carrier, No.15 at p.2; Daikin, No.24 at p.1; Emerson, No.14 at p.1; Lennox, No.19 at p.2; Nortek, No.13 at pp.1–2; Rheem, No.21 at pp.1–2)

A key factor in AHRI's argument was that the actual market saturation rate of furnace fans installed with higher-efficiency brushless permanent magnet ''BPM''[14] fan motors is higher than assumed in the analyses presented by DOE. (AHRI, No.25 at pp.2–3) DOE first

expected for such systems in field operation—the lower values are consistent with the lower external static pressure levels required in testing of blower-coil systems intended for mobile home and spaced-constrained applications (*see* Table 4 of appendix M1).

[11] To ensure consistency across analyses, DOE aggregated the data by applying market weightings to each type and brand of furnace model, using the same market shares that were used in the previous analysis for the 2016 CAC TP Rulemaking.

[12] For example, under DOE's proposed changes to appendix M1, for a two-stage coil-only system in a conventional application that has a cooling full-load air volume rate of 1640 scfm and a cooling minimum (*i.e.,* part-load) air volume rate of 1,230, the default fan power at full load would be calculated as (441 W/1000scfm × 1640 scfm = 723 W); and default fan power at part-load would be calculated as (360 W/1000scfm × 1230 scfm = 443 W).

[13] DOE's analysis included weighting based on market share by brand, installations per cooling capacity range, and projected shares in 2021 for different furnace fan motor types.

[14] In their comment, AHRI used the term ''electronically commutated motor'' (ECM) to describe higher-efficiency motors available in the furnace fans market. However, all instances in this final rule have been changed to ''brushless permanent magnet'' (BPM) which better describes the motor construction.

presented its assumptions regarding relative prevalence of BPM motors for furnace fans in a December 5, 2016, Technical Support Document (''TSD'') used for the concurrent energy conservation standards (''ECS'') rulemaking. EERE–2014–BT–STD–0048–0098 (''December 2016 CAC ECS TSD''). In that document, DOE described its findings that in 2021,[15] the estimated mix of blower types in existing furnaces would be 77 percent permanent split capacitor (''PSC''), 15 percent constant-speed BPM, and 9% constant-torque BPM. (EERE–2014–BT–STD–0048–0098, page 7–16) DOE assumed the same proportion of furnace fan motor types in its analysis for the March 2022 CAC TP NOPR.

In order to support its claim that the market saturation rate of BPM furnace fan motors was higher than the rate estimated by DOE, AHRI cited the 2019 compliance date for efficiency standards for furnace fans and stated that nearly all new furnaces shipped since 2019 have exclusively used BPMs. (AHRI, No.25 at pp.2–3) AHRI also claimed that the pending refrigerant change in the U.S. will require replacement of R–410A systems in both indoor and outdoor units for CAC systems, starting in 2025. AHRI asserted that due to these regulations, consumers with older furnaces would be more likely to simultaneously replace their furnaces at the same time as a whole-system CAC replacement, leading to a wave of newly installed furnace fans using BPM fan motors. *Id.* AHRI then forecasted the number of installed furnaces and percent share of furnaces with BPM furnace fans using DOE's estimates for equipment retirement Weibull curves, AHRI historical shipments data,[16] and 2015 Residential Energy Consumption Survey (RECS) microdata.[17] Ultimately, AHRI forecasted the penetration of BPM furnace fan motors to reach 50 percent by 2025. *Id.* NCP and Nortek both supported AHRI's analysis regarding the relative prevalence of furnace fans having BPM motors, stating that the Fan Energy Rating (FER) standards effectively obsoleted PSC motors in new furnace fans in favors of BPM motors. (NCP, No.16 at pp.8–9; Nortek, No.13 at p.2) NCP reiterated AHRI's claim that future refrigerant regulations could increase the pace of furnace replacements and thus accelerate the adoption of furnace fans with BPM motors. (NCP, No.16 at p.8)

To evaluate AHRI's claims about furnace fan BPM penetration rates, DOE reconstructed AHRI's analysis using RECS microdata and engineering assumptions about typical furnace lifetime and historical prevalence of BPM fan motors in furnace fans. DOE estimated the annual inflows and outflows (*i.e.,* new sales and decommissioning at end-of-life) of BPM furnace fan motors, using the assumption that all new furnace fan motors would be BPM in years 2019 and onwards. Because AHRI did not explicitly describe how hypothetical refrigerant regulations would translate into accelerated uptake in furnace fans having BPM motors, DOE did not account for an increased rate of ''whole-system'' CAC replacements (and therefore furnace fan replacements) when evaluating furnace fan BPM penetration forecasts. Using these assumptions, DOE estimates that the percentage of installed BPM furnace fan motors in 2021 to be 29 percent (as compared to 24 percent[18] estimated in the December 2016 CAC ECS TSD). Further, DOE's estimates support AHRI's claim that the installed base of BPM furnace fans is likely to grow to 40 percent by 2023 and 50 percent by the year 2025. Therefore, DOE has used these values of BPM market penetration to re-evaluate the NOPR analysis to calculate default low-stage fan power coefficients and fan heat coefficients in the next section.

c. Determining Low-Stage Coefficients

In consideration of DOE's proposals regarding default fan power coefficients, AHRI also asserted that DOE's analysis included incorrect assumptions about the relationship between electrical power consumption and delivered airflow, which they claimed should be a cubic relationship based on fan affinity laws. AHRI provided aggregated data from a selection of 78 furnace fans to support their assertions. *Id.* at pp.3–4. Lennox and Rheem reiterated AHRI's comment, stating that the application of the same default coefficient at part-load airflows is not representative of the performance of the two-stage equipment operation, as the fan efficiency improves as airflow is reduced thus increasing overall system efficiency. (Lennox, No.19 at p.2, Rheem, No.21 at pp.1–2) Lennox and Rheem also elaborated that fan affinity laws show that fan speed and power have a cubic relationship, not the constant relationship[19] currently used in the test procedure. *Id.* AHRI further claimed that of the 78 collected furnace fans in their data set, there was not a statistically significant difference in full-load performance (measured in Watts per cfm) between models having furnace fans with PSC motors and models having furnace fans with PBM motors. As a result, AHRI did not argue that the full-load default fan power and heat coefficients should be changed but did suggest lower default fan power and fan heat coefficients low-stage operation. AHRI proposed default low-stage fan power coefficients of 322 W/1000 scfm for conventional systems and 296 W/1000 scfm for mobile-home/space-constrained systems.[20] (AHRI, No.25 at pp.3–4) As indicated, Carrier, Daikin, Emerson, Lennox, Nortek, and Rheem all referenced the AHRI analysis in their comments and supported the alternate default fan power coefficients proposed by AHRI. (Carrier, No.15 at p.2; Daikin, No.24 at p.1; Emerson, No.14 at p.1; Lennox, No.19 at p.2; Nortek, No.13 at pp.1–2; Rheem, No.21 at pp.1–2)

DOE understands the theoretical basis of fan laws which describe a cubic relationship between fan shaft power and delivered air volume rate for an idealized fan. However, real fan shaft power does not always consistently follow the fan laws[21] and motor efficiency generally decreases as shaft power decreases from rated load,[22] which would cause motor input power to deviate from the cubic relationship even if the shaft power followed it. The AHRI comment does not provide a more

[15] At the time the 2016 CAC ECS TSD was drafted, the proposed compliance date for amended standards was Jan. 1, 2021—therefore DOE forecasted the fan motor proportions in the anticipated year that standards would come into effect. In the January 2017 direct final rule regarding energy conservation standards (82 FR 1786, January 6, 2017) (''January 2017 CAC ECS Direct Final Rule''), however, the compliance date was delayed by two years to January 1, 2023. DOE did not provide estimates of assumed furnace fan motor composition in the year 2023.

[16] AHRI historical shipments estimates available online at: *https://ahrinet.org/resources/statistics/historical-data/furnaces-historical-data.*

[17] Residential Energy Consumption Survey data available online at: *https://www.eia.gov/consumption/residential/data/2015/.*

[18] BPM estimate from 2016 CAC ECS TSD reflects the sum of CT–BPM (9%) and CA–BPM (15%).

[19] The DOE test procedure does not prescribe a constant default fan power, but rather a constant default fan power *coefficient,* so that the calculated fan power varies linearly with air volume rate. See appendix M1, sections 3.3, 3.5.1, 3.7, and 3.9.1.

[20] AHRI also provided corresponding default fan heat coefficients of 1099 Btu/h/1000scfm and 1010 Btu/h/1000scfm for conventional and mobile-home/space-constrained coil-only CACs, respectively.

[21] This catalog of several indoor air handling units demonstrates on the 6th page examples of fan performance curves, where the fan efficiency does not always follow a simple quadratic curve: *https://content.greenheck.com/public/DAMProd/Original/10002/IAH_catalog.pdf.*

[22] As per ANSI/AMCA Standard 241–21 (Test Procedure for Calculating Fan Energy Index (FEI) for Commercial and Industrial Fans and Blowers), the motor efficiency for variable-speed motors is not always directly proportional to the load, as demonstrated in Figure F.3. Source: *https://www.amca.org/assets/resources/public/pdf/Publications/AMCA-214-21.pdf.*

detailed breakdown of analytical results allowing confirmation of general consistency of the two analytical approaches. As noted, DOE has re-evaluated the NOPR analysis to calculate default low-stage fan power coefficients and fan heat coefficients, using the assumption that BPM furnace fan penetration is 40 percent in the year 2023 (the compliance date of CAC energy conservation standards in terms of appendix M1 metrics). 10 CFR 430.32(c)(5). DOE re-analyzed the same dataset used in the furnace fans rulemaking and applied a proportion of 40 percent BPM and 60 percent PSC motors, while keeping all other elements of the analysis unchanged (*see* 79 FR 506, Jan. 3, 2014). For the reasons described in section III.C.1.e of this document, DOE did not consider separate default fan power coefficients for space-constrained coil-only CACs and is instead continuing to treat mobile-home and space-constrained systems jointly. This evaluation results in default low-stage fan power and heat coefficients that are lower than the values proposed in the March 2022 CAC TP NOPR, and DOE is adopting these lower values in this final rule. The fan motor re-weighting had negligible impact on the full-load airflow values for default fan power and default fan heat coefficients, therefore, DOE is not amending the full-load values in this final rule, consistent with comments received from AHRI. (AHRI, No.25 at p.3) The results of DOE's analysis are summarized in Table III–1.

TABLE III–1—DEFAULT FAN POWER AND FAN HEAT COEFFICIENTS FOR COIL-ONLY CACS AND HPS

System type	Air volume rate (%)	Default fan power coefficient (W/1000scfm)	Default fan heat coefficient (Btu/h/1000scfm)
Conventional Coil-Only	100	441	1505
	75	335	1143
Mobile-Home and Space-Constrained Coil-Only	100	406	1385
	75	308	1051

d. Interpolated Coefficients Between 75 and 100 Percent Air Volume Rate

In the March 2022 CAC TP NOPR, DOE also stated that the reduced air volume rate used for low-stage operation of two-stage coil-only systems may be higher than 75 percent of the full-load air volume rate, if the manufacturer's instructions specify a higher part-load air volume rate. DOE proposed that in such cases, (*i.e.,* in any case where the reduced air volume rate is greater than 75 percent of the full-load air volume rate) the default fan power values associated with full-load air volume rate be used. However, DOE hypothesized that in these scenarios, the appropriate default fan power coefficient and default fan heat coefficient may be values between the reduced values discussed above and the values used for full-load air volume rate. DOE set out two alternative options to its proposed approach: (1) allowing the reduced value up to a threshold value, *e.g.,* 80 percent of full-load air volume rate, above which the full-load value would be required, and (2) requiring a linear interpolation of the default fan power coefficient between the reduced value at 75 percent of full-load air volume rate to the full-load value at 100 percent.[23] 78 FR 16830, 16835.

AHRI, Carrier, Daikin, Emerson, Lennox, and Nortek all supported the second alternative option set forth by DOE, *i.e.,* requiring a linear interpolation of the default fan power coefficient based on percentage full-load air volume rate. (AHRI, No.25 at p.6; Carrier, No.15 at p.2; Daikin, No.24 at p.1; Emerson, No.14 at pp.1–2; Lennox, No.19 at p.2; Nortek, No.13 at p.1) AHRI provided a table of power consumption rate as a function of airflow percentage and stated that a third-order equation would be most accurate, however intermediate values for default fan power coefficient would be most easily calculated using linear interpolation. (AHRI, No.25 at pp.4–6)

Based on the comments, DOE is finalizing the approach of requiring linear interpolation of default fan power and default fan heat coefficients for all tests where the specified airflow is between 75 percent and 100 percent of the full load air volume rate.

e. Considerations for Space-Constrained Systems

As previously mentioned in section III.C.1.b, NCP supported AHRI's claims that due to the FER furnace fan standards coming into effect in 2019, and due to anticipated refrigerant regulations, the relative penetration rate of furnace fans with BPM motors is higher than the proportion estimated by DOE in the January 2017 CAC TP Final Rule. (NCP, No.16 at pp.8–9) NCP also remarked that DOE's proposal for default fan power coefficients implies that space-constrained coil-only units are similar to those of mobile homes, and implies that both should use a default fan power and capacity adjustment that is representative of operation at a minimum external static pressure (ESP) of 0.30 inches w.c.[24] NCP asserted that data based on mobile homes is not an appropriate basis for space-constrained condensing units used in multi-family housing applications. NCP claimed that although the size of the indoor units is similarly restricted in mobile-home and space-constrained applications, mobile-home applications do not limit the size of the outdoor unit in the same way as space-constrained installations, which require a smaller footprint for the condensing unit. NCP elaborated that this discrepancy allows for mobile-home systems to have a relatively larger condenser coil surface area (providing improved performance) and that their models of space-constrained outdoor units do not have sufficient space to increase the condenser coil size. NCP thus asserted that the default fan power coefficients proposed by DOE in the March 2022 CAC TP NOPR remains unrealistic for NCP's space-constrained CAC systems and would prohibit NCP from meeting the minimum energy efficiency standard. NCP requested that if the Department does not continue to waive requirements for coil-only testing of space-constrained condensing units, DOE should amend the default fan

[23] For example, for non-mobile-home and non-space-constrained systems, if a linear interpolation of the default fan power coefficient is required, it would be equal to 360 + (441 − 360)*(%FLAVR − 75%)/(100% − 75%), where %FLAVR is the reduced air volume rate used for the test expressed as a percentage of the full load air volume rate.

[24] Appendix M1 requires that both ducted space-constrained and ducted mobile-home CACs be tested at a minimum ESP of 0.30 inches w.c. 87 FR 16834 (Mar. 24, 2022) (citing 82 FR 1426, 1453 (Jan. 5, 2017)).

power and fan heat coefficients to reflect real world conditions. (NCP, No.16 at pp. 7–8) NCP provided confidential information regarding the performance of their ''Through-the-Wall'' (TTW) space-constrained condensing units when paired with various indoor unit air handlers, including different NCP-branded air handlers and with other brands of furnaces (indicative of a coil-only installation). NCP then incorporated its findings along with the data provided by AHRI and proposed a default fan power coefficient of 321 Watts per 1000 scfm for space-constrained coil-only CAC systems operating at low-stage airflow. *Id.* at p.9.

In response to NCP's assertion that separate test procedure considerations should be given for default fan power coefficients for space-constrained CAC systems vs those for mobile-home CAC systems, DOE notes that this topic was previously discussed in the January 2017 CAC TP Final Rule. In that rule DOE determined, with stakeholder support, appropriate default fan power and default fan heat coefficients for mobile home coil-only systems required to be tested at a minimum external static pressure of 0.30 in. w.c. 82 FR 1426, 1451–1452. DOE also noted in that final rule that recommendation #2 of the January 2016 Appliance Standards and Rulemaking Federal Advisory Committee (ASRAC) CAC/HP Working Group Term Sheet (2016 CAC Term Sheet) recommended 0.30 inches w.c. as the minimum external static pressure requirement for testing space-constrained CACs *Id.* DOE is maintaining the determination from the January 2017 CAC TP Final Rule and the current test procedure approach, which uses the same default fan power coefficient and default fan heat coefficient for space-constrained and mobile home CAC.

2. Variable-Speed Coil-Only Test Procedure

a. Background

As discussed, appendices M and M1 contain provisions for testing split-system CAC/HPs equipped with ''coil only'' indoor units that, in a field installation, are paired with an existing furnace or other air handler that includes the fan required to circulate conditioned air through ductwork. These provisions apply to single-stage and two-stage systems and address only two levels of air volume rate, for full-load and minimum operation.[25] Appendices M and M1 do not include provisions for testing variable-speed systems equipped with coil-only indoor units (''VSCO'' CACs). In the March 2022 CAC TP NOPR, DOE discussed waiver requests that it had received from multiple manufacturers regarding the test provisions for VSCO CACs. 82 FR 16830, 16836–16837. The various waiver requests are summarized in this final rule in Table III–2.

With the exception of the Goodman Manufacturing Company, L.P. (''Goodman'') petition for waiver (86 FR 40534 (July 28, 2021)), all petitioners submitted petitions for waiver for products that use ''non-communicative'' conventional controls, *i.e.,* controls that use low-voltage on-off signals from the thermostat to indicate the need for conditioning in the conditioned space. As required under the specified alternate test procedures for these ''non-communicative variable-speed coil-only systems,'' they must be tested according to the appendix M provisions applicable to variable-speed systems (*e.g.,* three different compressor speeds in the cooling mode), except that the subject systems must be tested using the full-load cooling air volume rate at all test conditions. (GD Midea, EERE–2017–BT–WAV–0060, No. 1, pp. 1–3; TCL, EERE–2018–BT–WAV–0013, No. 1, pp. 2–4; LG, EERE–2019–BT–WAV–0023, No. 1, pp 3–4) DOE noted that the waivers for non-communicative systems indicated only that ''compressor speed varies based only on controls located on the outdoor unit.'' (GD Midea, EERE–2017–BT–WAV–0060, No. 1, p. 6; TCL, EERE–2018–BT–WAV–0013, No. 1, p. 4; LG, EERE–2019–BT–WAV–0023, No. 1, pp 2) An interim test procedure waiver was also granted to Goodman for their ''communicative'' variable-speed, coil-only CAC/HPs. Goodman's petition claimed that for their systems, both the outdoor unit and indoor coil communicate with each other to control the variable-speed compressor, along with the multi-speed indoor fan. 86 FR 40534, 40539. The Goodman interim waiver test procedure specifies use of the cooling full-load air volume rate for the full-load cooling and full-load heating tests; and the cooling minimum air volume rate for the cooling minimum, heating minimum, cooling intermediate, and heating intermediate tests. *Id.*

TABLE III–2—STATUS AND DETAILS OF VARIABLE-SPEED, COIL ONLY (VSCO) WAIVER REQUESTS

Manufacturer	Petition description	Docket	Status
GD Midea Heating & Ventilating Equipment Co., Ltd. (GD Midea).	Non-communicating VSCO. Full load air volume rate used for intermediate and minimum.	EERE–2017–BT–WAV–0060.	Interim and Waiver Granted.
TCL air conditioner (zhongshan) Co. Ltd. (“TCL AC”).	Non-communicating VSCO. Full load air volume rate used for intermediate and minimum.	EERE–2018–BT–WAV–0013.	Interim and Waiver Granted.
LG Electronics U.S.A., Inc. (LGE)	Non-communicating VSCO. Full load air volume rate used for intermediate and minimum.	EERE–2019–BT–WAV–0023.	Interim Granted.
Goodman	Communicating VSCO. Minimum air volume rate used for intermediate and minimum.	EERE–2021–BT–WAV–0001.	Interim Granted.

In the March 2022 CAC TP NOPR, DOE explained that it was reconsidering its approach to the waivers for the non-communicative VSCO systems. First, DOE explained that the waiver petitions had not provided information regarding, nor had DOE evaluated, the compressor speed selections used for different test conditions specified in appendix M or M1. 87 FR 16830, 16836. DOE elaborated that it had also not compared these speed selections with those used by blower-coil variable speed systems for the same test conditions. *Id.* DOE determined that based on the

[25] Section 3.1.4.1.1.c (cooling full-load air volume rate), section 3.1.4.2.c (cooling minimum air volume rate), section 3.1.4.4.2.c (heating full-load air volume rate), and section 3.1.4.5.2.d (heating minimum air volume rate) of appendix M1.

information received and evaluated, it could not conclude that the alternate test procedures specified in the waivers are representative of average use cycles of CAC/HPs. *Id.* DOE proposed provisions as generally prescribed in the relevant waivers, except that, for all variable-speed coil-only systems, regardless of communicative capability, use of a reduced-air volume rate would be allowed for part-load operation, *i.e.,* using the cooling minimum air volume rate for the cooling minimum, heating minimum, cooling intermediate, and heating intermediate tests. 87 FR 16830, 16837–16838. The proposed test procedure also incorporated the reduced default fan power and default fan heat coefficients at reduced air volume rates discussed in section III.C.1 of this document.

Regarding indoor airflow rate for VSCO systems, DOE pointed out that the test procedure for two-stage coil-only systems is premised on the system using a two-stage thermostat and associated wiring that responds to indoor temperature measurements and sends voltage signals that enable two-stage control of both the compressor speed and the indoor fan speed. 87 FR 16830, 16836–16837. DOE similarly assumed the presence of necessary wiring for the installation of variable-speed systems. *Id.* DOE elaborated that if the system does not include the capability to control an existing furnace fan at two air volume rates, the manufacturer would have the option of specifying minimum/intermediate air volume rates equal to the full-load air volume rate. *Id.*

Regarding compressor speed control for VSCO systems, DOE proposed to define ''communicating control'' in the context of variable-speed, coil-only CAC/HPs in order to differentiate between the test procedure provisions that would be applicable to communicating systems from those applicable to non-communicating systems. 87 FR 16830, 16837–16838. See section III.C.2.b. DOE further proposed provisions for setting compressor speed reflecting the attributes of the controls. Specifically, DOE proposed to require that non-communicative variable-speed coil-only systems be tested using an on-off control signal consistent with the control characteristics and also eliminating the E_V test for cooling and $H2_V$ for heating as well as including $H2_2$, $H2_1$, and $H3_1$ for heating. In contrast, DOE proposed that systems that meet the newly proposed criteria for ''communicating'' control would use compressor speeds and tests consistent with the existing variable-speed test procedure for blower-coil systems. *Id.*

With respect to DOE's proposal to add testing provisions for VSCO CACs in appendix M1, Carrier, Joint Advocates, Lennox, Nortek, and Rheem commented that they supported DOE's proposals to add testing provisions for variable-speed coil-only CAC/HPs. (Carrier, No.15 at p.1, Joint Advocates, No.18 at p.2, Lennox, No.19 at p.3, Nortek, No.13 at p.2, Rheem, No.21 at p.2) Carrier stated that they agreed that a communicating and non-communicating procedure should be created, and supported DOE's proposed test procedure for each type of system. (Carrier, No.15 at p.1) The Joint advocates added that they supported incorporating provisions for testing variable-speed coil-only units to ensure that the test procedure reflects differences in system controls architecture between communicating and non-communicating systems. (Joint Advocates, No.18 at p.2) They further commented that DOE's hybrid approach for aligning minimum air volume requirements between two-capacity and variable-speed coil-only units (for both communicating and non-communicating systems) was logical, as non-communicating systems have characteristics of both variable-speed and two-stage systems due to limitations of the less sophisticated control systems. *Id.* Lennox stated that DOE's proposal provides a consistent test method according to defined system capabilities while allowing for expanded opportunity for variable speed equipment to be installed in replacement applications with existing furnace or modular blowers. (Lennox, No.19 at p.3) Nortek explicitly stated that they were in favor of adopting the test procedures that were contained in the waivers, giving the Goodman waiver (86 FR 40534 (July 28, 2021)), as an example. AHRI commented that they agreed that systems meeting the criteria for variable-speed communicating coil-only CAC or HP definition should follow the existing variable-speed test procedure, although AHRI proposed an alternate definition for communicating control as described in section III.C.2.b of this document. (AHRI, No.25 at p.6)

b. Test Differences Based on Communicating Capability

As previously stated, the test procedure for two-stage coil-only systems is premised on the system using a two-stage thermostat and associated wiring that responds to indoor temperature measurements and sends voltage signals that enable two-stage control of both the compressor speed and the indoor fan speed. A more sophisticated control approach is required to enable a variable speed system to modulate compressor speed control (*e.g.,* proprietary thermostat, serial communication wiring, and/or electronic sensors at the indoor coil). In the March 2022 CAC TP NOPR, DOE proposed to define ''variable-speed communicating oil-only central air conditioner or heat pump'' in section 1.2 of appendix M1, to distinguish variable-speed coil-only systems with such controls, as a variable-speed compressor system having a coil-only indoor unit that is installed with a control system that (1) communicates the difference in space temperature and space setpoint temperature (not a setpoint value inferred from on/off thermostat signals) to the control that sets compressor speed; (2) provides a signal to the indoor fan to set fan speed appropriate for compressor staging and air volume rate; and (3) has installation instructions indicating that the required control system meeting both (1) and (2) must be installed. 87 FR 16830, 16837.

DOE also proposed to define variable-speed systems that do not have this communicating feature as a variable-speed compressor system having a coil-only indoor unit that does not meet the definition of variable-speed communicating coil-only central air conditioner or heat pump. *Id.*

DOE elaborated that variable-speed coil-only systems that meet the ''communicating'' definition would be tested like any other variable-speed system, except that the heating full-load air volume rate would be equal to the cooling full-load air volume rate, and the intermediate and minimum cooling and heating air volume rates would all be the higher of (1) the rate specified by the installation instructions included with the unit by the manufacturer and (2) 75 percent of the full-load cooling air volume rate. *Id.*

DOE further proposed that those variable-speed coil-only systems that are not ''communicating'' as defined above would be tested with additional limitations as if they have some variable-speed system characteristics and some two-stage coil-only system characteristics. Specifically, (a) the outdoor unit and/or the indoor unit would be provided with a control signal indicating operation at high or low stage, rather than testing with compressor speed fixed at specified speeds, and (b) air volume rates would be determined consistent with the requirement for two-stage coil-only systems. *Id.* A key implication of (a) is that there would be no intermediate compressor speed operation. Under DOE's proposed test procedure, many of the requirements associated with variable-speed operation would, however, be retained. For example, such systems would be allowed to have ''minimum speed-limiting'' control for heat pump mode (*see* the alternative calculations representing minimum-speed operation in appendix M1, section 4.2.4.b). The test method for non-communicating variable-speed coil-only systems would include requiring tests for minimum-speed operation for both the 35 °F and 17 °F heating test conditions so that the HSPF2 calculations utilize test results for appropriate compressor speeds. Also, the full compressor speed during heating mode operation would be allowed to vary with outdoor temperature, there would be an $H1_N$ test to represent the nominal capacity, and the same provisions for calculation of full-speed capacity and power applied to conventional variable-speed systems would be used (*see, e.g.,* the calculations in appendix M1, sections 3.6.4, 4.2.4.c and 4.2.4.d). If a manufacturer chooses to run the optional $H1_2$ test (*i.e.,* if compressor speed for the $H1_N$ test is different than compressor speed for the $H3_2$ test, and the manufacturer chooses to run the $H1_2$ test rather than use the standardized slope factors described in appendix M1, section 3.6.4.b), then the test would be run with over-ride of compressor speed using the same speed as used for the $H3_2$ test. This is the only test for which such over-ride would be allowed.

To ensure consistency of testing, it may be necessary for manufacturers to certify whether a variable-speed coil-only rating is based on non-communicating or communicating control. However, this change was not proposed in the March 2022 CAC TP NOPR and may be considered in a separate rulemaking.

In the March 2022 CAC TP NOPR, DOE acknowledged that there may be variable-speed control technology that cannot be tested according to the proposed test approach described previously for non-communicating variable-speed coil-only systems. 87 FR 16830, 16838. Specifically, the test approach may not result in tests that meet the stability requirements for testing (*i.e.,* the measurements might not meet the tolerance requirements in Table 2 of ANSI/ASHRAE 37–2009, ''Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment'' (''ASHRAE 37–2009''), which is incorporated by reference by the DOE test procedure). Or the proposed test procedure might evaluate such a basic model in a manner so unrepresentative of its true energy consumption characteristics as to provide materially inaccurate comparative data. *Id.* DOE stated that in this case, the manufacturer would be able to petition DOE for a waiver and include a suggested alternate test procedure as provided in 10 CFR 430.27. DOE elaborated that as part of its review of such a waiver and alternate test procedure, DOE would consider the correlation between results of a suggested alternate test procedure and results of testing when using the two-stage two-wire controls expected to be available in a general coil-only system installation, recognizing that the latter testing may involve dynamics that exceed the measurement tolerances discussed above. DOE would also consider the control hardware involved in achieving appropriate control for indoor and outdoor conditions and some understanding of how the control works. *Id.*

With respect to DOE's proposal to define variable speed communicating coil-only CACs and HPs, Emerson supported the differentiation of communicating and non-communicating variable speed CACs that maintains the ability to set compressor speed and optimize airflow relative to the compressor speed. (Emerson, No.14 at p.3) The Joint Advocates supported DOE's proposed definition but encouraged DOE to revise the definition to clarify that the installation instructions refer to those of the indoor unit (not of the control system). (Joint Advocates, No.18 at pp.2–3) AHRI commented that they supported the concept of the definition but recommended modifications to be more inclusive of other approaches. AHRI proposed an alternate definition as follows:

Variable-Speed Communicating Coil-Only Central Air Conditioner or Heat Pump means a variable-speed compressor system having a coil-only indoor unit that is installed with communicative controls to change the compressor speed by 3 or more speeds and indoor air flow by 2 or more speeds and controls the system by monitoring the change in system control parameter/s and automatically sets the compressor speed, indoor air flow and other system components as required to maintain the indoor room temperature. (AHRI, No.25 at p.6)

Carrier, Daikin, Nortek, and Samsung incorporated AHRI's proposed definition in their comments. (Carrier, No.25 at pp.2–3; Daikin, No.24 at p.2; Nortek, No.13 at p.2; Samsung, No.22 at p.2) AHRI, Carrier, Daikin, Nortek, and Samsung all agreed that DOE's proposed definition is too restrictive and should be modified to allow for potential alternate control strategies that could be used to properly control compressor speed and coordinate with indoor fan speed. *Id.* AHRI, Daikin, and Samsung stated that communication of set point and indoor temperature is not the only parameter that can be used to set fan and compressor speeds, suggesting that it is not necessary to achieve proper compressor control, and provided hypothetical examples of other control parameters that could be used to set compressor speeds, such as outside air conditions, indoor humidity levels, or refrigerant pressures and temperatures. (AHRI, No. 25 at p.6; Daikin, No.24 at p.2; Samsung, No.22 at pp.1–2) Daikin elaborated that the DOE definition should be modified to allow for technology advancements in control technology and recommended a definition similar to the definition for ''demand defrost control systems'', which requires that the control scheme ''monitor one or more parameters that always vary.'' (Daikin, No.24 at p.2) Samsung elaborated that DOE's proposal would require a communicating thermostat, which they claimed to be unnecessary for achieving appropriate compressor and fan control and stated would add unnecessary cost to the consumer. (Samsung, No.22 at pp.1–2)

While DOE acknowledges that there may be other control approaches to set compressor speed other than approaches that communicate the difference in space temperature and space setpoint temperature, DOE notes that minimizing this difference between a controlled parameter and its setpoint is the key function of the control system, and use of this parameter to set conditioning system operation is a fundamental feature of most modern control systems. In its proposal, DOE distinguished between communicating and non-communicating based on whether the system includes this fundamental aspect of control systems. DOE premised its proposals on the understanding that non-communicating systems would likely encounter greater issues regarding the representativeness of field-versus-tested performance, as compared to communicating systems.

As mentioned, DOE acknowledges that other control approaches may provide control represented adequately by the fixed-speed testing that is currently prescribed in its test procedures for CAC/HP system but given the fundamental difference in the control approach, *i.e.,* not using information about the space temperature deviation from setpoint, DOE does not believe there has been sufficient information provided confirming this adequacy. As DOE considers more comprehensive test procedure changes in a future rulemaking, it will further evaluate this issue and is open to revising the definition accordingly. Also, the proposed definition does not restrict other control parameters in addition to the space temperature offset from setpoint being used by the control system to set system operation. Hence, DOE is adopting the definition for communicating and non-communicating variable-speed coil-only system as proposed.

As previously introduced, DOE also considered that it may be necessary for manufacturers to certify whether a variable speed coil-only rating is based on non-communicating or communicating control but did not propose any certification requirements in the March 2022 CAC TP NOPR and instead stated that these changes may be considered in a separate rulemaking. 87 FR 16830, 16838.

In response, the Joint Advocates supported the concept that DOE require certification of VSCO units as communicating or non-communicating and encouraged DOE to finalize all pertinent certification provisions as soon as possible. (Joint Advocates, No. 18 at p. 2) As indicated, DOE may consider certification requirements in a separate rulemaking.

c. Applicability to Variable Speed Blower Coil Systems

In the March 2022 CAC TP NOPR, DOE further discussed that installations using non-communicating controls may not be limited only to variable-speed coil-only systems but could also occur with variable-speed blower-coil systems. 87 FR 16830, 16838. DOE noted that the proposed test procedure distinguishes between the testing approach used for coil-only configurations and the testing approach used for blower-coil configurations. *Id.* DOE argued that as coil-only installations are much more likely than blower-coil installations to involve use of both the existing furnace fan and existing controls, the non-communicating test procedure should be reflective of coil-only installations because they are more representative than blower coil installations. *Id.*

With respect to the applicability of the proposed VSCO testing provisions to variable speed blower-coil CACs and HPs, Emerson commented that the ability to set compressor speed and optimize airflow rate relative to compressor speed may be even more important in blower-coil systems than in coil-only systems and requested that DOE address this point. (Emerson, No. 14 at p. 3) Trane similarly asserted that it is important that DOE addresses non-communicating, blower-coil variable speed systems in addition to the proposed provisions for coil-only systems. (Trane, No. 10 at p. 2) Trane stated that such blower-coil systems have the same issue of misrepresenting the applied performance (*i.e.,* the performance measured in a field installation) by allowing them to use the communicating, variable speed procedures. *Id.* Trane elaborated that the wiring and control of such systems is obvious from the installation instructions, and they operate in a similar fashion to the furnace-coil (*i.e.,* coil-only) combinations with one or two-stage fan operation. *Id.* Trane provided an example [26] of such a product where a variable-speed CAC outdoor unit is certified with an indoor blower-coil unit only capable of one stage of airflow operation, and the connections are non-communicating 24V signals between equipment and thermostat. *Id.*

DOE acknowledges the concerns expressed by Trane and Emerson that questions remain regarding use of non-communicating controls for blower-coil systems and whether the compressor and/or fan speeds used for testing such systems are representative of field operation. However, DOE initiated this rulemaking to address a focused group of known issues, including those that have been raised through the test procedure waiver process. As noted in the March 2022 CAC TP NOPR, DOE limited its proposals addressing potential concerns about variable-speed systems to coil-only systems and may more comprehensively address these issues for all variable-speed systems in a future rulemaking that will satisfy the 7-year lookback requirements (*see* 42 U.S.C. 6293(b)(1)(A)). 87 FR 16830, 16838.

d. Represented Values and Testing Requirements

Coil-only testing approaches for variable-speed systems address the installation of variable-speed technology in which the newly installed system uses existing components, for example an existing furnace fan. For single-capacity and two-capacity split-system air-conditioners, certification requirements anticipate this likely installation scenario by requiring that such models include performance representations with a coil-only combination representative of the least-efficient combination in which the outdoor unit is sold (*see* 10 CFR 429.16(a)(1)). For variable speed split-system air conditioners, represented values are required for every individual combination distributed in commerce, including all coil-only and blower-coil combinations (*see* 10 CFR 429.16(a)(1)). However, there is no requirement that each model of outdoor unit include at least one representation based on the least-efficient coil-only combination distributed in commerce. In the March 2022 CAC TP NOPR, DOE considered whether such a requirement may be appropriate for variable-speed systems. 87 FR 16830, 16838–16839.

Through a review of product datasheets and installation instructions, DOE found that there is a wide range of instruction regarding whether variable-speed CAC systems must be paired with specific models of indoor units and/or air movers (*e.g.,* furnaces) in order to achieve the represented performance. *Id.* DOE identified that some literature is very clear that achieving the rated performance for a given outdoor unit is contingent on installation with specific components (*e.g.,* communicating controls and indoor fans capable of variable-speed operation), while other literature does not mention the need for such components. *Id.* DOE identified that this latter group is not limited to brands that have been granted test procedure waivers or interim waivers for testing variable-speed coil-only systems, indicating that the issue is more broadly applicable to variable-speed CAC installations and it is possible that variable-speed systems are being installed in coil-only applications for which representations of performance are not representative of actual performance (because the represented values are based on blower-coil pairing while the installation scenario is coil-only). *Id.* However, because less than 5 percent of variable speed system installations are coil-only [27] and the number of certified combinations of VSCO systems is a small percentage [28] of overall variable

[26] Trane provided an example of a Bosch system with AHRI reference number 206395973 and provided a link to the installation instructions: *https://www.bosch-thermotechnology.us/us/media/country_pool/documents/bosch_ids_bva15_iom_10.2020.pdf.*

[27] Based on information DOE has from the previous energy conservation standards rulemaking pertaining to central air conditioners and heat pumps. *See* 82 FR 1786.

[28] For example, there are roughly 27,000 combinations listed in the AHRI Database for which a non-zero intermediate indoor air volume rate is listed, indicating that the combination is a variable-speed model. DOE reviewed the current certifications in the certification compliance management system and found that there are approximately 400 variable-speed coil-only combinations, representing roughly 1.5 percent of

speed system certifications, DOE concluded that VSCO installations are not likely representative of variable speed system operation as a whole. *Id.*

In the March 2022 CAC TP NOPR, in order to improve representativeness of the representations of VSCO installations DOE proposed tested-combination requirements pertaining to variable speed systems, summarized here in Table III–3. 87 FR 16830, 16839.

TABLE III–3—PROPOSED TESTED COMBINATION REQUIREMENTS FOR VARIABLE SPEED SPLIT-SYSTEM CACS

Scenario	Required tested combination
Outdoor unit is distributed in commerce with any non-communicating coil-only combination(s)	Variable Speed Non-Communicating Coil-Only.
Outdoor unit is distributed in commerce with any communicating coil-only combination(s), but no non-communicating coil-only combination.	Variable Speed Communicating Coil-Only.
Outdoor unit is only distributed in commerce with blower-coil combinations	Variable Speed Blower-Coil.

In the March 2022 CAC TP NOPR, DOE noted that the variable-speed coil-only waiver petitions addressed both air-conditioners and heat pumps. 87 FR 16380, 16389. Thus, DOE considered whether the coil-only tested combination requirement should apply to variable speed heat pumps and/or to single-stage and/or two-stage heat pumps. *Id.* DOE noted that coil-only heat pumps allow the heating system to provide heat either using the furnace or the heat pump. *Id.* There has been greater interest in such systems in recent years, since they provide heating with a furnace in extreme cold conditions for which a heat pump may have limited capacity and/or reduced efficiency.[29] DOE proposed to require coil-only tested combinations for variable-speed heat pumps, but not for single- and two-stage heat pumps, because DOE expects that the representativeness of blower-coil tests would deviate more from coil-only tests for variable-speed systems, due to the use of a variable-speed indoor fan and use of an intermediate air volume rate used for intermediate-speed testing for variable-speed systems. *Id.* DOE argued that the test procedures for single-stage and two-stage heat pumps are more restrictive with regard to allowed air volume rates and thus performance differences between blower-coil and coil-only operation would be less. *Id.*

Regarding variable-speed coil-only systems using indoor units manufactured by independent coil manufacturers (''ICMs''), in the March 2022 CAC TP NOPR, DOE noted that the regulations require certification of the performance of every individual combination distributed in commerce, including both blower-coil and coil-only (*see* 10 CFR 429.16(a)(1)). *Id.* However, a tested combination for an ICM indoor unit must include the least-efficient outdoor unit with which the indoor unit is distributed in commerce (*see* 10 CFR 429.6(b)(2)(i)). *Id.* DOE stated in the NOPR that it does not believe any changes are needed with respect to ICM certifications as the current regulations already encompass representing all combinations distributed in commerce, including noncommunicating and communicating variable-speed coil only systems. *Id.* Further, DOE noted that the least-efficient outdoor unit with which the indoor unit is distributed in commerce is not likely to be a variable-speed system, and thus the question of communicating or non-communicating coil-only status does not apply. *Id.*

DOE received comments from multiple stakeholders regarding its proposals for represented values and testing requirements for VSCO CACs and HPs.

Lennox agreed with DOE's proposal not to require that all variable-speed CACs and HPs have a coil-only representation, as is required for single- and two-stage split air-conditioning systems. (Lennox, No. 19 at p. 3)

Rheem disagreed with DOE's proposal to implement differing test methods for communicating and non-communicating VSCO systems. (Rheem, No. 21 at p. 2) Rheem elaborated that even though they support the DOE proposal to expand the federal test procedure to account for coil-only variable speed systems, the exclusive distinction between communicating and non-communicating classifications for coil-only variable speed systems creates additional complexity and has the potential to add more test burden while reducing market flexibility. *Id.* Rheem stated that ideally there would only be one test procedure for coil-only variable speed systems, and preferably the one test would be the non-communicating method, as this would likely represent the least efficient system that may be installed the field. *Id.* Rheem recommended that DOE reconsider the merits of implementing differing test methods and suggested further study by DOE to quantify the difference in efficiency representation between the test methods for communicating versus non-communicating prior to incorporating this into the final rule. *Id.*

DOE is working to better understand the differences in performance between communicating and non-communicating systems but believes that the fundamental differences in the control architecture of the two approaches will lead to performance differences. For example, DOE expects that non-communicating VSCO systems, when subjected to an applied load, will likely demonstrate ''hunting'' for compressor speed, fan speeds, and valve positions, which would reduce the measured efficiency and potentially invalidate test results. For communicating VSCO systems, however, DOE expects that these systems will be more likely to include the requisite hardware and controls architecture to accurately and repeatably set position of modulating components during testing.

Trane commented that although DOE's recommendations for variable-speed coil-only test procedures were a good start at addressing 24V coil-only ratings with variable speed outdoor units, it needs to be expanded. (Trane, No. 10 at pp. 1–2) Trane specified that in situations where two-stage thermostats are paired with a two-stage airflow capable furnace, the proposed procedure is a reasonable rating approach, but that in the converse case with a single-stage thermostat or a single-stage airflow furnace, the proposed procedure will inflate the unit efficiency. *Id.* Trane recommended that two-different 'coil-only ratings' should be listed for such systems. *Id.* Trane elaborated that an accessory note would indicate the applicable installation (1-stage or 2-stage). *Id.* The rating

the total variable speed combinations certified to the Department.

[29] *https://www.trane.com/residential/en/resources/glossary/dual-fuel-heat-pump/* (last accessed 2/4/2022).

procedure for the 1-stage case would essentially follow the single capacity system rating procedures, whereas the 2-stage case would follow the procedure proposed by DOE in the March 2022 CAC TP NOPR. *Id.* Trane also provided two connection diagrams [30] as examples. *Id.* Both diagrams showed connection with either a 1-stage thermostat and indoor unit or a 2-stage thermostat and indoor unit. *Id.*

DOE notes that representations of performance for both single-stage and two-stage installations are not required for two-stage coil-only systems. The two-stage coil only test provisions in the current DOE test procedure are premised on the installation location having two-stage thermostat wiring (Final Rule Technical Supporting Document, EERE–2014–BT–STD–0048, No. 98, p. 8–25). DOE similarly assumes the presence of the necessary wiring for the installation of variable-speed coil-only systems in two-stage configuration.

Daikin commented that due to the nature of variable-speed CAC and HP, having a coil-only representation requirement for ICMs may be appropriate. (Daikin, No. 24 at p. 2) DOE notes that the current requirements in 10 CFR 429.16 already require a representation for every combination distributed in commerce, and hence any coil-only product distributed in commerce by an ICM would already be required to have a coil-only representation for variable-speed combinations with which it is distributed in commerce. The further clarification of non-communicating VSCO combinations in this rule extends that requirement such that there must at least be a representation based on the non-communicating VSCO test procedure if non-communicating combinations are distributed in commerce.

Daikin and Rheem disagreed with the proposal to require the tested combination to be coil-only for variable-speed systems that are distributed in commerce in some cases with coil-only combinations. (Daikin, No. 24 at p. 2; Rheem, No. 21 at p. 2) Daikin claimed that a mandatory coil-only tested combination requirement for variable speed systems would burden manufacturers of such systems with additional testing requirements and would force lower represented values not indicative of variable speed performance in typical installations. (Daikin, No. 24 at p. 2) Daikin stated that manufacturers would still test a blower-coil combination if the regulations require them to test a coil-only combination, because of the vast majority of full-system installations for VS systems. *Id.* Although Daikin did not explain why a manufacturer couldn't test a coil-only combination and use an alternative efficiency determination method (''AEDM'') to determine the representative value for blower-coil systems with which the same outdoor unit is paired, DOE acknowledges that the wider range of air volume rates allowed with blower-coil testing as compared with coil-only testing [31] could make the use of testing (as opposed to an AEDM) more important in determination of an accurate representation for blower-coil systems than for coil-only systems. In addition, the Emerson comments described in the following paragraph suggest that many variable-speed outdoor models with blower-coil representations may be distributed in commerce for a small percentage of installations in coil-only combinations (*see* Emerson, No. 14 at p. 2). Although not explicitly mentioned in comments addressing this topic, DOE realizes that manufacturers may have already completed testing for many models in advance of the January 1, 2023, date on which appendix M1 will be required—requiring a coil-only representation at this late stage may require additional testing. Thus, DOE is partially retracting the proposed requirement for a coil-only tested combination for VS systems distributed in commerce in coil-only combinations. Specifically, DOE is maintaining this requirement only for non-communicating coil-only combinations. As already discussed, the control approach for non-communicating systems is fundamentally different than the control approach for communicating systems. Hence, DOE is not convinced that a test using the provisions for communicating VS systems (either blower-coil or coil-only) would provide sufficient indication of non-communicating performance to allow accurate prediction of non-communicating performance using an AEDM based on the communicating system test. Thus, DOE will not require at this time that the tested combination be coil-only in cases where only communicating VSCO combinations (and no non-communicating VSCO combinations) are distributed in commerce with a given outdoor unit. However, DOE may reconsider these decisions in a later rulemaking.

Emerson commented that it agreed with DOE's assessment that less than 5 percent of variable speed systems are installed as coil-only configurations today. (Emerson, No. 14 at pp. 1–2) However, Emerson commented that it believes that two-stage CACs currently have a similarly small portion of installations in a coil-only configuration, and elaborated that they believe that energy specifications and test procedures should be technology-neutral and advocated that all modulating technology (*i.e.,* two or more stages) should be treated in the same manner regarding coil-only representation requirements. *Id.* Emerson asserted that because of the ability to install VSCO CACs with a non-communicating thermostat, and because coil-only installation percentages are similar between variable speed and two-stage CACs, the coil-only representation requirement should either apply for both technologies or for neither technology. *Id.* Emerson provided examples of variable speed CAC product literature indicating that even for outdoor units with communicating capability, there are instructions for installation in a non-communicating setup using a conventional 24V non-communicating thermostat control.[32] *Id.* Emerson also highlighted that in some cases, the product literature provides instructions for a non-communicating coil-only installation but shows represented values that are unclear whether they are derived from a blower-coil pairing or from the non-communicating coil-only installation.[33] *Id.* Emerson elaborated that this creates the possibility that variable speed systems are currently being installed in coil-only applications

[30] Trane provided examples of two Bosch systems with AHRI reference numbers 206395973 and 206395967 and provided a link to the installation instructions: *https://www.bosch-thermotechnology.us/us/media/country_pool/documents/bosch_ids_bovb18_iom_10.2020.pdf.*

[31] As described in section III.C.2.c, VSCO systems will use at most two air volume rates, while blower-coil VS systems may have multiple air volume rates. First, there is an intermediate air volume rate explicitly anticipated for such systems (*see* appendix M1, section 3.1.4.3). Also, as discussed in section III.D.1, DOE is clarifying that air volume rate may change with outdoor air temperature.

[32] Emerson identified the Bosch BOVB 18 split system heat pump with ratings as low as 15 SEER (link: *https://issuu.com/boschthermotechnology/docs/bosch_ids_family?fr=sYmYyNDIwODA0Mzg*) and the Daikin FTQ series heating and cooling systems, with SEER ratings from 14.8–16 SEER (link: *https://backend.daikincomfort.com/docs/default-source/product-documents/light-commercial/brochures/cb-ftqducted.pdf?sfvrsn=608a2626_20&_ga=2.261207556.887080242.1653602507-1260064005.1653602507&_gl=1*1cbcmhc*_ga*MTI2MDA2NDAwNS4xNjUzNjAyNTA3*_ga_MXJ05EZJZT*MTY1MzYwMjUwNi4xLjEuMTY1MzYwMjU5OS4w*).

[33] Emerson identified the Lennox Elite Series EL18XCV Units (link: *https://tech.lennoxintl.com/C03e7o14l/VIu12Ch2uV/507955-01a.pdf*) and the Carrier 24VNA0 Infinity Variable Speed Air Conditioners with Greenspeed Intelligence (link: *https://esmithair.com/wp-content/uploads/2020/02/Air-Conditioners_24VNA0.pdf*).

for which the system representations may not be representative of actual performance. *Id.*

In response to Emerson's comments about installation instructions allowing for installation of non-communicating coil-only installations for VS systems that presumably are tested on the basis of blower-coil configurations, DOE notes that 10 CFR 429.16 already requires that representations be provided for all combinations distributed in commerce. Hence, representations are required for coil-only combinations for any VS outdoor unit that is distributed in commerce in such combinations. The changes in this final rule stipulate that any such coil-only representation be based on whether the control system with which it is installed is communicating or non-communicating.

In response to Emerson's comments that coil-only installations are rare also for two-stage systems, DOE notes that the comments received on the topic of the default fan power values for low-stage operation when testing two-stage coil-only systems (*see* section III.C.1) suggests otherwise. None of the comments addressed the possibility that a coil-only configuration may not be representative of two-stage system installations. Further, the discussion emphasized the trends in motor technology of furnaces that have shipped in recent years (*see, e.g.,* AHRI, No. 25 at p. 3), suggesting that the representative air movers for two-stage systems will in many cases be existing furnaces rather than the fans of blower-coils systems. Hence, in this final rule DOE has not removed the coil-only representation requirement for two-stage systems or added such a requirement for variable-speed systems.

In summary, manufacturers will be required to represent variable-speed ACs based on how they distribute them in commerce, which includes whether they are coil-only communicating, coil-only noncommunicating, or blower coil, as applicable to a given model of outdoor unit.

3. Space-Constrained Coil-Only CAC Ratings

a. Background

In the March 2022 CAC TP NOPR, DOE discussed the current requirements for determining represented values of energy efficiency and capacity for CACs and HPs at § 429.16(a). 87 FR 16830, 16839–16841. This section specifies that for each model of outdoor unit of a split-system CAC with single-stage or two-stage compressors, manufacturers are required to provide represented values based on at least one coil-only combination that is representative of the least efficient combination distributed in commerce with that model of outdoor unit. The requirement to provide coil-only ratings for each basic model also applies to single split CACs designed for space-constrained applications (''SC–CAC''). Additional blower-coil ratings are allowed (*i.e.,* optional) for any applicable individual combinations, if distributed in commerce. 10 CFR 429.16(a).

DOE also discussed the related waiver requests received from manufacturers of space-constrained split-system CACs following the January 2017 CAC TP Final Rule. 87 FR 16830, 16839–16841. DOE received petitions for test procedure waivers from National Comfort Products (''NCP''), AeroSys, and First Company related to the represented value requirements for space-constrained split-system CACs. *Id.* Each petitioner claimed that specified basic models of SC–CAC outdoor units listed in their respective petitions are designed and intended to be sold only with proprietary blower-coil indoor units equipped with high-efficiency electronically commutated (''ECM'') fan motors, and not as a coil-only combination, and therefore requested exemption from the requirements at 10 CFR 429.16(a)(1) to provide represented values as a coil-only combination. (NCP, EERE–2017–BT–WAV–0030, No. 1 at p. 1; AeroSys, EERE–2017–BT–WAV–0042; No. 1 at p. 1; First Co., EERE–2018–BT–WAV–0012, No. 2 at p. 1) As described in the March 2022 CAC TP NOPR, DOE denied First Co.'s petition, Aerosys filed for bankruptcy following DOE's granting them an interim waiver, and DOE granted an interim waiver applicable for appendix M to NCP on May 15, 2018. 87 FR 16830, 16841.

In the March 2022 CAC TP NOPR, DOE proposed several revisions related to representation requirements for space-constrained split-system CACs. 87 FR 16830, 16840–16841. Specifically, DOE proposed to amend the language in the table found in 10 CFR 429.16(a)(1) to clarify the rating requirements pertaining to single-split CACs with single-stage or two-stage compressors.[34] *Id.* DOE also tentatively concluded that measuring the performance of space-constrained systems exclusively with high-efficiency blower-coil combinations, as requested in waiver petitions from NCP, AeroSys, and First Co., is not generally representative of field operation. *Id.* DOE also noted that because NCP's waiver petition and the prescribed alternate test procedure are specific to appendix M, the interim waiver will terminate on the date on which testing is required under appendix M1 (*i.e.,* January 1, 2023). *Id.* DOE therefore did not propose amendments to appendix M1 to incorporate the interim test procedure waiver granted to NCP, and requested comment on these proposals. *Id.*

The Joint Advocates and Lennox supported DOE's proposal to require coil-only representations for all single- and two-stage single-split system CACs, including space-constrained systems. (Joint Advocates, No. 18 at p. 3; Lennox, No. 19 at p. 3) Lennox elaborated on their support by stating that consistency in requirements across similar product types provides consumers with more information to properly compare product choices and promotes market fairness.

In contrast with the Joint Advocates and Lennox, AHRI and NCP did not support DOE's proposal. (AHRI, No. 25 at pp. 2–3; NCP, No. 16 at pp. 2–10) AHRI and NCP criticized several aspects of DOE's proposal to require coil-only ratings for space-constrained CACs. *Id.* In general, AHRI and NCP critiqued the factual basis underlying DOE's assumptions that a coil-only rating would be most representative of real-world performance for space-constrained systems, and asserted that DOE must amend the test procedure in appendix M1 to incorporate the interim waiver granted to NCP. (AHRI, No. 25 at p. 3; NCP, No. 16 at p. 2) NCP also claimed that they would face undue burden from DOE's proposal, related to sunk design and testing costs and potential redesign costs they claim would be required to generate a compliant coil-only rating. (NCP, No. 16 at p. 2) AHRI elaborated by claiming that DOE did not provide persuasive data to justify not amending appendix M1 to specify testing of space-constrained split-system CACs in a manner consistent with NCP's waiver and that the test procedure outlined in the waiver produces results that more accurately reflect the performance of space-constrained CAC systems, as opposed to a coil-only rating. (AHRI, No. 25 at p. 3)

b. Applicability of Coil-Only Requirement

In the March 2022 CAC TP NOPR, DOE briefly discussed some of the reasoning from past documents used to

[34] DOE's proposed clarifications would require every single-stage and two-stage outdoor unit of single-split CAC to have a compliant rating with a coil-only combination that is distributed in commerce and representative of the least efficient combination distributed in commerce for that particular model of outdoor unit.

support the coil-only representation requirement for spilt-system air conditioners generally. 87 FR 16830, 16847. DOE also discussed the applicability of the coil-only requirement for space-constrained CACs, specifically. 87 FR 16830, 16841. This section provides a more extensive discussion of the historical context to further support DOE's position on this matter, in light of comments on this rulemaking as well as historical assertions from manufacturers of space-constrained products that the coil-only provisions should not apply to these products (*e.g.,* see First Co. comments at EERE–2016–BT–TP–0029, No. 21 at p. 2).

The historical application of the coil-only representation requirement to SC–CACs involves several changes in regulatory provisions for this type of product, including the provisions for ''Through-the-Wall'' (TTW) product classes of CACs and HPs. In their waiver petition, and in comments in response to the March 2022 CAC TP NOPR, NCP refers to their models of space-constrained CACs as ''TTW'' products. However, while the models that were the subjects of the NCP waiver are physically installed through the exterior wall, the specific term ''through-the-wall'' no longer has regulatory meaning as a defined class of products. As explained in the following paragraphs, the TTW product class expired from DOE definitions in 2010 and is no longer applicable.

In a May 2002 final rule for energy conservation standards for CACs and HPs, (''May 2002 CAC ECS Final Rule''), DOE established separate product classes of SC and TTW product classes. 67 FR 36368, 36406 (May 23, 2002). DOE defined TTW CACs and HPs based on physical characteristics of the unit (*i.e.,* limitations on cooling capacity and heat exchanger area), and the installation scenario (*i.e.,* designed to be installed within a fixed-size opening in an external wall). 10 CFR 430.2. The definition for TTW CACs was also limited to products manufactured prior to January 23, 2010. *Id.* In an August 2004 rulemaking for energy conservation standards for CACs and HPs (''August 2004 CAC ECS Final Rule''), DOE elaborated that after January 23, 2010, the standards for space-constrained products would apply to TTW CACs and HPs. 69 FR 50997, 50998 (August 17, 2004). In a June 2011 direct final rule (DFR) regarding energy conservation standards for residential furnaces and CACs/HPs (''June 2011 Furnaces & CAC ECS DFR'') DOE discussed the recent expiration of the through-the-wall product class for CACs. 76 FR 37408, 37446 (June 27, 2011). DOE noted that the TTW product class expired on January 23, 2010, and reclassified all TTW products into corresponding classes of space-constrained CACs. *Id.* To further illuminate this point, DOE added a footnote to the energy conservation standards tables at § 430.32(c)(2) to clarify the treatment of TTW product classes. 76 FR 37408, 37546.

The existence of the TTW product class (and subsequent expiration in 2010) interacts with the coil-only representation requirements described by DOE in other documents. In an October 2007 test procedure final rule for CACs (''October 2007 CAC TP Final Rule''), DOE discussed the required indoor unit combinations for determination of represented values for CACs and HPs. 72 FR 59906, 59913–59914 (October 10, 2007). DOE clarified in this rule that for most classes of single-stage, single-split CACs the highest sales volume indoor unit would be a coil-only indoor unit, and thus DOE's regulations required that represented values for these systems be determined based on a coil-only pairing. *Id.* DOE included exemptions to the coil-only representation requirement for certain kinds of single-stage, single-split CACs that would likely be distributed in commerce only with blower-coil indoor units. *Id.* These exempted product classes included mini-splits, multi-splits, and TTW units. *Id.* For each of these classes, DOE clarified in the October 2007 CAC TP Final Rule that representations could be based on blower-coil combinations. *Id.*

In subsequent documents, DOE re-iterated the coil-only representation requirement and clarified the applicability to space-constrained CACs. In a draft guidance document published August 19, 2014 (''2014 CAC Guidance''), DOE stated that split-system CACs with more than one compressor stage may be tested and rated as a blower-coil combination only if the condensing unit is sold exclusively with blower-coil indoor units. EERE–2014–BT–GUID–0033–0001, p. 1. The 2014 CAC Guidance stated that per existing regulations in the CFR, no provisions existed permitting use of a blower-coil for testing and rating a split-system central air conditioner where the condenser unit is also offered for sale with a coil-only indoor unit and that, furthermore, there was no provision in the CFR permitting the use of a blower-coil for testing and rating a condensing unit with a single-speed compressor. *Id.* Soon thereafter, DOE published a test procedure final rule pertaining to CACs and HPs (''June 2016 CAC TP Final Rule''). 81 FR 36992 (June 8, 2016). DOE adopted language that explicitly required a coil-only representation requirement for single-split single- and two-stage CACs into its provisions at 10 CFR 429.16(a)(1), which became effective 180 days following the publication of the final rule (*i.e.,* December 5, 2016). DOE also adopted these provisions for space-constrained split-system CACs given that they are subject to the same test procedures and sampling plans as non-space-constrained single-split air conditioners. 81 FR 36992, 37002. DOE also adopted provisions at § 429.16(b)(2) requiring that such systems be tested with ''the model of coil-only indoor unit that is likely to have the largest volume of retail sales with the particular model of indoor unit.'' 81 FR 36992, 37050.

In the January 2017 CAC TP Final Rule, DOE kept the same approach from the June 2016 CAC TP Final Rule requiring that represented values for one- and two-stage single-split CACs (including space-constrained) must be determined based on a coil-only value representative of the least-efficient combination distributed in commerce with that particular model of outdoor unit. DOE amended the tested combination requirements to prevent possible conflict between the representation requirements and the tested combination requirements. Instead of requiring the ''highest sales volume'' indoor unit in the tested combination, the January 2017 CAC TP Final Rule required, simply, ''A model of coil-only indoor unit''. 82 FR 1426, 1470. This clarification made clear that in all instances, one- and two-stage single-split CACs (including space-constrained) were required to test and determine represented values based on a coil-only indoor unit, regardless of prevalence of retail sales.

In the January 2017 CAC TP Final Rule, DOE also fielded comments from manufacturers of space-constrained CACs regarding the interplay of the TTW and space-constrained product classes with the coil-only representation and testing requirements. 82 FR 1426, 1461–1462. DOE reiterated that an exclusion for coil-only testing of space-constrained products was never established, and that manufacturers of space-constrained products had always been subject to the coil-only rating requirement, as clarified in the June 2016 CAC TP Final Rule. *Id.* DOE also alluded to the expiration of the TTW product class, describing that the coil-only exclusion for TTW CACs, previously present in 10 CFR 429.16(a)(2)(ii), would not encompass the circumstances described by the commenters. *Id.* DOE reiterated that while the language being adopted in the January 2017 CAC TP Final Rule explicitly removed the exclusion from a coil-only testing requirement for TTW units sold and installed with blower-coil units—it would have no effect on the ratings procedures for space-constrained units (due the 2010 expiration of the TTW product class), which are subject to the same coil-only provisions as for other split system CACs. *Id.*

In summary, single-split single-stage CACs, including space-constrained CACs, have historically always been subject to a coil-only representation requirement, via application of the highest-sales-volume-combination (HSVC) concept. DOE has, at multiple points, made this requirement more explicit in the regulatory text but has consistently held that space-constrained CACs were never excluded from this requirement. For space-constrained CACs meeting the historical definition of through-the-wall (TTW) products, DOE has similarly explained in multiple documents that this product class expired in January 2010 at which point TTW products were subsumed by the space-constrained product class, which DOE explained explicitly in the January 2017 CAC TP Final Rule (82 FR 1426, 1462). Through these facts it is evident that through-the-wall space-constrained CACs, such as those identified in NCP's waiver petition, have been subject to the coil-only rating requirement at least since 2010, and the January 2017 CAC TP Final Rule did not represent the first instance of this practice.

c. Other Considerations

i. Prevalence of Coil-Only Installations for Space-Constrained CACs

In response to the March 2022 CAC TP NOPR, NCP commented that it does not manufacture a coil-only indoor unit that may be matched with the condensing units specified in their waiver, nor do they identify or offer any other coil-only matched system for distribution in commerce. (NCP, No. 16 at p.10) Additionally, AHRI and NCP questioned the representativeness of a coil-only rating for space-constrained products. Specifically, they both challenged DOE's assumption that the relative division of coil-only installations applies equally between typical CAC and space-constrained CAC. (AHRI, No. 25 at p. 2; NCP, No. 16 at pp. 3–5) AHRI asserted that space-constrained CAC systems are typically installed in multi-family buildings (as opposed to single-family homes) and claimed that coil-only installations for space-constrained systems are significantly less common than coil-only installations for conventional split CACs. (AHRI, No. 25 at p. 2) AHRI cited DOE's determination that, in 2021, 39% of split-system CAC installations would be blower-coil indoor units and the remaining 61 percent would be coil-only installations.[35] *Id.* AHRI contrasted this with 2015 RECS microdata showing that for multi-family buildings, only 45 percent of buildings use natural gas or other fuel source for heating while 55 percent of buildings use electric resistance heating. *Id.* DOE interprets AHRI's comment to imply that space-constrained CACs are most typically installed in multi-family housing, and multi-family buildings are predominated by electric heating (which would be indicative of a blower-coil CAC using electric resistance heating elements) rather than combustion heating (which would be indicative of a coil-only CAC paired with a furnace). Therefore, AHRI's comment implies that space-constrained CACs would be represented more accurately by a blower-coil combination instead of a coil-only combination. NCP reiterated the data presented by AHRI and commented that coil-only installations for space-constrained systems are uncommon. (NCP, No. 16 at pp. 3–5)

DOE notes that although AHRI provided summary data regarding the heating source for multi-family buildings, neither AHRI nor NCP provided concrete data showing the relative proportion of coil-only installations for space-constrained CACs vs coil-only installations for conventional CACs. DOE finds that AHRI's inference that a higher proportion of electric heating in multi-family homes does not constitute sufficient evidence to conclude that the proportion of coil-only installations for space-constrained systems is lower than the proportion for conventional systems. With respect to NCP's comment that they do not manufacture or specify coil-only indoor units to be paired with their TTW condensing units, DOE notes that the coil-only representation requirement is equally applicable for all single- and two-stage split-system CACs. This requirement accounts for the likelihood that CAC outdoor units may be installed as a coil-only configuration, even if not specified as such by the outdoor unit manufacturer. In this manner, the coil-only requirement provides a conservative estimate of performance that captures the range of likely installation scenarios for these products. Therefore, DOE concludes that an approach consistent with the January 2017 CAC TP Final Rule (*i.e.,* requiring coil-only representations for all single- and two-stage split system CACs, including space-constrained) provides more representative measurement of space-constrained system performance. DOE also acknowledges Lennox's comment stating that by continuing to require a coil-only representation for all types of split-system CACs, consumers would have better ability to compare products on the basis of cost-efficiency tradeoffs. (Lennox, No. 19 at p. 3)

ii. Systems Distributed in Commerce

In the March 2022 CAC TP NOPR, DOE highlighted instances for which outdoor units designed for space-constrained applications are being distributed in commerce without a corresponding blower-coil indoor unit, indicating the potential for pairing a replacement outdoor unit with an existing indoor unit using a legacy fan that would not likely be comparable to the ECM fan of the blower-coil indoor unit on which the system rating is based. 87 FR 16830, 16841. DOE noted that the cited example is for sale of an NCP outdoor unit, which indicates that it is impossible to ensure its installation with a blower-coil indoor unit, as suggested by NCP's waiver petition. *Id.*

AHRI and NCP challenged DOE's conclusion that NCP's space-constrained CAC models are distributed in commerce with a coil-only indoor unit pairing. (AHRI, No. 25 at p. 2; NCP, No. 16 at p. 10) NCP stated that they do not manufacture a coil-only indoor unit that may be matched with their space-constrained condensers, nor do they identify or offer any other coil-only matched system for distribution in commerce. (NCP, No. 16 at p. 10) NCP also noted that in the case identified by DOE of an online distributor selling NCP's space-constrained outdoor units in an unmatched pairing, this was in error and that NCP quickly took actions to rectify the situation. *Id.* NCP demonstrated steps they undertake to ensure that its space-constrained condenser units are properly sold and marketed as matching pairs with blower-coil indoor units and offered to provide enhanced documentation including a product label. *Id.* NCP concluded by stating that as a small company, it does not have the appropriate resources to police the

[35] As introduced in section III.D.1.b of this rulemaking, DOE first discussed its assumptions regarding market penetration rates for various types of furnace fan motors in the December 2016 CAC ECS TSD (EERE–2014–BT–STD–0048–0098, page 7–16). These same proportions were carried through in the analysis proposed in the March 2022 CAC TP NOPR.

actions of distributors or installers. (NCP, No. 16 at p. 7) AHRI offered similar commentary, claiming that DOE made a logical leap by attributing the actions of a single distributor to actions taken by NCP, and asserted that the distributor did not follow manufacturer sales guidelines. (AHRI, No. 25 at p. 2)

Regarding NCP's claim that the example provided by DOE was an aberration and not representative of their normal distribution practices, DOE has found additional evidence beyond what was presented in the NOPR demonstrating that NCP condensers may be distributed in commerce as unspecified pairings. DOE has found additional listings from two other distributors advertising NCP condensing units (in fact, the same units identified in NCP's interim waiver) being sold without a matched blower-coil indoor unit.[36] Further, while DOE acknowledges NCP's status as a small business entity, and the potential difficulties with policing the activity of distributors, DOE notes that the coil-only representation requirement for split-system one and two-stage CACs is designed to capture the range of installations scenarios in which these systems are likely to be installed. Correspondingly, the coil-only representation requirement offers a conservative method that ensures that consumers would be purchasing systems that are compliant with national standards, even if installed in a coil-only configuration.

iii. Interaction With Energy Conservation Standards

Notwithstanding their concerns about the representativeness of coil-only representations for space-constrained CACs, NCP stated that they have begun the process of designing and testing modifications to their space-constrained outdoor units that could allow certifications with coil-only representations (such as incorporating high-efficiency DC fan motors, microchannel heat exchangers and/or proprietary compressor developments), but that these design changes would come at a considerable cost increase.[37] (NCP, No. 16 at pp. 5–7) NCP claimed that they utilize the most efficient components available that are economically justifiable and asserted that the technical constraints preventing the certification of its space-constrained condenser units as a coil-only combination have not changed since they submitted their original waiver petition. *Id.* Particularly, NCP highlighted that they are limited in what they can do to improve the efficiency of the units due to the dimensional restrictions of the space-constrained configuration. *Id.* NCP also provided data showing that even if DOE were to introduce a lower default fan power coefficient for coil-only CACs at low-stage operation (as discussed in section III.C.1 of this final rule), it would still be difficult to meet DOE standards. *Id.*

AHRI and NCP also claimed that DOE's decision at this stage in the process to terminate and discontinue the test procedure waiver for appendix M by not incorporating it into the M1 procedure would place undue burden on NCP, a small manufacturer. (AHRI, No. 25 at p. 2; NCP, No. 16 at pp. 9–10) AHRI stated that manufacturers have substantially completed testing according to appendix M1 and that NCP was in the process of finalizing M1 product designs and preparing for 2023 implementation. (AHRI, No. 25 at p. 2) NCP stated that its space-constrained condensing units are designed and intended to be paired with specified air handlers. (NCP, No. 16 at pp. 9–10) NCP elaborated that due to the new M1 testing procedures they have designed, prototyped, tested, and begun manufacture of a new air handler, which they asserted was an arduous, costly undertaking for a small business. *Id.* NCP also highlighted the challenges of simultaneously addressing the pending refrigerant change in 2025, which they asserted would require replacement of R–410a refrigerants in its outdoor units. *Id.* NCP concluded by stating that if DOE continues with the proposed approach of requiring coil-only representations for space-constrained systems tested according to appendix M1, it will require redesign of their space-constrained products (as previously described) and would substantially increase the burden and cost of testing as well as resource allocation for NCP. *Id.*

With respect to NCP and AHRI's arguments regarding the potential difficulties meeting standards, DOE notes that the stringency of standards for such TTW products have not changed since Jan 23, 2010 (the date when the TTW product class was subsumed by the space-constrained product class) and they have been required to meet a 12 SEER standard ever since. The stringency will also not be increasing for these products in the upcoming 2023 standards, where DOE has established equivalent-stringency SEER2 standards. Lennox concurred with DOE's finding that extending the current test procedure waivers for space-constrained systems is unnecessary, because adequate standards relief was already provided when DOE maintained the existing standard levels with no increase in stringency during the previous energy conservation standards rulemaking. (Lennox, No. 19 at pp. 3–4) Because DOE did not increase the stringency of standards for space-constrained systems in the previous ECS rulemaking, manufacturers of space-constrained systems who were already producing space-constrained products compliant with standards in terms of SEER and following the existing representation requirements (*i.e.,* based on a coil-only rating)[38] would not incur any costs in order to comply with SEER2 standards based on coil-only ratings. DOE also notes that in their comment, NCP identified several combinations of coil-only indoor units that were technologically capable of meeting SEER2 standard levels. Additionally, the topic of cost/efficiency tradeoffs for space-constrained systems was discussed in the previous ECS rulemaking, and are not subject to reevaluation in the context of this rulemaking, which is limited to the test procedure.

d. Conclusions

As described in preceding sections, DOE has made the following determinations regarding representation requirements for space-constrained CACs:

1. Single-split, single-stage CACs, including space-constrained CACs, have historically always been subject to a

[36] DOE identified the NCPE–418–5010 condensing unit sold as a standalone unit at both SkipTheWarehouse and on Johnstone Supply, available online at: *https://skipthewarehouse.com/ncpe4185010-15-ton-thru-the-wall-split-system-condensing-unit* and *https://www.johnstonesupply.com/product-view?pID=B61-354,* respectively.

[37] On August 11, 2022, NCP submitted an enclosure to their earlier comment that contained new test data and design information. NCP claimed that they had not yet identified a combination of components that would allow its TTW condensing units tested with coil-only indoor units to reach the applicable energy conservation standards and capacity requirements. NCP reiterated their opinion that the unacceptable test results were caused by the physical constraints placed on space-constrained TTW condensing units. (NCP, No. 26 at p.2) Available online at: *https://www.regulations.gov/document/EERE-2021-BT-TP-0030-0026.*

[38] See October 2016 CAC ECS notification of data availability NODA, where DOE described its provisional translations between SEER and SEER2 for space-constrained products. DOE conducted a crosswalk for SC–CACs to account for the increased minimum external static pressure requirement in appendix M1 which would increase the indoor fan power consumption. DOE's crosswalk analysis assumed a coil-only rating as the starting point (*i.e.,* for appendix M measurements), and a coil-only rating as the end point (*i.e.,* for appendix M1 measurements). 81 FR 74727, 74729–74730.

coil-only representation requirement. DOE has clarified this requirement at multiple points in the regulatory text, but has consistently held that space-constrained CACs were never excluded from this requirement.

2. For space-constrained CACs meeting the historical definition of through-the-wall (TTW) products, DOE has similarly explained in multiple documents that this product class expired in January 2010 at which point TTW products were subsumed by the space-constrained product class and became subject to the coil-only representation requirement.

3. Based on the best available data, the coil-only representation requirement for split-system space-constrained CACs is representative of real-world installations. This determination is supported by the finding that, despite manufacturer efforts, space-constrained outdoor units are still being distributed in commerce in a manner consistent with coil-only installations.

4. Space-constrained systems have been subject to a coil-only requirement since January 2010, and standards have remained at equivalent stringency since that time. Manufacturers of space-constrained systems that have been producing compliant products would not incur any costs in order to comply with SEER2 standards.

Further, DOE notes that the interim waiver granted to NCP was only applicable for appendix M, and NCP did not submit any waiver request applicable to appendix M1. As previously discussed, DOE proposed in the NOPR not to incorporate into appendix M1 the waiver method granted to NCP for appendix M. In summary, consistent with its proposals in the March 2022 CAC TP NOPR DOE is maintaining the requirement that space-constrained CACs follow the existing representation requirements at 10 CFR 429.16, including the requirement for all one- and two-stage split-system CACs to develop represented values based on testing with a coil-only indoor unit representative of the least efficient coil-only indoor unit distributed in commerce for that basic model.

D. Other Test Procedure Revisions

1. Air Volume Rate Changing With Outdoor Conditions

In the NOPR, DOE explained that requirements for setting air volume rate in section 3.1.4 of appendix M1 may be in conflict with instructions to use air volume rates that represent a ''normal installation'' in section 3.2, particularly for modern blower-coil systems with multiple-speed or variable-speed indoor fans and control systems, which may change air volume rate in response to operating conditions such as outdoor air temperature. 87 FR 16830, 16841. To address this issue, DOE proposed in the March 2022 CAC TP NOPR to explicitly state in Step 7 of sections 3.1.4.1.1.a, 3.1.4.2.a, and 3.1.4.3.a that, for blower-coil systems in which the indoor blower capacity modulation correlates with outdoor dry bulb temperature or sensible-to-total cooling capacity ratio, use an air volume rate that represents a normal operation. 87 FR 16830, 16841–16842. Also, DOE indicated that to ensure consistency of testing, it may be necessary for manufacturers to certify whether the system varies blower speeds with outdoor air conditions. However, certification is not being addressed in this rulemaking and may be addressed in a separate rulemaking. *Id.*

In response, Lennox, Rheem and Trane commented that they support DOE's proposal to add clarifying language to allow fan speed and air volume adjustments for varying outdoor conditions that are representative of normal field operation, for blower-coil systems with multiple-speed or variable-speed indoor fans. (Lennox, No. 19 at p. 4, Rheem, No. 21 at p. 2, Trane, No. 10 at p. 3) Rheem further commented that they also support the control system capability to adjust air volume rate as a function of outdoor air temperature, allowing such air volume rate variation during testing. (Rheem, No. 21 at pp. 2–3) In order to make the procedure more representative of field conditions, Rheem suggested that external static pressure should change in relation to full stage air flow by using the fan affinity laws, similar to external static adjustments for multi-stage equipment. *Id.* Additionally, Rheem suggested that DOE's proposal to add clarifying language for blower speed variation should apply to section 3.1.4.4.3.a, instead of section 3.1.4.3.a. *Id.* Trane pointed out that they have products that vary the fan speed based on various conditions such as outdoor ambient and stated that the proposed change is needed to clear up the discrepancy in procedures. (Trane, No. 10 at p. 3) They stated that there are several reasons why airflow may be varied from a nominal setting at different conditions; for example, to optimize sensible heat ratio and comfort, to maintain consistent heating supply air temperatures, and to maximize system efficiency. *Id.*

In response to Rheem's comment about external static adjustments, DOE believes that the proposed regulatory language already addresses this factor, in particular the language: ''and calculate the target minimum external static pressure as described in section 3.1.4.2 of this appendix,'' which is included in Step 7 where the proposed revisions were made. The adjustment of external static pressure described in section 3.1.4.2 specifies that pressure varies as the square of the air flow, consistent with the fan affinity laws mentioned by Rheem. Hence, DOE is finalizing the revision without additional changes in regard to instructions regarding external static pressure. Also, in response to Rheem, DOE acknowledges that the NOPR preamble incorrectly cited section 3.1.4.3.a instead of 3.1.4.4.3.a.—the change was proposed and is finalized in section 3.1.4.4.3.a.

NEEA pointed out that DOE's proposal does not require certification of the fan speeds that represent ''normal'' operation for the different test points, and expressed concern that this approach will allow products to be tested more favorably without confirmation that the testing represents how products operate in the field. (NEEA, No. 23 at p. 2) NEEA recommended that DOE verify blower speed variation with a load-based test procedure using native controls of the system. *Id.*

As previously stated, certification corresponding to the test procedure changes are not being addressed in this final rule but may be considered in a separate rulemaking. Regarding NEEA's recommendation for a test procedure requiring native controls, DOE notes that this test procedure rulemaking was initiated as a quick fix of a limited set of known issues, and that more comprehensive revisions to address native controls may be considered in a future rulemaking that would satisfy the 7-year lookback requirements. See further discussion in section III.B of this document.

Based on the comments received, DOE is finalizing the provisions regarding variation of indoor air volume rate by adopting the clarifying language to Step 7 of sections 3.1.4.1.1.a, 3.1.4.2.a, and 3.1.4.4.3.a, as proposed.

2. Wet Bulb Temperature for H4 5 °F Heating Tests

Appendix M1 specifies required and optional heating mode test conditions for heat pumps, designated as ''H'' conditions. See Tables 11 through 15 of appendix M1. Appendix M1 provides for conducting optional ''H4'' heating tests at a 5 °F outdoor ambient dry-bulb temperature and, at a maximum, a 3 °F outdoor wet-bulb temperature.[39] The 3 °F wet bulb condition represents an extremely dry air condition, which may be difficult to attain and maintain due to issues with infiltration and ground moisture passing through the floor in some laboratory setups. Consequently, in the March 2022 CAC TP NOPR, DOE proposed to amend the wet bulb test condition for all H4 tests to be 4 °F maximum instead of the current condition of 3 °F maximum. 87 FR 16830, 16842.

In response, Carrier, Daikin, Lennox, Nortek, NYSERDA, and Rheem commented that they all support DOE's proposal to increase the wet bulb test condition to 4 °F maximum from the 3 °F maximum for H4 tests. (Carrier, No. 15 at p. 1, Daikin, No. 24 at p. 2, Lennox, No. 19 at p. 4, Nortek, No. 13 at p. 3, NYSERDA, No. 17 at p. 2, Rheem, No. 21 at p. 3) Carrier stated that increasing the wet bulb test condition in the H4 test will reduce the test burden, and Lennox further asserted that conducting the H4 tests previously in various manufacturer laboratories has proven to be overly burdensome for the variety of reasons DOE cites in the CAC TP NOPR at 87 FR 16842. (Carrier, No. 15 at p. 1, Lennox, No. 19 at p. 4) Carrier and Lennox commented that increasing the maximum wet bulb temperature for the H4 test will significantly reduce manufacturer test burden. *Id.* Lennox commented that this will also help avoid additional capital investments in lab facilities for specialized equipment to attain the wet bulb requirement of 3 °F and this relief will allow more test facilities to be capable of validating performance at low ambient conditions while maintaining sufficiently low humidity conditions to provide reasonable test results. (Lennox, No. 19 at p. 4) Nortek also commented that increasing the wet bulb temperature on the H4 test from 3 °F to 4 °F will reduce their test burden by reducing the time required to remove moisture in achieving the wet bulb temperature test point. (Nortek, No. 13 at p. 3) NYSERDA commented that the proposed amendment of the wet bulb temperature conditions for the H4, $H4_2$, or $H4_3$ heating tests to a 4 °F maximum temperature will make the current optional cold temperature test easier to reliably replicate and should improve understanding of system performance at cold temperatures for more basic models being distributed in commerce. (NYSERDA, No. 17 at p. 2)

Based on the discussion presented in the March 2022 CAC TP NOPR and given the general support of the proposals by commenters, DOE is finalizing its amendment and increasing the wet bulb test condition to a maximum of 4 °F for H4 tests.

3. Hierarchy of Manufacturer Installation Instructions

Instructions for installation of CAC/HP products can take multiple forms, including documents shipped with the product, labels affixed to the outdoor unit and/or indoor unit, and online documents.

Section 2(A) of appendix M1 provides requirements regarding the installation instructions to be used and their order of precedence (*i.e.,* installation instruction hierarchy) for variable refrigerant flow (''VRF'') multi-split systems. Section 2(A) specifies that installation instructions that appear in the labels applied to the unit take precedence over installation instructions that are shipped with the unit. Further, Section 2(A) specifies that the term ''manufacturer's installation instructions'' does not include online manuals. Appendix M1 does not specify installation instruction hierarchy for any other types of CAC/HP products.

Throughout appendix M1, references to manufacturer's installation instructions are made regarding refrigerant charging requirements (section 2.2.5), installation of an air supply plenum adapter accessory for testing small-duct, high-velocity systems (section 2.4.1.c), and control circuit connections between the furnace and the outdoor unit for coil-only systems (section 3.13.1.a).

DOE notes that it initially proposed in a supplemental NOPR published November 9, 2015 (''November 2015 SNOPR'') that the hierarchy of installation instructions be located in proposed section 2.2.5.1 of appendix M1, which pertains to refrigerant charging requirements. *See* 80 FR 69278, 69350.[40] However, as finalized in the June 2016 CAC TP Final Rule, the installation instruction hierarchy provision was located within section 2(A) of appendix M1, and therefore applies only to testing of VRF multi-split systems. 81 FR 36992, 37060. The June 2016 CAC TP Final Rule did not provide a discussion of this change.

The requirements regarding installation instruction would be equally applicable to classes of CAC/HP other than VRF multi-split systems. As noted, manufacturer's installation instructions are referenced in a number of provisions in appendix M1. Therefore, in the March 2022 CAC TP NOPR, DOE proposed to add in section 2(B) of appendix M1, ''Testing Overview and Conditions for Systems Other than VRF,'' the same requirements associated with installation instructions that are in section 2(A), *i.e.,* what instructions can be used and what instructions take precedence. 87 FR 16830, 16842. Doe noted that this proposal would align the approach for all classes of CAC/HP with the current approach for VRF CAC. *Id.*

Lennox and Rheem commented that they support DOE's proposal for aligning the approach regarding installation instruction precedence for all classes of CAC/HP with the current approach of VRF AC. (Lennox, No. 19 at p. 4, Rheem, No. 21 at p. 3) Rheem further suggested that for clarity in the final rule, DOE should clearly specify whether a sticker on the unit takes precedence over installation instructions, particularly where use of the installation instructions is referenced in the appendix M1 test procedure (Rheem, No. 21 at p. 3). Additionally, Rheem stated that DOE also specifies a Section 2(B) will be added to appendix M1 to 10 CFR part 430. Rheem points out that Section 2(B) already exists in the test procedure, and therefore DOE should add a section 2(C) to capture these changes.[41] *Id.*

In response to Rheem's comment regarding addition of section 2(B) of appendix M1, DOE notes that it indicated that the additional requirements regarding installation instructions would be inserted ''in section 2(B),'' not that a new section 2(B) would be added. In response to the comment about clarifying whether a sticker on the unit takes precedence over installation instructions, DOE believes that the language proposed for section 2(B), ''Installation instructions that appear in the labels applied to the unit shall take precedence over installation instructions that come packaged with the unit,'' sufficiently clarifies this point. Specifically, ''installation instructions'' does extend to installation instructions that appear on the labels applied to the unit, and that such installation instructions take precedence over installation instructions that are not applied to the unit.

[39] The tests at this condition are optional for heat pumps, except for Triple-Capacity Northern heat pumps.

[40] DOE also notes that as initially proposed, installation instructions that are shipped with the unit were to take precedence over installation instructions that appear in the labels applied to the unit, but this hierarchy was reversed in the final rule. 81 FR 36992, 37060.

[41] In the May 2022 CAC TP NOPR, DOE had stated that they will add instructions to the already existing Section 2(B), and not that a new section is needed. Hence, DOE will not add a Section 2(C), as suggested by Rheem.

Trane commented that even though they agreed with hierarchy proposed by DOE, they raised a concern that that some combinations of indoor units require unique charging instructions, as opposed to the typical instructions, *i.e.,* subcooling target, listed on outdoor unit labels. (Trane, No. 10 at p. 3) They cited the variations of indoor internal coil volume with various matched pairs as the reason for this. Hence, Trane suggested that outdoor nameplates should have a footnote referring the installer to the indoor product instructions for any exception, unless otherwise noted. *Id.*

In response to Trane's comment, DOE agrees that there may be circumstances in which the very different design details of multiple indoor units paired with the same outdoor unit could affect the optimum installation approach. In such cases, the manufacturer has the discretion to indicate in the outdoor unit installation instructions that specific instructions provided with indoor units be followed. Such an approach would not be contrary to the established precedence of the outdoor unit's installation instructions and would not be contrary to the proposed appendix M1 requirements, as long as the instructions used are not online instructions. DOE does not believe that appendix M1 should be modified to specifically explain this possibility.

Hence, DOE is adding the installation instruction hierarchy to appendix M1 section 2(B) as proposed.

4. Adjusting Airflow Measurement Apparatus To Achieve Desired SCFM at Part-Load Conditions

Sections 3.1.4.1.1, 3.1.4.2, and 3.1.4.4.3 of appendix M1 each specify seven steps for achieving the correct air volume rate to be used for testing (cooling full-load air volume rate, cooling minimum air volume rate, and heating full-load air volume rate, respectively). Each of these sections indicates that the measured air volume rate when adjustments are complete should be used for all tests that call for the same nominal air volume rate, *i.e.,* cooling full-load, cooling minimum, or heating full-load air volume rate, using the final fan speed or control settings. However, when operating at different test conditions, differences in air density and/or loading of condensate on the indoor coil may lead to different measured air volume rates.[42] None of the section 3.1.4.1.1, 3.1.4.2, or 3.1.4.4.3 of appendix M1 indicate what adjustments are allowed or required to obtain the same air volume rate for different operating conditions. In order to clarify how to achieve the same air volume rates for different operating conditions, DOE proposed to explicitly require that the airflow measurement apparatus fan be adjusted if needed to maintain a constant air volume rate for all tests using the same nominal air volume rate. Similarly, the section would explicitly state that the speed and settings of the fan of the unit under test are not to be adjusted. 87 FR 16830, 16843 (March 24, 2022).

In response, Lennox commented that they support DOE's proposals to add more specific direction to step 7 of sections 3.1.4.1.1, 3.1.4.2, and 3.1.4.4.3, as proposed. (Lennox, No.19 at p.4) Rheem commented that although they agree that the proposed changes may assist in the repeatability of certification tests, they disagree that DOE's proposals would be more representative than the current test procedure. (Rheem, No. 21 at p. 3) Rheem stated that once a ducted CAC/HP is installed in a consumer's home, the airflow and external static pressure will change with conditions, as reflected in the current test procedure. *Id.* Rheem noted that in the discussion under III.C.1 of the NOPR, DOE proposed to allow the air volume rate to change if the native controls of the system modulate indoor blower capacity. Rheem recommended that DOE add language to clarify that this allowance to adjust the airflow measurement apparatus only applies to systems that do not modulate indoor blower capacity. *Id.*

DOE does not agree with Rheem's comment suggesting that the current test procedure does not allow adjustment of the airflow measurement apparatus fan. Specifically, the words, ''use the final speed or control settings'' is not clear regarding whether this applies to the unit under test, the code tester, or both. DOE notes that by not specifically precluding adjustment of the code tester fan, the current Federal test procedure does not fully specify the allowable fan adjustments, leaving open the possibility for clarification.

In response to Rheem's comment regarding clarifying language, DOE notes that the proposed additions indicate that the final indoor fan speed or control settings of the unit under test must be used for all tests that use the same nominal air volume rate (*e.g.,* cooling full-load air volume rate), and that the fan of the airflow measurement apparatus should be adjusted if needed to obtain the same air volume rate (in scfm), unless the system modulates the indoor blower speed for different outdoor conditions or to adjust the sensible to total heat ratio. DOE considers this text is sufficiently clear that the instructions apply to systems that do not modulate indoor blower capacity. Further, DOE points out that adjustment of the airflow measurement apparatus would very likely be required for systems that do modulate the indoor blower capacity, to maintain the relationship between air volume rate and external static pressure, as required by section 3.1.4.2 of appendix M1.

Hence, DOE is finalizing the changes to step 7 of the requirements for setting air volume rate as proposed.

5. Revision of Equations Representing Full-Speed Variable-Speed Heat Pump Operation at and Above 45 °F Ambient Temperature

In a variable speed system, the compressor's actual speed at its full-load condition may change as the outdoor temperature changes. While the compressor speed at full speed may differ at different outdoor temperatures, accuracy of predictions using the test results from two temperature conditions to calculate the performance for a third temperature condition is maximized when the same compressor speed is used for the tests at the two different ambient temperature conditions (*see, e.g.,* 81 FR 58164, 58178 (August 24, 2016)).

For calculation of full-speed compressor heating mode performance in the temperature ranges less than 17 °F and greater than or equal to 45 °F, the test procedure determines performance based on the $H3_2$ and $H1_2$ tests, which are conducted at 17 °F and 47 °F, respectively (*see* appendix M1, sections 4.2.4.c, which refers to equations 4.2.2–3 and 4.2.2–4 in Section 4.2.2). As indicated in appendix M1 in the Table 14 footnotes, the $H1_2$ test is run with the compressor speed that represents normal operation at 17 °F conditions. However, for many variable-speed heat pumps, this is a higher compressor speed than would be normal for operation at 47 °F conditions.

The $H1_N$ test represents normal 47 °F operation, as indicated in the Table 14 footnotes. For heat pumps with different normal speeds for 17 °F and 47 °F conditions, the full-speed compressor performance equation is not appropriately representative for temperatures greater than or equal to 45 °F. For example, at 47 °F, the equation would indicate that the capacity is equal to the $H1_2$ capacity, even though the $H1_N$ test is specifically intended to represent capacity at 47 °F. To rectify

[42] When operating in cooling mode, water vapor in the return air may condense and collect and flow down the coil into the indoor unit's drain pan. This removal of water vapor is called dehumidification—it occurs only in cooling mode and its magnitude depends on the test conditions.

this issue, DOE proposed in the March 2022 CAC TP NOPR to amend the portion of the equations representing performance in conditions warmer than 45 °F. 87 FR 16830, 16843. Specifically, DOE proposed that the capacity equation for this temperature range would be multiplied by the ratio of the capacities of the $H1_N$ and $H1_2$ tests. *Id.* Similarly, DOE proposed that the power input equation for this range would be multiplied by the ratio of the power inputs measured in the $H1_N$ and $H1_2$ tests. *Id.* DOE noted that this would change the calculated capacity and power input for the range of temperature above 45 °F to be consistent with the compressor speed of the $H1_N$ test (which is intended to represent performance in this range), rather than with the compressor speed of the $H3_2$ test, which is conducted in a 17 °F ambient temperature. *Id.*

In response, Lennox supported DOE's proposed change to the full-capacity performance equations for variable speed heat pumps in the ambient temperature range above 45 °F. (Lennox, No. 19 at p. 5) Rheem recommended that DOE does not make the proposed changes. (Rheem, No. 21 at p. 4) Rheem contended that the proposal to modify the capacity and power equations above 45 °F would not have significant effect on heat pump HSPF2 calculations, since variable speed applications would likely operate in low stage during low building load conditions. Rheem questioned the value of adding complexity to variable speed HSPF2 calculations if the change will not have meaningful effect on the results and recommends that DOE not change the current calculation method for HSPF2 of variable speed heat pumps. (Rheem, No. 21 at pp. 3–4) DOE considers that the proposed calculation changes (*i.e.,* applying a simple ratio coefficient) does not represent any significant increase in complexity compared to the overall scale of test procedure calculations and that it is important to provide for a more accurate calculation of HSPF2, even if the impact on the calculated HSPF2 value is minimal. Therefore, DOE is finalizing its proposed approach in this final rule.

6. Calculations for Triple-Capacity Northern Heat Pumps

Section 4.2.6 of appendix M1 includes additional steps for calculating HSPF2 of a heat pump having a triple-capacity compressor. Heat pumps with triple-capacity compressors respond to building heating load by operating at low (k=1), high (k=2), or booster (k=3) capacity or by cycling on and off at one or more of those stages. Section 4.2.6.5 covers the scenario where the heat pump alternates between high (k=2) and booster (k=3) compressor capacity to satisfy the building load. In this scenario, the total electrical power consumption is determined by calculating the fraction of time the system spends operating in the high and booster stage, respectively, and then weighting the steady-state power consumption at each operating state accordingly. Section 4.2.6.5 gives equations for calculating the fraction of load addressed by the high compressor stage, denoted as ''$X^{k=2}(T_j)$'', as well as the fraction of load addressed by the booster compressor stage ''$X^{k=3}(T_j)$''. These proportions should, by definition, be complementary because the system is either operating in high compressor stage or boost compressor stage. However, the equation for the booster capacity load factor ''$X^{k=3}(T_j)$'' is erroneously set equal to the high-capacity load factor ''$X^{k=2}(T_j)$'' as opposed to the complementary value ''1 $X^{k=2}(T_j)$.'' Therefore, DOE proposed to correct the booster capacity load factor equation to be defined as $X^{k=3}(T_j) = 1 - X^{k=2}(T_j)$. DOE did not receive any comments in response to its proposal, and is therefore finalizing its proposed approach in this final rule.

7. Heating Nominal Air Volume Rate for Variable-Speed Heat Pumps

Appendix M1 includes procedures for calculating the heating capacity and power input for variable-speed heat pumps at various test conditions. The $H1_N$ test is used to calculate the nominal heating capacity of the system at 47 °F ambient temperature, whereas the $H1_2$ test is used to calculate maximum heating capacity at 47 °F and the $H1_1$ test is used to calculate minimum heating capacity at 47 °F. Section 3.1.4.7 of appendix M1 requires that manufacturers must specify a heating nominal air volume rate for each variable-speed heat pump system and must provide instructions for setting the fan speed or controls. The heating full-load air volume rate is defined in section 3.1.4.4 of appendix M1, which ties the heating full-load air volume rate to the cooling full-load air volume rate and denotes static pressure requirements. However, in Table 14 to appendix M1 (which specifies heating mode test conditions for units having a variable-speed compressor), the $H1_N$ test (used for calculating nominal heating capacity at 47 °F) is erroneously specified as using the ''Heating Full-load'' air volume rate instead of the heating nominal air volume rate. Because the $H1_N$ test is intended to represent nominal heating capacity, DOE is amending Table 14 to specify the ''heating nominal air volume rate'' as defined in section 3.1.4.7 of appendix M1 as opposed to the ''heating full-load air volume rate''. As discussed in section III.C.2 of this final rule, DOE is also amending the test provisions for variable-speed compressor systems with coil-only indoor units. The amendments mentioned in this section only apply to variable-speed systems equipped with blower-coil indoor units, while variable-speed coil-only systems would be required to test using the heating full-load air volume rate at the $H1_N$ test condition.

DOE did not receive any comments in response to this issue in the March 2022 CAC TP NOPR and is finalizing its proposal to specify heating nominal air volume rate as the air volume rate to be used for the $H1_N$ heating test for variable-speed heat pumps.

8. Clarifications for HSPF2 Calculation

Section 4.2 of appendix M1 contains methodologies for calculating HSPF2 for all heat pumps. DOE has identified an instance where additional instruction may be warranted to make clear the calculation procedures across different types of heat pump systems. In the March 2022 CAC TP NOPR, DOE proposed to clarify the appropriate slope adjustment factor to be used in the calculation for building heating load (Equation 4.2–2). 87 FR 16830, 16844.

As written, Equation 4.2–2 refers to the heating load line slope adjustment factor ''C'', which varies by climate region according to Table 20. However, Table 20 includes both the ''C'' factor as well as a factor denoted ''C_{VS}''—the variable-speed slope factor, which includes different coefficients that impact calculation of HSPF2. C_{VS} is not explicitly referenced in the definitions surrounding Equation 4.2–2, therefore DOE proposed to amend the language of that paragraph to indicate that the slope adjustment factor ''C'' should be used when calculating building heating load except for variable-speed compressor systems, where the variable-speed slope adjustment factor ''C_{VS}'' should be used instead. *Id.*

DOE did not receive any comments regarding this proposal and is thus adopting its proposal to clarify the calculation process for heating load line slope factor as it pertains to variable-speed heat pumps.

9. Distinguishing Central Air Conditioners and Heat Pumps From Commercial Equipment

EPCA defines ''industrial equipment'' as equipment of a type which, among other requirements, is not a covered product under section 6291(a)(2), *i.e.,* not a covered consumer product. (42 U.S.C.6311(2)(A)) Small, large, and very large commercial package air conditioning and heating equipment are included as types of covered industrial equipment. (42 U.S.C.6311(1)(B,C,D))

EPCA defines ''central air conditioner'' as a product, other than a packaged terminal air conditioner, which is powered by single phase electric current, is air-cooled, is rated below 65,000 Btu per hour, is not contained within the same cabinet as a furnace the rated capacity of which is above 225,000 Btu per hour and is a heat pump or a cooling only unit. (42 U.S.C. 6291(21)) DOE understands that there are basic models on the market that meet the central air conditioner definition but are exclusively distributed in commerce for commercial and industrial applications. In DOE's view, there are certain types of equipment that meet the EPCA definition of CAC but that EPCA did not intend for DOE to regulate as consumer products. To clarify that any such model is not a central air conditioner, DOE proposed in the March 2022 CAC TP NOPR to revise the central air conditioner definition so that it explicitly excludes these equipment categories, similar to the way the original EPCA definition excludes packaged terminal air conditioners and packaged terminal heat pumps. The exclusion for single-package vertical air-conditioners and heat pumps would refer specifically to those models that could be confused with central air conditioners, *i.e.,* those that are single-phase with capacity less than 65,000 Btu/h, for which the test procedure notice of proposed rulemaking for single-package vertical air conditioners and heat pumps has proposed new definitions. 87 FR 2490, 2518 (January 14, 2022).

DOE emphasizes that the exclusion from the central air conditioner definition for a given model depends on whether it meets the definition for one of the excluded categories. For example, a model must meet the packaged terminal air conditioner definition in 10 CFR 431.92 to be considered to be a packaged terminal air conditioner. If such a model had both characteristics listed in the central air conditioner definition *and* similarities to packaged terminal air conditioners, but was not ''intended for mounting through the wall,'' it would be missing a key characteristic of the packaged terminal air conditioner definition. Unless it met the definition for one of the other categories proposed to be excluded, it would be considered a central air conditioner and covered under the applicable standards and test procedures in part 430 irrespective of whether it gets installed in a consumer or commercial building.

DOE did not receive any comments in response to its proposed clarification of the definition of central air conditioners and heat pumps at 10 CFR 430.2 to exclude other similar product categories for consideration of coverage. Therefore, DOE is finalizing its proposals from the NOPR without amendment in this final rule.

10. Additional Test Procedure Revisions

On May 8, 2019, AHRI submitted a comment responding to the notice of proposed rulemaking to revise and adopt procedures, interpretations, and policies for consideration of new or revised energy conservation standards (2020 Process Rule NOPR, 84 FR 3910, Feb. 13, 2019). The comment included as Exhibit 2 a ''List of Errors Found in appendix M and appendix M1'' (''AHRI Exhibit 2''). (EERE–2017–BT–STD–0062–0117 at pp. 23–24) Many of the errors pointed out by AHRI regard typographical errors in appendices M and M1. DOE published a correcting amendment to appendices M and M1 on December 2, 2021 (''December 2021 Correcting Amendment''). 86 FR 68389. The December 2021 Correcting Amendment addressed some of the ''Errors'' identified in AHRI Exhibit 2, but not all of them. In the March 2022 CAC TP NOPR, DOE proposed to address additional ''Errors'' identified in AHRI Exhibit 2, discussed in the following sections to improve accuracy and representativeness of the test procedures. 87 FR 16830, 16845.

a. Revisions Specific to Appendix M

AHRI's comment identified three areas of appendix M where they requested changes. (AHRI Exhibit 2, EERE–2017–BT–STD–0062–0117 at pp. 23–24) These are detailed in Table III–4. Additionally, DOE identified one transcription error in the December 2021 Correcting Amendment related to changes made in section 3.6.4 of appendix M. DOE is making corresponding revisions in this final rule to correct that transcription error.

TABLE III–4—AHRI-IDENTIFIED ERRORS TO APPENDIX M

Section	Original appendix M language	AHRI comment summary	Proposed change in the March 2022 CAC TP NOPR
1.2	Nominal cooling capacity is approximate to the air conditioner cooling capacity tested at A or A_2 condition. Nominal heating capacity is approximate to the heat pump heating capacity tested in H12 test (or the optional $H1_N$ test).	The $H1_N$ test is required in section 3.6.4, and section 3.6.4 designates the $H1_N$ test—not the $H1_2$ test.	Remove the "Optional $H1_N$ test" and replace the "$H1_2$" with "$H1_N$"
4.1.4.2	$A = EER^{k=1}(T_2) - B * T_2 - C * T_2^2$	The $EER^{k=1}(T_j)$ should be $EER^{k=2}(T_j)$ because the coefficient "A" only utilizes the maximum speed temperature, T_2.	Revise the formula to implement this change to $EER^{k=2}(T_j)$.
4.2.c	For a variable-speed heat pump, $\dot{Q}_h^k(47) = \dot{Q}_h^{k=N}(47)$, the space heating capacity determined from the $H1_N$ test.	2017 and later versions of appendix M use $H^{k=2}{}_{calc}$ for all conditions, as explained in 3.6.4. This should not be an exception for the rest of the calculations.	Accurately implement the change intended by the December 2021 Correcting Amendment.

The following sections discuss changes to the language of appendix M that DOE believes will improve clarity regarding how tests and calculations are to be conducted to determine capacity levels and efficiency metrics to address the topics identified in AHRI's comment.

i. Definition of Nominal Capacity

AHRI commented that the description of nominal heating capacity within the definition for ''nominal capacity'' in section 1.2 of appendix M incorrectly references the $H1_N$ test as ''optional.'' AHRI claimed that, on the contrary, the $H1_N$ test is required for heat pumps. (AHRI Exhibit 2, EERE–2017–BT–STD–0062–0117 at pp. 23–24) DOE agrees with the AHRI comment, since section 3.6.4, ''Tests for a Heat Pump Having a Variable-Speed Compressor,'' requires the $H1_N$ test. Therefore, DOE proposed in the March 2022 CAC TP NOPR to revise the definition of ''nominal capacity'' to remove the references to the $H1_2$ test in its entirety to avoid confusion. 87 FR 16830, 16845.

In response to the NOPR proposal, the CA IOUs commented that by making this reference to the $H1_N$ test, DOE is making the definition inapplicable to systems with single-speed and two-capacity compressors. (CA IOUs, No. 20 at pp.1–2) The CA IOUs proposed the following definition, so that it may be applicable to single-stage and two-stage heat pumps (additions in *italics,* deletions in [brackets]):

Nominal capacity means ''the capacity that is claimed by the manufacturer on the product name plate. Nominal cooling capacity is approximate to the air conditioner cooling capacity tested at A or A_2 condition. Nominal heating capacity is approximate to the heat pump heating capacity tested in the *H1 or* $H1_2$ test *for units that have a single-speed compressor, the* $H1_2$ *test for units that have a two-capacity compressor or are a triple-capacity northern heat pump,*[43] *or* [(or the optional $H1_N$ test).] *the* $H1_N$ *test for units that have a variable-speed compressor.*'' *Id.*

DOE notes that the term nominal heating capacity is only used to specify the heating capacity for the $H1_N$ test for variable-speed systems. Additionally, the term nominal capacity is not required for certification of CAC/HPs. Hence, DOE is not revising the definition as suggested by the CA IOUs and DOE is instead finalizing the definition as proposed in the March 2022 CAC TP NOPR.

ii. Revising Energy Efficiency Ratio Equation at Intermediate Compressor Speed

In section 4.1.4.2 of appendix M, there are a series of equations used to calculate $EER^{k=i}(T_j)$, the steady-state energy efficiency ratio of the test unit when operating at an intermediate compressor speed (k=i) for outdoor temperature T_j. This value is calculated using a quadratic equation: $EER^{k=i}(T_j) = A + B^*T_j + C^*T_j^2$. These coefficients (A, B and C) are calculated by their own respective formulae.

AHRI commented that the formula for the ''A'' coefficient has an error. Specifically, $EER^{k=1}(T_2)$ in the equation should be $EER^{k=2}(T_2)$ because the coefficient ''A'' only utilizes maximum-speed temperature T_2. (AHRI Exhibit 2, EERE–2017–BT–STD–0062–0117 at pp. 23–24) In the March 2022 CAC TP NOPR, DOE proposed to revise this calculation such that it uses the intended ''k=2''. 87 FR 16830, 16845. The use of ''k=2'' is supported both by its appearance in ASHRAE 116–2010, ''Methods for Testing for Rating Seasonal Efficiency of Unitary Air Conditioners and Heat Pumps'' (*see* page 25), and also in the DOE test procedure final rule that first established test methods for variable-speed systems. 49 FR 8304, 8316 (March 14, 1987).

DOE did not receive any comments in response to this proposed correction and is therefore finalizing its proposed approach in this final rule.

iii. Clarification of Compressor Speed Limits in Heating Tests for Heat Pumps Having a Variable-Speed Compressor

In the December 2021 Correcting Amendment, DOE discussed corrections to the compressor speed limitations for the $H1_N$ heating mode test for both appendices M and M1. 86 FR 68389, 68390. However, when setting out the correcting language in the amendatory instruction for appendix M, the instructions erroneously directed to revise the fifth sentence of paragraph a. to section 3.6.4, when the instructions were intended to revise the seventh sentence of the same paragraph. As currently printed, the text in paragraph a. of section 3.6.4 to appendix M includes two sentences starting with ''for a cooling/heating heat pump . . .'' that give conflicting instructions. Accordingly, DOE proposed in the March 2022 CAC TP NOPR to revise this paragraph to reflect the intent of the December 2021 Correcting Amendment and, by extension, the January 2017 CAC TP Final Rule. 87 FR 16830, 16845. DOE did not receive any comments and is therefore finalizing as proposed.

b. Revisions Specific to Appendix M1

AHRI's comment identified one area of appendix M1 where they requested a change. (''AHRI Exhibit 2,'' EERE–2017–BT–STD–0062–0117 at p. 23) This requested change is detailed in Table III–5.

TABLE III–5—AHRI-IDENTIFIED ERRORS TO APPENDIX M1

Section	Original appendix M1 language	AHRI comment summary	Proposed change in the March 2022 CAC TP NOPR
4.2	Q_h(47 °F): the heating capacity at 47 °F determined from the H2 $H1_2$or $H1_N$ test, Btu/h.	For variable speed heat pumps, the language should be clarified to $H^{k=2}{}_{calc}$.	Revise the language to be clearer about what capacity to use for different types of heating-only heat pumps.

The following sections discuss amendments to the language of appendix M1 that DOE believes will improve clarity regarding how tests and calculations are to be conducted to determine capacity levels and efficiency metrics to address the topic identified in AHRI's comment, additional topics in comments from interested parties, and other areas for improvement identified by DOE.

i. Detailed Descriptions of Capacity for Different Subcategories

AHRI commented that in Section 4.2 of appendix M1, which describes the calculation for HSPF2 for different subcategories of heat pumps, there is a lack of clarity in the term for heating capacity measured at 47 °F, ''Q_h(47 °F),'' in Equation 2–2, the building load, ''BL(T_j),'' equation. (''AHRI Exhibit 2,'' EERE–2017–BT–STD–0062–0117 at p. 23) Currently, the description of Q_h(47 °F) says that it is ''determined from the H, $H1_2$ or $H1_N$ test.'' Additionally, the first ''H'' is missing an additional character to specify the appropriate test point. DOE agrees with

[43] Appendix M1, section 1.2, defines ''triple-capacity, northern heat pump'' as a heat pump that provides two stages of cooling and three stages of heating. The two common stages for both the cooling and heating modes are the low-capacity stage and the high-capacity stage. The additional heating mode stage is the booster capacity stage, which offers the highest heating capacity output for a given set of ambient operating conditions.

AHRI's assessment of this description, and DOE proposed in the March 2022 CAC TP NOPR to revise this description to include specific instructions for which test point is appropriate for different heat pump subcategories. DOE proposed to specify that the H1 test is for a heat pump with a single-speed compressor, the $H1_2$ test is for a heat pump with a two-speed compressor, and the $H1_N$ test is for a heat pump with a variable-speed compressor. 87 FR 16830, 16846.

DOE did not receive any comments in response to its proposed clarifications and is thus finalizing as proposed in this rule. DOE notes that AHRI Exhibit 2 used a ''$H^{k=2}{}_{calc}$'' term that does not exist in the referenced section of appendix M1. While DOE is revising this section to add clarity in light of AHRI's general comment, DOE will not be proposing to make the exact edit proposed by AHRI.

ii. Heating Building Load Line for Regions Other Than IV

Trane commented that the denominator in equation 4.2–2, the building heating load, ''$BL(T_j)$,'' equation, the expression ''$T_{zl} - 5$ °F'' should be replaced with ''$T_{zl} - T_{OD}$''. (Trane, No. 10 at p. 2) Trane asserted that they made this recommendation based on previous DOE rulemakings, including the August 2016 SNOPR for the 2017 appendix M1 rule (81 FR 58164 and 82 FR 1426, respectively). They stated that when the building load is calculated for regions other than Region IV, then using 5 °F instead of the specific region's T_{OD} would result in incorrect calculation of HSPF2. *Id.*

In the January 2017 CAC TP Final Rule, DOE stated that the appearance of T_{OD} instead of 5 °F in the denominator of equation 4.2–2 was a mistake, that first appeared in the November 2015 SNOPR.[44] 82 FR 1426, 1454. Therefore, DOE will not be making the change to equation 4.2–2 as suggested by Trane, and the denominator shall remain as ''$T_{zl} - 5$ °F''.

iv. Low-Static Ducted Blower-Coil Test Procedures

In response to the March 2022 CAC TP NOPR, AHRI and Samsung commented that currently, appendix M1 does not allow testing of Low Static Single Zone units, and requested that the definition of a low-static blower-coil system be expanded to include some products that cannot accommodate the 0.5 inches w.c. necessary for testing. (AHRI, No. 25 at p. 7, Samsung, No. 22 at pp. 2–3) They suggested the following revised version of the current definition in section 1.2 of 10 CFR part 430, appendix M1 (commenters' additions in *italics*):

Low static blower-coil system means, (a) A ducted multi split or multi head mini split system for which the indoor unit produce greater than 0.01 inches w.c. and a maximum of 0.35 inches w.c. external static pressure when operated at the cooling full load air volume rate not exceeding 400 cfm per rated ton of cooling, *or (b) A ducted single zone mini split for which the indoor unit produces a maximum of 0.25 inches w.c. external static pressure not exceeding 350 cfm/ton when operated at the highest possible air flow rate and has a rated heating or cooling capacity less than 24,500 Btu/h. Id.*

Samsung specifically pointed out that many of their Low Static Ducted Variable-Speed Mini-Split Heat Pumps (''Low Static VSMSHP'') were previously covered by appendix M (Table 4 of Section 3.1.4.1), but cannot be tested according to appendix M1, because these products have a maximum operating ESP of 0.24 inches w.c. and cannot operate at the 0.5 inches w.c. set as the minimum ESP in appendix M1. (Samsung, No.22 at pp.2–3) They further asserted that their Low Static VSMSHPs[45] were designed to be installed in tight locations, that they can be installed with or without ducts, and that there are other manufacturers that Samsung is aware of that currently manufacture and sell similar products. (Samsung, No.22 at p.3)

DOE has received no petitions for waiver of the CAC test procedure from any manufacturers requesting relief from the ESP conditions set in appendix M1. Additionally, in the November 2015 SNOPR, DOE did propose to establish a ''short-ducted'' product class with lower ESP testing requirements (80 FR 74020, 69355) but stakeholders ultimately rejected this proposal, as reflected by the 2016 CAC Term Sheet recommending ESP levels for various types of CAC systems. Notably, ''short-duct'' configurations were not included in that list, so short-duct systems would be considered ''conventional'' single-split ducted systems. Also, recommendation #2 of the 2016 CAC Term Sheet states that the minimum required ESP for CAC/HP blower coil systems other than mobile home systems, ceiling-mount and wall-mount systems, low and mid-static multi-split systems, space-constrained systems, and small-duct, high-velocity systems should be 0.50 inches w.c. for all capacities. (*See* 2016 CAC Term Sheet: Docket No. EERE–2014–BT–STD–0048, No. 76) During the August 2016 SNOPR public meeting and in written comments, many stakeholders expressed support for the new minimum external static requirements that DOE proposed. JCI, Goodman, Unico, AHRI, NEEA, Carrier/UTC, Lennox, Ingersoll Rand, and Nortek expressed support for DOE's proposal to require conventional systems to be tested at a minimum external static pressure of 0.5 inches w.c. consistent with Recommendation #2 of the 2016 CAC Term Sheet. (JCI, No. 24 at p. 15; Goodman, No. 39 at p. 13; Unico, No. 30 at p. 6; AHRI, No. 27 at p. 16; NEEA, No. 35 at p. 3; Carrier/UTC, No. 36 at p. 9; Lennox, No. 25 at p. 10; Ingersoll Rand, No. 38 at p. 5; Nortek, No. 22 at p. 11)

Based on the evidence presented in the previous paragraph, DOE believes that revising the definition of low-static blower coil systems, as suggested by AHRI and Samsung, would conflict with the intent of stakeholders' comments when establishing appendix M1, and could potentially create an unfair competitive advantage for such systems by allowing more lenient testing conditions (and thus comparatively higher ratings) as compared to conventional centrally-ducted systems tested at minimum ESPs exceeding 0.50 inches w.c. Therefore, DOE is not revising the definition for low-static blower coil systems in this final rule, nor is it including any new test provisions to accommodate these system types. DOE notes that there is no restriction in the definition for non-ducted indoor units that would preclude these systems from being tested and certified as non-ducted systems, comparable to 1-to-1 mini-splits. See section 1.2 of appendix M1. DOE also notes that its regulations at 10 CFR 430.27 provide that any interested person may seek a waiver from the test procedure requirements if certain conditions are met. A waiver allows manufacturers to use an alternate test procedure upon the grounds that the basic model contains one or more design characteristics which either prevent testing of the basic model according to the prescribed test procedures or cause the prescribed test

[44] Bruce Harley Energy Consulting (BHEC) provided some field monitoring data and analysis of heating loads conducted at the request of PG&E, for seven homes covering regions I/II, IV and V. The initial comparison of regional heating load lines with the load lines determined for the seven monitored locations led to the conclusion that equation 4.2.2 in the August 2016 SNOPR incorrectly included the term T_{OD}. (BHEC, No. 28 at pp. 3–6)

[45] Samsung provided information about their Low Static VSMSHP, which is available online at: *https://www.samsunghvac.com/light-commercial/slim-duct.*

procedures to evaluate the basic model in a manner so unrepresentative of its true energy and/or water consumption characteristics as to provide materially inaccurate comparative data. 10 CFR 430.27(a)(1).

c. Revisions to Both Appendices M and M1

AHRI Exhibit 2 claimed that there are two sections in both appendices M and M1 that contain similar errors. 87 FR 16830, 16846–16847. These errors are detailed below in Table III–6. DOE is finalizing these revisions as proposed by AHRI and indicated in the table.

Table III-6: AHRI-Identified Errors in Both Appendices M and M1

Section	Original Appendices M and M1 Language	AHRI Comment Summary	Proposed Change in the March 2022 CAC TP NOPR
4.2.3.3	$PLF_j = 1 - C_D^{h(k=2)} * [1 - X^{k=1}(T_j)$	The trailing square bracket "]" is missing and "$X^{k=1}(T_j)$" should be "$X^{k=2}(T_j)$"	Add the square bracket and revise the equation in appendix M.[1]
4.2.3.4	$\frac{RH(T_j)}{N} = (BL(T_j) * \frac{[\dot{Q}_h^{k=2}(T_j) * \delta'(T_j)]}{3.413 \frac{Btu}{Wh}} * \frac{n_j}{N}$	The multiplication operator between $BL(T_j)$ and the square bracket should be subtraction	Revise the equation to have the subtraction

[1]The equation is correct in section 4.2.3.3 of appendix M1.

The following sections discuss changes to the language of both appendices M and M1 that DOE believes will improve clarity regarding how tests and calculations are to be conducted to determine capacity levels and efficiency metrics.

i. Revising Part Load Factor Equation for Heat Pumps in Section 4.2.3.3

AHRI's comment claims that the part load factor (PLF) equation in section 4.2.3.3 of both appendices M and M1 contain two errors. (''AHRI Exhibit 2,'' EERE–2017–BT–STD–0062–0117 at p. 23) The first error is that the equation is missing a closing square bracket, and the second is that the heating mode low-capacity load factor, ''$X^{k=1}(T_j)$,'' is incorrectly referenced instead of the high-capacity load factor, ''$X^{k=2}(T_j)$.'' *Id.* DOE notes that this equation is actually correct in appendix M1. The high-capacity load factor is appropriate in this equation because section 4.2.3.3 applies to heat pumps that only operate at high (k=2) compressor capacity. Therefore, the high-capacity load factor should be used in this case for the part load factor. In the March 2022 CAC TP NOPR, DOE proposed to revise this formula in appendix M to include the closing square bracket and to use the high-capacity load factor. 87 FR 16830, 16846. DOE did not receive any comments in response to its proposal and is therefore finalizing as proposed in this rule.

ii. Revising the Ratio of Electrical Energy Used for Resistive Space Heating Equation in Section 4.2.3.4

AHRI has identified an error in the equation for electrical energy consumed by the heat pump for electric resistance auxiliary heating for bin temperature, T_j divided by the total number of hours in the heating season, ''$RH(T_j)/N$,'' used in section 4.2.3.4 of both appendices M and M1. AHRI indicated that the equation used in section 4.2.3.4 includes a multiplication operator where it should have subtraction. 87 FR 16830, 16846–16847. The subtraction operator is consistent with all other instances of $RH(T_j)/N$ in both appendices M and M1. DOE agrees that the equation for $RH(T_j)/N$ in section 4.2.3.4 of both appendices M and M1 is incorrect, and therefore DOE is revising this equation to include the subtraction operator rather than a multiplication operator.

E. Other Revisions Regarding Representations

Manufacturers, including importers, must use product-specific certification templates to certify compliance to DOE. For CAC/HPs, the certification template reflects the general certification requirements specified at 10 CFR 429.12 and the product-specific requirements specified at 10 CFR 429.16. As discussed in the previous paragraphs, DOE is not making any amendments related to certification requirements in this rulemaking and any such changes may be addressed in a future rulemaking.

1. Required Represented Values for Models Certified Compliant With Regional Standards

DOE's standards for CAC at 10 CFR 430.32(c) include both amended national standards with which compliance is required for models manufactured on or after January 1, 2023, and amended regional standards with which compliance is required for units installed on or after January 1, 2023. See 10 CFR 430.32(c)(5) and (6). In addition, as discussed in section III.B.3, DOE's regulations at 10 CFR 429.16 describe certification requirements for central air conditioners and central air conditioning heat pumps, and paragraph (a)(1) of the section requires single-split CACs with single-stage or two-stage compressors, at a minimum, to rate each outdoor model as part of a coil-only combination representative of the least efficient combination distributed in commerce with that particular outdoor unit.

On December 16, 2021, DOE issued final guidance regarding whether a model of outdoor unit for a single-split-system AC with single-stage or two-stage compressor whose coil-only rating under M1 does not meet regional standards, but where certain blower-coil combinations that include the outdoor model do meet regional standards, can be installed in the SE or SW region (referred to in this final rule as the ''CAC Regional Guidance'').[46] DOE's guidance states that ''In order to be installed in the SE or SW region, the outdoor unit must have at least one coil-only combination that is compliant with the regional standard applicable at the time of installation.''

As background, DOE finalized provisions related to this issue in the June 2016 CAC TP Final Rule (81 FR 36992, 37001) with subsequent minor revisions via the January 2017 CAC TP Final Rule (82 FR 1426); a July 2016 final rule regarding enforcement (81 FR 45387, July 14, 2016) (''July 2016 Enforcement Final Rule''); and the January 2017 CAC ECS Direct Final Rule (82 FR 1786, January 6, 2017). These provisions were based on consensus recommendations by two ASRAC Working Groups—a Regional Standards Enforcement Working Group (''Enforcement WG'') that concluded on October 24, 2014 (*see* final report: Docket No. EERE–2011–BT–CE–0077, No. 70), and a Central Air Conditioner and Heat Pump Energy Conservation Standards Working Group (''ECS WG'') that concluded on January 19, 2016 (*see* 2016 CAC Term Sheet: Docket No. EERE–2014–BT–STD–0048, No. 76).

The July 2016 Enforcement Final Rule adopted several provisions of relevance here, with a focus on enforcement of the existing energy conservation standards:

• *10 CFR 429.102(c)(4)* contains provisions regarding what a ''product installed in violation'' includes, specifying, among other things: (1) A complete central air conditioning system that is not certified as a complete system that meets the applicable standard; (2) combinations that were previously validly certified may be installed after the manufacturer has discontinued the combination, provided the combination meets the currently applicable standard; and (3) an outdoor unit that is part of a certified combination rated less than the standard applicable in the region in which it is installed. 81 FR 45387, 45393–45394.

• *10 CFR 429.158(a)* specifies that if DOE determines a model of outdoor unit fails to meet the applicable regional standard(s) when tested in a combination certified by the same manufacturer, then the outdoor unit basic model will be deemed noncompliant with the regional standard(s). 81 FR 45387, 45397.

• *10 CFR 430.32(c)(3) and (4)* provides that any outdoor unit model that has a certified combination with a rating below 14 SEER cannot be installed in either the southern or southwest region. 81 FR 45387, 45391.

The June 2016 CAC TP Final Rule adopted several certification provisions of relevance here, with a focus on the amended energy conservation standards recommended by the ECS WG. In particular, the June 2016 CAC TP Final Rule noted that the ECS WG recommended energy conservation standards for central air conditioners based on coil-only ratings. 81 FR 36992, 37002 (June 8, 2016). The recommended standard levels for split system air conditioners may very well have been higher if they had been based on blower-coil ratings. For example, the recommended standard levels for split system heat pumps, which are based on blower-coil ratings, are approximately one point higher than those for split system air conditioners.

In addition, the ECS WG recommended that DOE implement the requirement that every single-split air conditioner combination distributed in commerce must be rated, and that every single-stage and two-stage condensing (outdoor) unit distributed in commerce (other than a condensing unit for a 1-to-1 mini split) must have at least 1 coil-only rating that is representative of the least efficient coil distributed in commerce with a particular condensing unit. Every condensing unit distributed in commerce must have at least 1 tested combination, and for single-stage and two-stage condensing units (other than condensing units for a 1-to-1 mini split) this must be a coil-only combination. (Docket No. EERE–2014–BT–STD–0048, No. 76, Recommendation #7) In the June 2016 CAC TP Final Rule, DOE adopted these recommendations along with regional limitations for represented values of individual combinations:

• *10 CFR 429.16(a)(1)* contains provisions for required represented values, stating that for single-split system AC with single-stage or two-stage compressor, every individual combination distributed in commerce must be rated as a coil-only combination. For each model of outdoor unit, this must include at least one coil-only value that is representative of the least efficient combination distributed in commerce with that particular model of outdoor unit. Additional blower-coil representations are allowed for any applicable individual combinations, if distributed in commerce. 81 FR 36992, 37002.

• *10 CFR 429.16(b)(2)(i)* specifies that for each basic model of single-split system AC with single-stage or two-stage compressor, the model of outdoor unit must be tested with a model of coil-only indoor unit. 81 FR 36992, 37002.

• *10 CFR 429.16(a)(4)(i)* [as modified in the January 2017 CAC TP Final Rule] states that a basic model may only be certified as compliant with a regional standard if all individual combinations within that basic model meet the regional standard for which it is certified, and that a model of outdoor unit that is certified below a regional standard can only be rated and certified as compliant with a regional standard if the model of outdoor unit has a unique model number and has been certified as a different basic model for distribution in each region. 81 FR 36992, 37012 [as 10 CFR 429.16(a)(3)(i)]; 82 FR 1426.

DOE notes that the July 2016 Enforcement Final Rule stated that the adopted provisions in 10 CFR 430.32(c)(3) and (4) were meant to be complementary to the regional limitations adopted in the June 2016 CAC TP Final Rule at 10 CFR 429.16(a)(3)(i) [now 10 CFR 429.16(a)(4)(i)]. 81 FR 45387, 45391. In the January 2017 CAC ECS Direct Final Rule, DOE adopted additional language in 10 CFR 430.32 relevant to the amended standards:

• *10 CFR 430.32(c)(6)(ii)* provides that any outdoor unit model that has a certified combination with a rating below the applicable standard level(s) for a region cannot be installed in that region. The least-efficient combination of each basic model must comply with this standard. 82 FR 1786, 1857.

Finally, DOE notes that the general enforcement provisions in subpart C to part 429 also apply to CAC standards (both national and regional), including:

• *10 CFR 429.102(a)(1)*, specifying that the failure of a manufacturer to properly certify covered products in accordance with 10 CFR 429.12 and 429.14 through 429.62 is a prohibited act subject to enforcement action.

[46] The CAC Regional Guidance is available online at *https://www.energy.gov/sites/default/files/2021-12/cac-regional-guidance.pdf.*

Taken together, the regional standards, certification, and enforcement provisions require that, in order to comply with a regional standard, the least efficient combination of each basic model must comply. 10 CFR 430.32(c)(6)(ii). Further, each basic model of single-split system AC with single-stage or two-stage compressor must include a represented value for a coil-only combination representative of the least efficient combination distributed in commerce with the model of outdoor unit, and each model of outdoor unit must be tested with a model of coil-only indoor unit. (10 CFR 429.16(a)(1) and (b)(2)(i)) While manufacturers can create a regional-specific basic model under 10 CFR 429.16(a)(4)(i), such a basic model must still be certified properly according to the other provisions in that section. As such, in order to comply with a regional standard, a regional-specific basic model of single-split system AC with single-stage or two-stage compressor must include at least one coil-only combination that complies with the regional standard. Failure to certify a regional-specific basic model according to the provisions in 10 CFR 429.16(a)(1) and (b)(2)(i) is a prohibited act under 10 CFR 429.102(a)(1).

Similarly, 10 CFR 429.102(c)(4)(i) states that combinations that were previously validly certified may be installed after the manufacturer has discontinued the combination, provided the combination meets the currently applicable standard. The provision at 10 CFR 429.102(c)(4)(i) was designed to allow sell-through of inventory that manufacturers had discontinued for reasons other than non-compliance with a regional standard. 81 FR 45387, 45393. It was not intended, nor in the light of all other provisions can it be read, as allowing installation of models of outdoor unit that do not comply with the applicable regional standard at the time of installation (*i.e.,* have no combinations of coil-only units that comply with the amended regional standards, which, as stated previously, were developed based on coil-only ratings). Based on this background, the CAC regional guidance states in part:

In general, a basic model may be certified as compliant with a regional standard (and, as of January 1, 2023, meets the applicable amended regional standard) only if all individual combinations within that basic model meet the regional standard for which it is certified. All individual model combinations within a basic model must include, for single-split-system AC with single-stage or two-stage compressor (including space-constrained and small-duct, high velocity (SDHV) systems), a coil-only combination representative of the least-efficient combination in which the specific outdoor unit is distributed in commerce. *See* 10 CFR 429.16(a)(1) and (a)(4)(i); 430.32(c)(6).

A manufacturer may sell an outdoor unit of identical design in the SE and SW regions, if the manufacturer separates the basic model (*i.e.*, outdoor unit model) into different basic models with unique model numbers for distribution in each region, provided that the basic models for the SE and SW regions: (1) do not include any individual combinations that are not compliant with the regional standard applicable at the time of installation; and (2) include at least one coil-only combination that is representative of the least-efficient combination in which the specific outdoor unit is distributed in commerce. *Id.*

DOE notes that the install-through provisions in 10 CFR 429.102(c)(4)(i) allows existing stock of discontinued basic model combinations to be installed in the SE or SW regions as long as they were previously validly certified as compliant to the regional standards applicable at the time of installation. DOE further notes that the term ''previously validly certified'' means that all combinations within the basic model must show compliance with the regional standard applicable at the time of installation, including, for single-split-system AC with single-stage or two-stage compressor (including space-constrained and SDHV systems), a coil-only combination representative of the least-efficient combination in which the specific outdoor unit is distributed in commerce, in order for the install-through provisions to apply.

In the March 2022 CAC TP NOPR, DOE proposed to add direction to the regulatory text in 10 CFR 429.16(a)(1) and (a)(4)(i), 429.102(c)(4)(i) and (iii), and 430.32(c)(6)(ii) to more explicitly cross-reference the existing regulatory text to clarify the interplay of the existing requirements and reinforce the guidance. 87 FR 16830, 16848.

In addition, DOE notes that the table in 10 CFR 429.16(a)(1) states that the required coil-only value must be ''representative of the least efficient combination *distributed in commerce with that particular model of outdoor unit*'' (emphasis added). Sections 429.140 through 429.158 provide enforcement procedures specific to regional standards, 10 CFR 429.142 includes records retention of information regarding sales of outdoor units, indoor units, and single-package units, and 10 CFR 429.144 specifies requirements for records requests. When determining if a model of indoor unit is distributed in commerce with a particular model of outdoor unit, DOE may review catalogs, product literature, installation instructions, and advertisements, and may also request sales records.

Finally, 10 CFR 429.158 discusses products determined noncompliant with regional standards. Paragraphs (a) and (b) cross-reference 10 CFR 429.102(c), stating that the certifying manufacturer is liable for distribution of noncompliant units in commerce. DOE notes that 10 CFR 429.102(c) refers to distributors, contractors, and dealers, while 10 CFR 429.102(a)(10) states that it is prohibited ''for any manufacturer or private labeler to knowingly sell a product to a distributor, contractor, or dealer with knowledge that the entity routinely violates any regional standard applicable to the product.'' Therefore, DOE proposed in the March 2022 CAC TP NOPR that 10 CFR 429.158(a) and (b) cross-reference 10 CFR 429.102(a)(10) rather than 10 CFR 429.102(c).[47] 87 FR 16830, 16848.

In response, the Joint Advocates and Lennox declared that they supported DOE's proposed regulatory text in 10 CFR part 429 that clarified the requirements regarding required represented values for models certified compliant with regional standards. (Joint Advocates, No. 18 at p. 3, Lennox, No. 19 at p. 5) DOE is therefore finalizing its proposals from the March 2022 CAC TP NOPR to amend §§ 429.16, 429.102, 429.158, and 430.32 to clarify the interaction of the existing requirements and reinforce the guidance.

Additionally, Rheem commented that DOE should provide additional clarity on the efficiency cross references between appendices M and M1 for products installed on or after January 1, 2023. (Rheem, No. 21 at p. 4) Because Rheem did not identify any specific issues regarding the clarity of DOE's proposed provisions, DOE cannot further clarify them at this time.

F. Test Procedure Costs and Impact

As discussed, DOE's existing test procedures for CAC/HPs appear at appendices M and M1 (both titled ''Uniform Test Method for Measuring the Energy Consumption of Central Air Conditioners and Heat Pumps''). In this final rule, DOE is amending the existing test procedure for CACs and HPs to

[47] In the March 2022 CAC TP NOPR, DOE had mistakenly modified 10 CFR 429.102(c) to 10 CFR 429.102(b) in the regulatory text. Daikin has pointed this out (Daikin, No. 24 at p. 2), and the corrections have been made in the regulatory text for the final rule.

provide additional detail and instruction to ensure the representativeness of the test procedure and to reduce potential burden. DOE is making amendments in appendix M that do not impact testing procedures and solely provide additional clarity. DOE is also making limited amendments to appendix M1, which is the required test procedure beginning January 1, 2023. For each amendment described in this final rule, DOE considered the potential for changes to test procedure costs.

Regarding the test procedure for variable speed coil-only central air conditioners and heat pumps (described in III.C.2), DOE's amendments provide new instructions for testing VSCO systems which are not currently prescribed in the DOE test procedure, despite the fact that these products are currently subject to energy conservation standards. Because the current test provisions are insufficient for testing VSCO, the relative cost of the amended provisions cannot be compared. Regarding the amendments to introduce a low-stage default coil-only fan power coefficient (described in III.C.1) and to revise the equations for full-capacity operation of variable-speed heat pumps at and above 45 °F (described in III.D.5), DOE finds that these amendments would only impact calculation methods and would have no impact on test costs.

There are several other test procedure amendments which DOE similarly does not believe will cause manufacturers to incur any additional test procedure costs. Specifically, the amendments described in section III.D.1 revise text regarding variation of fan speed with ambient temperature; the amendments described in section III.D.4 explicitly indicate that the airflow measurement apparatus fan should be adjusted to maintain constant airflow for certain models, and the amendments described in section III.D.3 clarify that the instructions on a label affixed to the unit take precedence over the instructions shipped with the unit. DOE finds that these revisions each provide additional instruction to improve consistency of testing but do not increase either the number of tests or the duration of tests. The amendment to the wet bulb temperature maximum for the 5 °F ambient temperature condition, discussed in section III.D.2, adjusts the required test condition from 3 °F to 4 °F. DOE proposed this change in part based on feedback from manufacturers that the proposed change to 4 °F wet bulb temperature maximum would be easier to achieve than 3 °F and would require less time spent trying to achieve conditions. As such, DOE does not anticipate that this provision would increase the burden of conducting testing under appendix M1.

Finally, the amendments in 10 CFR part 429 neither modify the test procedure nor increase the number of units that would be required to be tested. Thus, DOE does not anticipate these additional procedures will cause any increased test procedure costs.

DOE has, therefore, determined that the test procedures as amended by this final rule would improve the representativeness, accuracy, and reproducibility of the test results, and would not be unduly burdensome for manufacturers to conduct or result in increased testing cost as compared to the current test procedure.

G. Compliance Date and Waivers

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, beginning 180 days after publication of the final rule in the **Federal Register**, 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. (42 U.S.C. 6293(c)(2)) 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 the deadline. (42 U.S.C. 6293(c)(3)) 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 430.27(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 GD Midea Heating and Ventilating Equipment Co. (83 FR 56065, Case No. 2017–013) and TCL AC (84 FR 11941, Case No. 2018–009); and interim waivers granted to National Comfort Products (83 FR 24754, Case No. 2017–008), Aerosys (83 FR 24762, Case No. 2017–008), LG Electronics (85 FR 40272, Case No. 2019–008), and Goodman (86 FR 40534, Case No. 2021–001). To the extent such waivers and interim waivers permit the petitioner to test according to an alternate test procedure to appendix M, such waivers and interim waivers will terminate on the date testing is required according to appendix M1 (*i.e.,* January 1, 2023), independent of this rulemaking. To the extent such waivers and interim waivers permit the petitioner to test according to an alternate test procedure to appendix M1 at such time as testing is required according to appendix M1, such waivers and interim waivers will terminate on January 1, 2023. DOE notes that the waiver issued to Johnson Controls (83 FR 12735, Case No. CAC–051; 84 FR 52489, Case No. CAC–050) will terminate on January 1, 2023, the date beginning which testing according to appendix M1 is required, independent of this final rule.

H. Requests for Standards Relief

DOE understands that changes to testing requirements may create additional burdens for ensuring compliance with the amended energy conservations that take effect on January 1, 2023, and those effects may not be realized equally across different types and sizes of manufacturers. In response to the March 2022 CAC TP NOPR, DOE received a comment from at interested party (LBA, No. 3) requesting relief from standards, which is discussed.

As previously introduced, LBA also commented on the March 2022 CAC TP NOPR requesting relief from energy conservations standards. Specifically, LBA requested DOE to delay the installation deadline for products that will be compliant with the new Regional Standards, citing the issues in unprecedented delays of products due to the current state of the global supply chain. (LBA, No.3 at p.1) LBA requested DOE to delay the installation of new CAC/HPs compliant with appendix M1 in the Southeast and Southwest Regions to July 1, 2023. *Id.* LBA stated that for constructions of new homes, the air handler unit, furnace and fans (*i.e.,* the indoor components) are installed during the ''rough-in'' phase, while the outdoor condensing unit is installed several months later during ''closing''. *Id.* Hence, LBA believes that a delay in the deadlines of enforcement of Regional Standards would allow pairing of equipment compliant with the SEER1 rating (appendix M) with that complaint with SEER2 (appendix M1). *Id.*

In response to the LBA request for relief, while DOE recognizes that manufacturers across various industries are facing unique and unforeseeable circumstances in light of the global effects of the pandemic, and that the scope of those impacts will vary by company, by product, and possibly even by model, DOE is not at this time extending this type of relief from compliance with the 2023 energy conservation standards. In consideration of these requests, DOE takes into account the full range of these circumstances and their impacts, including any factors that may be unique to particular products or equipment, including the lead time in advance of the relevant compliance date. In this regard, DOE notes that the regional standards applicable to central air conditioners installed on or after January 1, 2023, were adopted in a direct final rule more than five years ago, in January 2017. Moreover, the rule was a product of negotiated rulemaking that included various manufacturers and trade representatives.

Although no manufacturers specifically requested relief from standards, DOE notes that standards compliance is a factor in specific issues raised by certain commenters, specifically the case of NCP's space-constrained products. In its waiver request, NCP requested that if DOE does not incorporate provisions from the previously granted interim test procedure waiver into the amended Federal test procedure in appendix M1, then DOE must allow for NCP to continue testing and certifying its space-constrained CACs in a manner consistent with the granted test procedure waivers until 2025, noting the time needed to modify its condensing units and certify them as compliant with the amended standards, and asserted that because their space-constrained condensing units represent less than 0.1 percent of the overall CAC market, the requested delay in test procedure effective date would not have a significant impact on overall energy efficiency.[48] (NCP, No 16 at pp. 9–10) While the specific request in NCP's comments pertain to the testing and certification requirements, an extension of these provisions would effectively provide NCP with a less burdensome near-term pathway to compliance with the 2023 standards relative to other manufacturers who are subject to the existing provisions. For reasons stated previously in this rule, DOE takes the view that, based on the considerations given in prior energy conservation standards and test procedure rulemakings, NCP and other space-constrained product manufacturers have had sufficient time to adjust their product designs to ensure compliance with the energy conservation standards.

However, in acknowledgement of the potential inequities in compliance burdens as described by NCP and LBA, DOE notes that additional compliance flexibilities for small business manufacturers may be available through other means. For example, EPCA provides that a manufacturer whose annual gross revenue from all of its operations does not exceed $8 million may apply for an exemption from all or part of an energy conservation standard for a period not longer than 24 months after the effective date of the final rule establishing the standard. Additionally, section 504 of the Department of Energy Organization Act (42 U.S.C. 7194, as codified), provides authority for the Secretary to adjust a rule issued under EPCA in order to prevent ''special hardship, inequity, or unfair distribution of burdens'' that may be imposed on that manufacturer as a result of such rule. Manufacturers should refer to 10 CFR part 430, subpart E, and 10 CFR part 1003 for additional details.

With respect to representations, DOE notes that under 42 U.S.C. 6293(c)(2), effective 180 days after an amended test procedure is prescribed or established, no manufacturer, distributor, retailer, or private labeler of a covered product may make any representation with respect to energy use or efficiency unless such product has been tested in accordance with such amended test procedures and such representation fairly discloses the results of such testing. Additionally, under 42 U.S.C. 6293(c)(3), on the petition of any manufacturer, distributor, retailer, or private labeler, filed not later than the 60th day before the expiration of the period involved, the aforementioned 180-day period may be extended by the Secretary with respect to the petitioner (but in no event for more than an additional 180 days) if the Secretary determines that the requirements of paragraph (c)(2) would impose undue hardship on such petitioner.

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

[48] DOE is interpreting NCP's statement to mean ''overall energy use'', which would be the relevant metric impacted by changes in composition of the CAC market.

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 has made its procedures and policies available on the Office of the General Counsel's website: *www.energy.gov/gc/office-general-counsel.*

DOE is establishing a limited number of amendments to the test procedure for central air conditioners and heat pumps (''CAC/HPs'') to address specific issues that have been raised in test procedure waivers regarding appendix M1 to subpart B of 10 CFR part 430. In this final rule, DOE is adopting the following updates to the test procedure for CACs/HPs:

1. Update default fan power coefficients and default fan heat coefficients for coil-only CACs and HPs that can utilize part-load air volume rates.
2. Define ''variable-speed communicating coil-only central air conditioner or heat pump'' and prescribe an appropriate test procedure.
3. Add the control system capability to adjust air volume rate as a function of outdoor air temperature for blower-coil systems with multiple-speed or variable-speed indoor fans.
4. Amend the wet bulb test condition for the 5 °F dry bulb, outdoor ambient test to have a 4 °F maximum wet bulb temperature.
5. Add direction to prioritize the instructions presented in the label attached to the unit over the instructions included in the installation instructions shipped with the unit.
6. Add specific instruction to adjust the exhaust fan speed to achieve a constant cooling full-load air volume rate through the airflow measurement apparatus.
7. Revise the equations representing full-capacity performance of variable-speed heat pumps for the temperature range above 45 °F to be more consistent with field operation.
8. Provide additional direction regarding the regional standard requirements in 10 CFR part 429.

For manufacturers of CACs/HPs, the Small Business Administration (''SBA'') has set a size threshold, which defines those entities classified as ''small businesses'' for the purposes of the statute. DOE used the SBA's small business size standards to determine whether any small entities would be subject to the requirements of the rule. See 13 CFR part 121. The equipment covered by this rule is classified under North American Industry Classification System (''NAICS'') code 333415,[49] ''Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing.'' In 13 CFR 121.201, the SBA sets a threshold of 1,250 employees or fewer for an entity to be considered as a small business for this category. DOE identified manufacturers using DOE's Compliance Certification Database (''CCD''),[50] the AHRI database,[51] the California Energy Commission's Modernized Appliance Efficiency Database System (''MAEDbS''),[52] the ENERGY STAR Product Finder database,[53] and prior CAC/HP rulemakings. DOE used the publicly available information and subscription-based market research tools (*e.g.,* reports from Dun & Bradstreet) [54] to identify 33 original equipment manufacturers (''OEMs'') of the covered equipment. Of the 33 OEMs, DOE identified eight domestic manufacturers of CACs/HPs that meet the SBA definition of a ''small business.''

As discussed in more detail in section III.F of this document, DOE has determined that the amendments to the test procedure would not require retesting or re-rating. For variable-speed coil-only units, DOE notes that the test procedure adopted in this final rule provides new instructions for testing VSCO systems that are not currently prescribed in the DOE test procedure, despite the fact that these products are currently subject to energy conservation standards. Because the current test provisions are insufficient for testing VSCO, the relative cost of the amended provisions cannot be compared. While DOE believes the variable-speed coil-only units will be isolated to a very small fraction of models distributed in commerce (*i.e.,* less than 1 percent based on manufacturer representations in DOE's current Compliance Management Database), a manufacturer will need to ensure their representations are made in accordance with these amendments. DOE notes that none of the variable-speed coil-only basic models certified currently with DOE are manufactured by small manufacturers. Additionally, the test procedure amendments would not result in any change in burden associated with the DOE test procedure for CACs/HP. Therefore, DOE concludes that the test procedure amendments in this final rule would 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 the 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 central air conditioners and heat pumps 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, including central air conditioners and heat pumps. (*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 central air conditioners and heat pumps in this final rule. Instead, DOE may consider proposals to amend the certification requirements and reporting central air conditioners and heat pumps under a separate rulemaking regarding appliance and equipment certification. DOE will address changes to OMB Control Number 1910–1400 at that time, as necessary.

---

[49] 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 on June 20, 2022).

[50] DOE's Compliance Certification Database is available at: *www.regulations.doe.gov/ccms* (last accessed June 20, 2022).

[51] The AHRI Database is available at: *www.ahridirectory.org/* (last accessed June 20, 2022).

[52] California Energy Commission's MAEDbS is available at *cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx* (last accessed June 20, 2022).

[53] The ENERGY STAR Product Finder database is available at *energystar.gov/productfinder/* (last accessed June 20, 2022).

[54] *app.dnbhoovers.com.*

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 central air conditioners and heat pumps. 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 products 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 proposed rule authorizes or requires use of commercial standards, the notice of proposed 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 central air conditioners and heat pumps adopted in this final rule do not incorporate any new commercial standards or test procedures that are not already incorporated by reference [55] at 10 CFR 430.3 and therefore DOE has not re-assessed such standards as part of this final rule.

M. Description of Materials Incorporated by Reference.

The following standard was previously approved for incorporation by reference in appendix M1 where it appears, and no change is being made:

ANSI/ASHRAE Standard 37–2009, Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment, ANSI approved June 25, 2009;

N. 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).

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 430

Administrative practice and procedure, Confidential business information, Energy conservation, Household appliances, Imports, Incorporation by reference, Intergovernmental relations, Small businesses.

Signing Authority

This document of the Department of Energy was signed on October 5, 2022, 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 October 7, 2022.

Treena V. Garrett,

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

For the reasons stated in the preamble, DOE amends parts 429 and 430 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. Section 429.16 is amended by:

■ a. Revising table 1 to paragraph (a)(1);

■ b. Revising paragraph (a)(4)(i); and

■ c. Revising the table in paragraph (b)(2)(i).

The revisions read as follows:

§ 429.16 Central air conditioners and central air conditioning heat pumps.

(a) * * *

(1) * * *

[55] The June 2016 CAC TP Final Rule incorporated by reference into appendix M several commercial standards and test procedures. 81 FR 36992, 37056–37057. In the January 2017 CAC TP Final Rule, DOE incorporated by reference in appendix M1 the same set of standards and test procedures. 82 FR 1426, 1467.

TABLE 1 TO PARAGRAPH (a)(1)

Category	Equipment subcategory	Required represented values
Single-Package Unit	Single-Package Air Conditioner (AC) (including space-constrained). Single-Package Heat Pump (HP) (including space-constrained).	Every individual model distributed in commerce.
Outdoor Unit and Indoor Unit (Distributed in Commerce by Outdoor Unit Manufacturer (OUM)).	Single-Split-System AC with Single-Stage or Two-Stage Compressor (including Space-Constrained and Small-Duct, High Velocity Systems (SDHV)).	Every individual combination distributed in commerce. Each model of outdoor unit must include a represented value for at least one coil-only individual combination that is distributed in commerce and which is representative of the least efficient combination distributed in commerce with that particular model of outdoor unit. For that particular model of outdoor unit, additional represented values for coil-only and blower-coil individual combinations are allowed, if distributed in commerce.
	Single-Split System AC with Other Than Single-Stage or Two-Stage Compressor (including Space-Constrained and SDHV).	Every individual combination distributed in commerce, including all coil-only and blower-coil combinations.
	Single-Split-System HP (including Space-Constrained and SDHV).	Every individual combination distributed in commerce.
	Multi-Split, Multi-Circuit, or Multi-Head Mini-Split Split System—non-SDHV (including Space-Constrained).	For each model of outdoor unit, at a minimum, a non-ducted "tested combination." For any model of outdoor unit also sold with models of ducted indoor units, a ducted "tested combination." When determining represented values on or after January 1, 2023, the ducted "tested combination" must comprise the highest static variety of ducted indoor unit distributed in commerce (*i.e.*, conventional, mid-static, or low-static). Additional representations are allowed, as described in paragraphs (c)(3)(i) and (ii) of this section, respectively.
	Multi-Split, Multi-Circuit, or Multi-Head Mini-Split Split System—SDHV.	For each model of outdoor unit, an SDHV "tested combination." Additional representations are allowed, as described in paragraph (c)(3)(iii) of this section.
Indoor Unit Only Distributed in Commerce by Independent Coil Manufacturer (ICM).	Single-Split-System Air Conditioner (including Space-Constrained and SDHV). Single-Split-System Heat Pump (including Space-Constrained and SDHV).	Every individual combination distributed in commerce.
	Multi-Split, Multi-Circuit, or Multi-Head Mini-Split Split System—SDHV.	For a model of indoor unit within each basic model, an SDHV "tested combination." Additional representations are allowed, as described in paragraph (c)(3)(iii) of this section.
Outdoor Unit with no Match		Every model of outdoor unit distributed in commerce (tested with a model of coil-only indoor unit as specified in paragraph (b)(2)(i) of this section).

* * * * *

(4) * * *

(i) *Regional.* A basic model (model of outdoor unit) may only be certified as compliant with a regional standard if all individual combinations within that basic model meet the regional standard for which it is certified, including the coil-only combination as specified in paragraph (a)(1) of this section, as applicable. A model of outdoor unit that is certified below a regional standard can only be rated and certified as compliant with a regional standard if the model of outdoor unit has a unique model number and has been certified as a different basic model for distribution in each region, where the basic model(s) certified as compliant with a regional standard meet the requirements of the first sentence. An ICM cannot certify an individual combination with a rating that is compliant with a regional standard if the individual combination includes a model of outdoor unit that the OUM has certified with a rating that is not compliant with a regional standard. Conversely, an ICM cannot certify an individual combination with a rating that is not compliant with a regional standard if the individual combination includes a model of outdoor unit that an OUM has certified with a rating that is compliant with a regional standard.

* * * * *

(b) * * *

(2) * * *

(i) * * *

TABLE 2 TO PARAGRAPH (b)(2)(i)

Category	Equipment subcategory	Must test:	With:
Single-Package Unit	Single-Package AC (including Space-Constrained). Single-Package HP (including Space-Constrained).	The individual model with the lowest seasonal energy efficiency ratio (SEER) (when testing in accordance with appendix M to subpart B of 10 CFR part 430) or SEER2 (when testing in accordance with appendix M1 to subpart B of 10 CFR part 430).	N/A.
Outdoor Unit and Indoor Unit (Distributed in Commerce by OUM).	Single-Split-System AC with Single-Stage or Two-Stage Compressor (including Space-Constrained and Small-Duct, High Velocity Systems (SDHV)).	The model of outdoor unit	A model of coil-only indoor unit.
	Single-Split-System HP with Single-Stage or Two-Stage Compressor (including Space-Constrained and SDHV).	The model of outdoor unit	A model of indoor unit.
	Single-Split System AC or HP with Other Than Single-Stage or Two-Stage Compressor having a non-communicating coil-only individual combination (including Space-Constrained and SDHV).	The model of outdoor unit	A model of non-communicating coil-only indoor unit.
	Single-Split System AC or HP with Other Than Single-Stage or Two-Stage Compressor without a non-communicating coil-only individual combination (including Space-Constrained and SDHV).	The model of outdoor unit	A model of indoor unit.
	Multi-Split, Multi-Circuit, or Multi-Head Mini-Split Split System—non-SDHV (including Space-Constrained).	The model of outdoor unit	At a minimum, a "tested combination" composed entirely of non-ducted indoor units. For any models of outdoor units also sold with models of ducted indoor units, test a second "tested combination" composed entirely of ducted indoor units (in addition to the non-ducted combination). If testing under appendix M1 to subpart B of 10 CFR part 430, the ducted "tested combination" must comprise the highest static variety of ducted indoor unit distributed in commerce (*i.e.*, conventional, mid-static, or low-static).
	Multi-Split, Multi-Circuit, or Multi-Head Mini-Split Split System—SDHV.	The model of outdoor unit	A "tested combination" composed entirely of SDHV indoor units.
Indoor Unit Only (Distributed in Commerce by ICM).	Single-Split-System Air Conditioner (including Space-Constrained and SDHV).	A model of indoor unit	The least efficient model of outdoor unit with which it will be paired where the least efficient model of outdoor unit is the model of outdoor unit in the lowest SEER combination (when testing under appendix M to subpart B of 10 CFR part 430) or SEER2 combination (when testing under appendix M1 to subpart B of 10 CFR part 430) as certified by the OUM. If there are multiple models of outdoor unit with the same lowest SEER (when testing under appendix M to subpart B of 10 CFR part 430) or SEER2 (when testing under appendix M1 to subpart B of 10 CFR part 430) represented value, the ICM may select one for testing purposes.
	Single-Split-System Heat Pump (including Space-Constrained and SDHV).	Nothing, as long as an equivalent air conditioner basic model has been tested If an equivalent air conditioner basic model has not been tested, must test a model of indoor unit.	
	Multi-Split, Multi-Circuit, or Multi-Head Mini-Split Split System—SDHV.	A model of indoor unit	A "tested combination" composed entirely of SDHV indoor units, where the outdoor unit is the least efficient model of outdoor unit with which the SDHV indoor unit will be paired. The least efficient model of outdoor unit is the model of outdoor unit in the lowest SEER combination (when testing under appendix M to subpart B of 10 CFR part 430) or SEER2 combination (when testing under appendix M1 to subpart B of 10 CFR part 430) as certified by the OUM. If there are multiple models of outdoor unit with the same lowest SEER represented value (when testing under appendix M to subpart B of 10 CFR part 430) or SEER2 represented value (when testing under appendix M1 to subpart B of 10 CFR part 430), the ICM may select one for testing purposes.
Outdoor Unit with No Match		The model of outdoor unit	A model of coil-only indoor unit meeting the requirements of section 2.2e of appendix M or M1 to subpart B of 10 CFR part 430.

* * * * *

■ 3. Section 429.102 is amended by revising paragraphs (c)(4)(i) and (iii) to read as follows:

§ 429.102 Prohibited acts subjecting persons to enforcement action.

* * * * *

(c) * * *

(4) * * *

(i) A complete central air conditioning system that is not certified as a complete system that meets the applicable standard. Combinations that were previously validly certified may be installed after the manufacturer has discontinued the combination, provided all combinations within the basic model, including for single-split-system AC with single-stage or two-stage compressor at least one coil-only combination as specified in paragraph (a)(1) of this section, comply with the regional standard applicable at the time of installation.

* * * * *

(iii) An outdoor unit that is part of a certified combination rated less than the standard applicable in the region in which it is installed or, where applicable, an outdoor unit with no certified coil-only combination as specified in paragraph (a)(1) of this section that meets the standard applicable in the region in which it is installed.

§ 429.158 [Amended]

■ 4. Section 429.158 is amended by removing ''§ 429.102(c)'' in paragraphs (a) and (b) and adding in its place ''§ 429.102(a)(10)''.

PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS

■ 5. The authority citation for part 430 continues to read as follows:

Authority: 42 U.S.C. 6291–6309; 28 U.S.C. 2461 note.

■ 6. Section 430.2 is amended by revising the definition for ''Central air conditioner or central air conditioning heat pump'' to read as follows:

§ 430.2 Definitions.

* * * * *

Central air conditioner or central air conditioning heat pump means a product, other than a packaged terminal air conditioner, packaged terminal heat pump, single-phase single-package vertical air conditioner with cooling capacity less than 65,000 Btu/h, single-phase single-package vertical heat pump with cooling capacity less than 65,000 Btu/h, computer room air conditioner, or unitary dedicated outdoor air system as these equipment categories are defined at 10 CFR 431.92, which is powered by single phase electric current, air cooled, rated below 65,000 Btu per hour, not contained within the same cabinet as a furnace, the rated capacity of which is above 225,000 Btu per hour, and is a heat pump or a cooling unit only. A central air conditioner or central air conditioning heat pump may consist of: A single-package unit; an outdoor unit and one or more indoor units; an indoor unit only; or an outdoor unit with no match. In the case of an indoor unit only or an outdoor unit with no match, the unit must be tested and rated as a system (combination of both an indoor and an outdoor unit). For all central air conditioner and central air conditioning heat pump-related definitions, see appendix M or M1 of subpart B of this part.

* * * * *

■ 7. Section 430.32 is amended by revising paragraph (c)(6)(ii) to read as follows:

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

* * * * *

(c) * * *

(6) * * *

(ii) Any model of outdoor unit that has a certified combination with a rating below the applicable standard level(s) for a region cannot be installed in that region. The least-efficient combination of each basic model, which for single-split-system air conditioner (AC) with single-stage or two-stage compressor (including space-constrained and small-duct high velocity systems (SDHV)) must be a coil-only combination, must comply with the applicable standard. See 10 CFR 429.16(a)(1) and (a)(4)(i).

* * * * *

■ 8. Appendix M to subpart B of part 430 is amended by:

■ a. Revising the Note;

■ b. Revising the definition of ''nominal capacity'' in section 1.2;

■ c. Revising paragraph a. in section 3.6.4;

■ d. Revising section 4.1.4.2;

■ e. Revising the introductory text to section 4.2.3;

■ f. Revising the equations following the word ''Where:'' in section 4.2.3.3; and

■ g. Revising section 4.2.3.4.

The revisions read as follows:

Appendix M to Subpart B of Part 430—Uniform Test Method for Measuring the Energy Consumption of Central Air Conditioners and Heat Pumps

Note: Prior to January 1, 2023, if using the appendix M test procedure for representations, including compliance certifications, with respect to the energy use, power, or efficiency of central air conditioners and central air conditioning heat pumps, any such representations must be based on the results of testing pursuant to either this appendix or the procedures in appendix M as it appeared at 10 CFR part 430, subpart B, in the 10 CFR parts 200 to 499 edition revised as of January 1, 2022. Any representations made with respect to the energy use or efficiency of such central air conditioners and central air conditioning heat pumps must be in accordance with whichever version is selected. Any representations, including compliance certifications, made with respect to the energy use, power, or efficiency of central air conditioners and central air conditioning heat pumps made on or after January 1, 2023, must be based on the results of testing pursuant the procedures in appendix M1 to this subpart.

* * * * *

1. * * *

1.2 Definitions

* * * * *

Nominal capacity means the capacity that is claimed by the manufacturer on the product name plate. *Nominal cooling capacity* is approximate to the air conditioner cooling capacity tested at A or A_2 condition. *Nominal heating capacity* is approximate to the heat pump heating capacity tested in $H1_N$ test.

* * * * *

3. * * *

3.6.4 Tests for a Heat Pump Having a Variable-Speed Compressor

a. Conduct one maximum temperature test ($H0_1$), two high temperature tests ($H1_N$ and $H1_1$), one frost accumulation test ($H2_V$), and one low temperature test ($H3_2$). Conducting one or both of the following tests is optional: An additional high temperature test ($H1_2$) and an additional frost accumulation test ($H2_2$). If desired, conduct the optional maximum temperature cyclic ($H0C_1$) test to determine the heating mode cyclic-degradation coefficient, $C_D{}^h$. If this optional test is conducted but yields a tested $C_D{}^h$ that exceeds the default $C_D{}^h$ or if the optional test is not conducted, assign $C_D{}^h$ the default value of 0.25. Test conditions for the eight tests are specified in Table 14 to this appendix. The compressor shall operate at the same heating full speed, measured by RPM or power input frequency (Hz), for the $H1_2$, $H2_2$ and $H3_2$ tests. For a cooling/heating heat pump, the compressor shall operate for the $H1_N$ test at a speed, measured by RPM or power input frequency (Hz), no lower than the speed used in the A_2 test if the tested $H1_N$ heating capacity is less than the tested A_2 cooling capacity. The compressor shall operate at the same heating minimum speed, measured by RPM or power input frequency (Hz), for the $H0_1$, $H1C_1$, and $H1_1$ tests. Determine the heating intermediate compressor speed cited in Table 14 using the heating mode full and minimum compressors speeds and:

$$Heating\ intermediate\ speed = Heating\ minimum\ speed + \frac{Heating\ full\ speed - Heating\ minimum\ speed}{3}$$

Where a tolerance on speed of plus 5 percent or the next higher inverter frequency step from the calculated value is allowed.

* * * * *

4. * * *

4.1.4.2 Unit Operates at an Intermediate Compressor Speed (k=i) In Order To Match the Building Cooling Load at Temperature T_j, $\dot{Q}_c^{k=1}(T_j) < BL(T_j) < \dot{Q}_c^{k=2}(T_j)$

$$\frac{q_c(T_j)}{N} = \dot{Q}_c^{k=i}(T_j) * \frac{n_j}{N}$$

$$\frac{e_c(T_j)}{N} = \dot{E}_c^{k=i}(T_j) * \frac{n_j}{N}$$

Where:

$\dot{Q}_c^{k=i}(T_j) = BL(T_j)$, the space cooling capacity delivered by the unit in matching the building load at temperature T_j, Btu/h. The matching occurs with the unit operating at compressor speed k=i.

$\dot{E}_c^{k=i}(T_j) = \frac{\dot{Q}_c^{k=i}(T_j)}{EER^{k=i}(T_j)}$, the electrical power input required by the test unit when operating at a compressor speed of k=i and temperature T_j, W.

$EER^{k=i}(T_j)$ = the steady-state energy efficiency ratio of the test unit when operating at a compressor speed of k=i and temperature T_j, Btu/h per W.

Obtain the fractional bin hours for the cooling season, n_j/N, from Table 19 to this appendix. For each temperature bin where the unit operates at an intermediate compressor speed, determine the energy efficiency ratio $EER^{k=i}(T_j)$ using, $EER^{k=i}(T_j) = A + B\ T_j + C * T_j^2$.

For each unit, determine the coefficients A, B, and C by conducting the following calculations once:

$$A = EER^{k=2}(T_2) - (B * T_2) - (C * T_2^2)$$

$$B = \frac{EER^{k=1}(T_1) - EER^{k=2}(T_2) - D * [EER^{k=1}(T_1) - EER^{k=v}(T_v)]}{T_1 - T_2 - D * (T_1 - T_v)}$$

$$C = \frac{EER^{k=1}(T_1) - EER^{k=2}(T_2) - B * (T_1 - T_2)}{T_1^2 - T_2^2}$$

$$D = \frac{T_2^2 - T_1^2}{T_v^2 - T_1^2}$$

Where:

T_1 = the outdoor temperature at which the unit, when operating at minimum compressor speed, provides a space cooling capacity that is equal to the building load ($\dot{Q}_c^{k=l}(T_l) = BL(T_1)$), °F. Determine T_1 by equating Equations 4.1.3–1 and 4.1–2 to this appendix and solving for outdoor temperature.

T_v = the outdoor temperature at which the unit, when operating at the intermediate compressor speed used during the section 3.2.4 E_v test of this appendix, provides a space cooling capacity that is equal to the building load ($\dot{Q}_c^{k=v}(T_v) = BL(T_v)$), °F. Determine T_v by equating Equations 4.1.4–3 and 4.1–2 to this appendix and solving for outdoor temperature.

T_2 = the outdoor temperature at which the unit, when operating at full compressor speed, provides a space cooling capacity that is equal to the building load ($\dot{Q}_c^{k=2}(T_2) = BL(T_2)$), °F. Determine T_2 by equating Equations 4.1.3–3 and 4.1–2 to this appendix and solving for outdoor temperature.

$$EER^{k=1}(T_1) = \frac{\dot{Q}_c^{k=1}(T_1)\ [Equation\ 4.1.4\text{–}1,\ substituting\ T_1\ for\ T_j]}{\dot{E}_c^{k=1}(T_1)\ [Equation\ 4.1.4\text{–}2,\ substituting\ T_1\ for\ T_j]}, \text{Btu/h per W}$$

$$EER^{k=v}(T_v) = \frac{\dot{Q}_c^{k=v}(T_v)\ [Equation\ 4.1.4\text{–}3,\ substituting\ T_v\ for\ T_j]}{\dot{E}_c^{k=v}(T_v)\ [Equation\ 4.1.4\text{–}4,\ substituting\ T_v\ for\ T_j]}, \text{Btu/h per W}$$

$$EER^{k=2}(T_2) = \frac{\dot{Q}_c^{k=2}(T_2)\ [Equation\ 4.1.3\text{–}3,\ substituting\ T_2\ for\ T_j]}{\dot{E}_c^{k=2}(T_2)\ [Equation\ 4.1.3\text{–}4,\ substituting\ T_2\ for\ T_j]}, \text{Btu/h per W}$$

* * * * *

4.2.3 Additional Steps for Calculating the HSPF of a Heat Pump Having a Two-Capacity Compressor

The calculation of the Equation 4.2–1 to this appendix quantities differ depending upon whether the heat pump would operate at low capacity (section 4.2.3.1 of this appendix), cycle between low and high capacity (section 4.2.3.2 of this appendix), or operate at high capacity (sections 4.2.3.3 and 4.2.3.4 of this appendix) in responding to the building load. For heat pumps that lock out low capacity operation at low outdoor temperatures, the outdoor temperature at which the unit locks out must be that specified by the manufacturer in the certification report so that the appropriate equations can be selected.

* * * * *

4.2.3.3 Heat Pump Only Operates at High (k=2) Compressor Capacity at Temperature T_j and Its Capacity Is Greater Than the Building Heating Load, $BL(T_j) < Q_h^{k=2}(T_j)$

* * * * *

$X^{K=2}(T_J) = BL(T_j/\dot{Q}^{k=2}{}_h(T_j)$; and
$PLF_j = 1 - C^h{}_D\ (k = 2) * [1 - X^{k=2}(T_j)]$.

* * * * *

4.2.3.4 Heat Pump Must Operate Continuously at High (k=2) Compressor Capacity at Temperature T_j, $BL(T_j) \geq \dot{Q}_h^{k=2}(T_j)$

$$\frac{e_h(T_j)}{N} = \dot{E}_h^{k=2}(T_j) * \delta'(T_j) * \frac{n_j}{N}$$

$$\frac{RH(T_j)}{N} = \frac{BL(T_j) - [\dot{Q}_h^{k=2}(T_j) * \delta'(T_j)]}{3.413\frac{Btu}{Wh}} * \frac{n_j}{N}$$

Where:

$$\delta'(T_j) = \begin{cases} 0, & if\ T_j \leq T_{off}\ or\ \dfrac{\dot{Q}_h^{k=2}(T_j)}{3.413 * \dot{E}_h^{k=2}(T_j)} < 1 \\ \dfrac{1}{2}, & if\ T_{off} < T_j \leq T_{on}\ and\ \dfrac{\dot{Q}_h^{k=2}(T_j)}{3.413 * \dot{E}_h^{k=2}(T_j)} \geq 1 \\ 1, & if\ T_j > T_{on}\ and\ \dfrac{\dot{Q}_h^{k=2}(T_j)}{3.413 * \dot{E}_h^{k=2}(T_j)} \geq 1 \end{cases}$$

* * * * *

■ 9. Appendix M1 to subpart B of part 430 is amended by:
■ a. Adding a Note;
■ b. Adding in alphabetical order definitions for ''Variable-speed communicating coil-only central air conditioner or heat pump'' and ''Variable-speed non-communicating coil-only central air conditioner or heat pump'' in section 1.2;
■ c. Revising paragraph (B) and the undesignated paragraph following it and adding a second undesignated paragraph in section 2;
■ d. Revising section 3.1.2;
■ e. Revising paragraphs a. and b. in section 3.1.4.1.1;
■ f. Revising paragraphs a. and b. and adding paragraph f. in section 3.1.4.2:
■ g. Revising paragraph b. and adding paragraph d. in section 3.1.4.3;
■ h. Revising paragraph a. in section 3.1.4.4.3;
■ i. Adding paragraph d. in section 3.1.4.6;
■ j. Revising section 3.1.4.7;
■ k. Revising paragraph a., adding paragraph d. immediately following paragraph c., and revising Table 8 in section 3.2.4;
■ l. Revising paragraph d., redesignating paragraph e. as paragraph f., and adding a new paragraph e. in section 3.3;
■ m. Revising the introductory text, redesignating paragraphs a. and b. as paragraphs c. and d., respectively, adding new paragraphs a. and b., and revising newly redesignated paragraph c. in section 3.5.1;
■ n. Revising Table 11 in section 3.6.1;
■ o. Revising Table 12 in section 3.6.2;
■ p. Revising Table 13 in section 3.6.3;
■ q. Revising section 3.6.4 and adding sections 3.6.4.1 and 3.6.4.2;
■ r. Revising Table 15 in section 3.6.6;
■ s. Revising paragraph c., redesignating paragraphs d. and e. as paragraphs e. and f., respectively, and adding new paragraph d. in section 3.7;
■ t. Revising paragraph b. in section 3.8;
■ u. Revising paragraph b. in section 3.9.1;
■ v. Revising section 4.1.4;
■ w. Adding sections 4.1.4.2.1 and 4.1.4.2.2;
■ x. Revising the undesignated text after Table 20 and before paragraph a., including Equation 4.2–2, in section 4.2;
■ y. Revising the introductory text for section 4.2.3;
■ z. Revising section 4.2.3.4;
■ aa. Revising paragraphs a., b., c., and e., in section 4.2.4;
■ bb. Revising sections 4.2.4.1 and 4.2.4.2; and
■ cc. Removing the language ''and $X^{k=3}(T_j) = X^{k=2}(T_j)$'' and adding in its place ''and $X^{k=3}(T_j) = 1 - X^{k=2}(T_j)$'' in section 4.2.6.5.

The revisions and additions read as follows:

Appendix M1 to Subpart B of Part 430—Uniform Test Method for Measuring the Energy Consumption of Central Air Conditioners and Heat Pumps

Note: On or after January 1, 2023, and prior to April 24, 2023, any representations, including compliance certifications, made with respect to the energy use, power, or efficiency of central air conditioners and central air conditioning heat pumps must be based on the results of testing pursuant to either this appendix or the procedures in appendix M1 as it appeared at 10 CFR part 430, subpart B, in the 10 CFR parts 200 to 499 edition revised as of January 1, 2022.

Any representations made with respect to the energy use or efficiency of such central air conditioners and central air conditioning heat pumps must be in accordance with whichever version is selected.

On or after April 24, 2023, any representations, including compliance certifications, made with respect to the energy use, power, or efficiency of central air conditioners and central air conditioning heat pumps must be based on the results of testing pursuant to this appendix.

* * * * *

1.2 Definitions

* * * * *

Variable-speed communicating coil-only central air conditioner or heat pump means a variable-speed compressor system having a coil-only indoor unit that is installed with a control system that:

(a) Communicates the difference in space temperature and space setpoint temperature (not a setpoint value inferred from on/off thermostat signals) to the control that sets compressor speed;

(b) Provides a signal to the indoor fan to set fan speed appropriate for compressor staging; and

(c) Has installation instructions indicating that the control system having these capabilities must be installed.

* * * * *

Variable-speed non-communicating coil-only central air conditioner or heat pump means a variable-speed compressor system having a coil-only indoor unit that is does not meet the definition of variable-speed communicating coil-only central air conditioner or heat pump.

* * * * *

2 Testing Overview and Conditions

* * * * *

(B) For systems other than VRF, only a subset of the sections listed in this test procedure apply when testing and determining represented values for a particular unit. Table 1 to this appendix shows the sections of the test procedure that apply to each system. Table 1 is meant to assist manufacturers in finding the appropriate sections of the test procedure. Manufacturers are responsible for determining which sections apply to each unit tested based on the model characteristics. The appendix sections provide the specific requirements for testing. To use Table 1, first refer to the sections listed under ''all units''. Then refer to additional requirements based on:

(1) System configuration(s),

(2) The compressor staging or modulation capability, and

(3) Any special features.

Testing requirements for space-constrained products do not differ from similar products that are not space-constrained, and thus space-constrained products are not listed separately in Table 1. Air conditioners and heat pumps are not listed separately in Table 1, but heating procedures and calculations apply only to heat pumps.

The ''manufacturer's published instructions,'' as stated in Section 8.2 of ANSI/ASHRAE Standard 37–2009 (incorporated by reference, see § 430.3) and ''manufacturer's installation instructions'' discussed in this appendix mean the manufacturer's installation instructions that come packaged with the unit or appear in the labels applied to the unit. Manufacturer's installation instructions do not include online manuals. Installation instructions that appear in the labels applied to the unit shall take precedence over installation instructions that come packaged with the unit.

* * * * *

3.1.2 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 specified speed or delivers the specified air volume rate. For variable-speed non-communicating coil-only air conditioners and heat pumps, the control system shall be provided with a control signal indicating operation at high or low stage, rather than testing with the compressor speed fixed at specific speeds, with the exception that compressor speed override may be used for heating mode test $H1_2$.

* * * * *

3.1.4.1.1 Cooling Full-Load Air Volume Rate for Ducted Units

* * * * *

a. For all ducted blower-coil systems, except those having a constant-air-volume-rate indoor blower:

Step (1) Operate the unit under conditions specified for the A test (for single-stage units) or A_2 test (for non-single-stage units) using the certified fan speed or controls settings, and adjust the exhaust fan of the airflow measuring apparatus to achieve the certified cooling full-load air volume rate;

Step (2) Measure the external static pressure;

Step (3) If this external static pressure is equal to or greater than the applicable minimum external static pressure cited in Table 4 to this appendix, the pressure requirement is satisfied; proceed to step 7 of this section. If this external static pressure is not equal to or greater than the applicable minimum external static pressure cited in Table 4, proceed to step 4 of this section;

Step (4) Increase the external static pressure by adjusting the exhaust fan of the airflow measuring apparatus until the first to occur of:

(i) The applicable Table 4 to this appendix minimum is equaled or

(ii) The measured air volume rate equals 90 percent or less of the cooling full-load air volume rate;

Step (5) If the conditions of step 4 (i) of this section occur first, the pressure requirement is satisfied; proceed to step 7 of this section. If the conditions of step 4 (ii) of this section occur first, proceed to step 6 of this section;

Step (6) Make an incremental change to the setup of the indoor blower (*e.g.,* next highest fan motor pin setting, next highest fan motor speed) and repeat the evaluation process beginning at step 1 of this section. If the indoor blower setup cannot be further changed, increase the external static pressure by adjusting the exhaust fan of the airflow measuring apparatus until the applicable Table 4 to this appendix minimum is equaled; proceed to step 7 of this section;

Step (7) The airflow constraints have been satisfied. Use the measured air volume rate as the cooling full-load air volume rate. Use the final indoor fan speed or control settings of the unit under test for all tests that use the cooling full-load air volume rate. Adjust the fan of the airflow measurement apparatus if needed to obtain the same full-load air volume rate (in scfm) for all such tests, unless the system modulates indoor blower speed with outdoor dry bulb temperature or to adjust the sensible to total cooling capacity ratio—in this case, use an air volume rate that represents a normal installation and calculate the target external static pressure as described in section 3.1.4.2 of this appendix.

b. For ducted blower-coil systems with a constant-air-volume-rate indoor blower. For all tests that specify the cooling full-load air volume rate, obtain an external static pressure as close to (but not less than) the applicable Table 4 to this appendix value that does not cause either automatic shutdown of the indoor blower or a value of air volume rate variation Q_{Var}, defined as follows, that is greater than 10 percent.

$$Q_{var} = \left[\frac{Q_{max} - Q_{min}}{\left(\frac{Q_{max} + Q_{min}}{2}\right)}\right] * 100$$

Where:

Q_{max} = maximum measured airflow value
Q_{min} = minimum measured airflow value
Q_{Var} = airflow variance, percent

Additional test steps as described in section 3.3.f of this appendix are required if the measured external static pressure exceeds the target value by more than 0.03 inches of water.

* * * * *

3.1.4.2 Cooling Minimum Air Volume Rate

* * * * *

a. For a ducted blower-coil system without a constant-air-volume indoor blower, adjust for external static pressure as follows:

Step (1) Operate the unit under conditions specified for the B_1 test using the certified fan speed or controls settings, and adjust the exhaust fan of the airflow measuring apparatus to achieve the certified cooling minimum air volume rate;

Step (2) Measure the external static pressure;

Step (3) If this pressure is equal to or greater than the minimum external static pressure computed in step 2 of this section, the pressure requirement is satisfied; proceed to step 7 of this section. If this pressure is not equal to or greater than the minimum external static pressure computed in step 2 of this section, proceed to step 4 of this section;

Step (4) Increase the external static pressure by adjusting the exhaust fan of the airflow measuring apparatus until either:

(i) The pressure is equal to the target minimum external static pressure, ΔP_{st_i}, computed in step 1 of this section; or

(ii) The measured air volume rate equals 90 percent or less of the cooling minimum air volume rate, whichever occurs first;

Step (5) If the conditions of step 4 (i) of this section occur first, the pressure requirement is satisfied; proceed to step 7 of this section. If the conditions of step 4 (ii) of this section occur first, proceed to step 6 of this section;

Step (6) Make an incremental change to the setup of the indoor blower (*e.g.,* next highest fan motor pin setting, next highest fan motor speed) and repeat the evaluation process beginning at step 1 of this section. If the indoor blower setup cannot be further changed, increase the external static pressure by adjusting the exhaust fan of the airflow measuring apparatus until it equals the minimum external static pressure computed in step 2 of this section; proceed to step 7 of this section;

Step (7) The airflow constraints have been satisfied. Use the measured air volume rate as the cooling minimum air volume rate. Use the final indoor fan speed or control settings of the unit under test for all tests that use the cooling minimum air volume rate. Adjust the fan of the airflow measurement apparatus if needed to obtain the same cooling minimum air volume rate (in scfm) for all such tests, unless the system modulates the indoor blower speed with outdoor dry bulb temperature or to adjust the sensible to total cooling capacity ratio—in this case, use an air volume rate that represents a normal installation and calculate the target minimum external static pressure as described in this section.

b. For ducted units with constant-air-volume indoor blowers, conduct all tests that specify the cooling minimum air volume rate—(*i.e.,* the A_1, B_1, C_1, F_1, and G_1 Tests)—at an external static pressure that does not cause either an automatic shutdown of the indoor blower or a value of air volume rate variation Q_{Var}, defined in section 3.1.4.1.1.b of this appendix, that is greater than 10 percent, while being as close to, but not less than the target minimum external static pressure. Additional test steps as described in section 3.3.f of this appendix are required if the measured external static pressure exceeds the target value by more than 0.03 inches of water.

* * * * *

f. For ducted variable-speed compressor systems tested with a coil-only indoor unit, the cooling minimum air volume rate is the higher of:

(1) The rate specified by the installation instructions included with the unit by the manufacturer; or

(2) 75 percent of the cooling full-load air volume rate. During the laboratory tests on a coil-only (fanless) system, obtain this cooling minimum air volume rate regardless of the pressure drop across the indoor coil assembly.

3.1.4.3 Cooling Intermediate Air Volume Rate

* * * * *

b. For a ducted blower-coil system with a constant-air-volume indoor blower, conduct the E_V Test at an external static pressure that does not cause either an automatic shutdown of the indoor blower or a value of air volume rate variation Q_{Var}, defined in section 3.1.4.1.1.b of this appendix, that is greater than 10 percent, while being as close to, but not less than the target minimum external static pressure. Additional test steps as described in section 3.3.f of this appendix are required if the measured external static pressure exceeds the target value by more than 0.03 inches of water.

* * * * *

d. For ducted variable-speed compressor systems tested with a coil-only indoor unit, use the cooling minimum air volume rate as determined in section 3.1.4.2(f) of this appendix, without regard to the pressure drop across the indoor coil assembly.

* * * * *

3.1.4.4.3 Ducted Heating-Only Heat Pumps

* * * * *

a. For all ducted heating-only blower-coil system heat pumps, except those having a constant-air-volume-rate indoor blower: conduct the following steps only during the first test, the H1 or $H1_2$ test:

Step (1) Adjust the exhaust fan of the airflow measuring apparatus to achieve the certified heating full-load air volume rate.

Step (2) Measure the external static pressure.

Step (3) If this pressure is equal to or greater than the Table 4 to this appendix minimum external static pressure that applies given the heating-only heat pump's rated heating capacity, the pressure requirement is satisfied; proceed to step 7 of this section. If this pressure is not equal to or greater than the applicable Table 4 minimum external static pressure, proceed to step 4 of this section;

Step (4) Increase the external static pressure by adjusting the exhaust fan of the airflow measuring apparatus until either:

(i) The pressure is equal to the applicable Table 4 to this appendix minimum external static pressure; or

(ii) The measured air volume rate equals 90 percent or less of the heating full-load air volume rate, whichever occurs first;

Step (5) If the conditions of step 4 (i) of this section occur first, the pressure requirement is satisfied; proceed to step 7 of this section. If the conditions of step 4 (ii) of this section occur first, proceed to step 6 of this section;

Step (6) Make an incremental change to the setup of the indoor blower (*e.g.,* next highest fan motor pin setting, next highest fan motor speed) and repeat the evaluation process beginning at step 1 of this section. If the indoor blower setup cannot be further changed, increase the external static pressure by adjusting the exhaust fan of the airflow measuring apparatus until it equals the applicable Table 4 to this appendix minimum external static pressure; proceed to step 7 of this section;

Step (7) The airflow constraints have been satisfied. Use the measured air volume rate as the heating full-load air volume rate. Use the final indoor fan speed or control settings of the unit under test for all tests that use the heating full-load air volume rate. Adjust the fan of the airflow measurement apparatus if needed to obtain the same heating full-load air volume rate (in scfm) for all such tests, unless the system modulates indoor blower speed with outdoor dry bulb temperature—in this case, use an air volume rate that represents a normal installation and calculate the target minimum external static pressure as described in section 3.1.4.2 of this appendix.

* * * * *

3.1.4.6 Heating Intermediate Air Volume Rate

* * * * *

d. For ducted variable-speed compressor systems tested with a coil-only indoor unit, use the heating minimum air volume rate, which (as specified in section 3.1.4.5.1.a.(3) of this appendix) is equal to the cooling minimum air volume rate, without regard to the pressure drop across the indoor coil assembly.

3.1.4.7 Heating Nominal Air Volume Rate

The manufacturer must specify the heating nominal air volume rate and the instructions for setting fan speed or controls. Calculate target minimum external static pressure as described in section 3.1.4.2 of this appendix. Make adjustments as described in section 3.1.4.6 of this appendix for heating intermediate air volume rate so that the target minimum external static pressure is met or exceeded. For ducted variable-speed compressor systems tested with a coil-only indoor unit, use the heating full-load air volume rate as the heating nominal air volume rate.

* * * * *

3.2.4 Tests for a Unit Having a Variable-Speed Compressor

a. Conduct five steady-state wet coil tests: the A_2, E_V, B_2, B_1, and F_1 Tests (the E_V test is not applicable for variable speed non-communicating coil-only air conditioners and heat pumps). Use the two optional dry-coil tests, the steady-state G_1 Test and the cyclic I_1 Test, to determine the cooling mode cyclic degradation coefficient, C_D^c. If the two optional tests are conducted and yield a tested C_D^c that exceeds the default C_D^c or if the two optional tests are not conducted, assign C_D^c the default value of 0.25. Table 8 specifies test conditions for these seven tests. The compressor shall operate at the same cooling full speed, measured by RPM or power input frequency (Hz), for both the A_2 and B_2 tests. The compressor shall operate at the same cooling minimum speed, measured by RPM or power input frequency (Hz), for the B_1, F_1, G_1, and I_1 tests. Determine the cooling intermediate compressor speed cited in Table 8 to this appendix, as required, using:

$$\text{Cooling intermediate speed} = \text{Cooling minimum speed} + \frac{\text{Cooling full speed} - \text{Cooling minimum speed}}{3}$$

Where a tolerance of plus 5 percent or the next higher inverter frequency step from that calculated is allowed.

* * * * *

d. For variable-speed non-communicating coil-only air conditioners and heat pumps, the manufacturer-provided equipment overrides for full and minimum compressor speed described in section 3.1.2 of this appendix shall be limited to two stages of digital on/off control.

TABLE 8—COOLING MODE TEST CONDITION FOR UNITS HAVING A VARIABLE-SPEED COMPRESSOR

Test description	Air entering indoor unit temperature (°F)		Air entering outdoor unit temperature (°F)		Compressor speed	Cooling air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb		
A_2 Test—required (steady, wet coil).	80	67	95	[1]75	Cooling Full	Cooling Full-Load.[2]
B_2 Test—required (steady, wet coil).	80	67	82	[1]65	Cooling Full	Cooling Full-Load.[2]
E_V Test—required[7] (steady, wet coil).	80	67	87	[1]69	Cooling Intermediate.	Cooling Intermediate.[3]
B_1 Test—required (steady, wet coil).	80	67	82	[1]65	Cooling Minimum	Cooling Minimum.[4]
F_1 Test—required (steady, wet coil).	80	67	67	[1]53.5	Cooling Minimum	Cooling Minimum.[4]
G_1 Test[5]—optional (steady, dry-coil).	80	([6])	67		Cooling Minimum	Cooling Minimum.[4]
I_1 Test[5]—optional (cyclic, dry-coil).	80	([6])	67		Cooling Minimum	([6])

[1] The specified test condition only applies if the unit rejects condensate to the outdoor coil.
[2] Defined in section 3.1.4.1 of this appendix.
[3] Defined in section 3.1.4.3 of this appendix.
[4] Defined in section 3.1.4.2 of this appendix.
[5] The entering air must have a low enough moisture content so no condensate forms on the indoor coil. DOE recommends using an indoor air wet bulb temperature of 57 °F or less.
[6] Maintain the airflow nozzle(s) static pressure difference or velocity pressure during the ON period at the same pressure difference or velocity pressure as measured during the G_1 Test.
[7] The E_V test is not applicable for variable-speed non-communicating coil-only air conditioners and heat pumps.

* * * * *

3.3 Test Procedures for Steady-State Wet Coil Cooling Mode Tests (the A, A_2, A_1, B, B_2, B_1, E_V, and F_1 Tests)

* * * * *

d. For mobile home and space-constrained ducted coil-only system tests,

(1) For two-stage or variable-speed systems, for all steady-state wet coil tests (*i.e.,* the A_1, A_2, B_1, B_2, E_V, and F_1 tests), decrease by the quantity calculated in Equation 3.3–1 to this appendix and increase by the quantity calculated in Equation 3.3–2 to this appendix.

$$\text{Equation 3.3-1} \quad \frac{(\mathrm{DFPC}_{MHSC} * 3.412)\ Btu/h}{1000\ scfm} * \dot{V}_S,$$

$$\text{Equation 3.3-2} \quad \frac{\mathrm{DFPC}_{MHSC}\ W}{1000\ scfm} * \dot{V}_S;$$

Where:

DFPC_{MHSC} is the default fan power coefficient (watts) for mobile-home and space-constrained systems,

$$\mathrm{DFPC}_{MHSC} = 308 + \frac{(406 - 308) * (\%FLAVR - 75\%)}{100\% - 75\%}$$

And %FLAVR is the air volume rate used for the test, expressed as a percentage of the cooling full load air volume rate. For all tests specifying the full-load air volume rate (*e.g.,* the A_2 and B_2 tests), set %FLAVR to 100%. For tests that specify the cooling minimum air volume rate or cooling intermediate air volume rate (*i.e.,* the A_1, B_1, E_V, and F_1 tests) and for which the specified minimum or intermediate air volume rate is greater than or equal to 75 percent of the cooling full-load air volume rate and less than the cooling full-load air volume rate, set %FLAVR to the ratio of the specified air volume rate and the cooling full-load air volume rate, expressed as a percentage.

(2) For single-stage systems, for all steady-state wet coil tests (*i.e.,* the A and B tests), decrease $Q_c^k(T)$ by the quantity calculated in Equation 3.3–3 to this appendix and increase $\dot{E}_c^k(T)$ by the quantity calculated in Equation 3.3–4 to this appendix.

$$\text{Equation 3.3-3} \quad \frac{1385\ Btu/h}{1000\ scfm} * \dot{V}_S, \text{ and}$$

$$\text{Equation 3.3-4} \quad \frac{406\ W}{1000\ scfm} * \dot{V}_S$$

Where $\dot{V}_S$ is the average measured indoor air volume rate expressed in units of cubic feet per minute of standard air (scfm).

e. For non-mobile, non-space-constrained home ducted coil-only system tests,

(1) For two-stage or variable-speed systems, for all steady-state wet coil tests (*i.e.,* the A_1, A_2, B_1, B_2, E_V, and F_1 tests), decrease $Q_c^k(T)$ by the quantity calculated in Equation 3.3–5 to this appendix and increase $\dot{E}_c^k(T)$ by the quantity calculated in Equation 3.3–6 to this appendix.

$$\text{Equation 3.3-5} \quad \frac{(\text{DFPC}_C * 3.412)\ Btu/h}{1000\ scfm} * \dot{V}_S, \text{ and}$$

$$\text{Equation 3.3-6} \quad \frac{\text{DFPC}_C\ W}{1000\ scfm} * \dot{V}_S$$

Where:

DFPC_C is the default fan power coefficient (watts) for non-mobile-home and non-space-constrained systems,

$$\text{DFPC}_C = 335 + \frac{(441 - 335) * (\%FLAVR - 75\%)}{100\% - 75\%}$$

And %FLAVR is the air volume rate used for the test, expressed as a percentage of the cooling full load air volume rate. For all tests specifying the full-load air volume rate (*e.g.,* the A_2 and B_2 tests), set %FLAVR to 100%. For tests that specify the cooling minimum air volume rate or cooling intermediate air volume rate (*i.e.,* the A_1, B_1, E_V, and F_1 tests) and for which the specified minimum or intermediate air volume rate is greater than or equal to 75 percent of the cooling full-load air volume rate and less than the cooling full-load air volume rate, set %FLAVR to the ratio of the specified air volume rate and the cooling full-load air volume rate, expressed as a percentage.

(2) For single-stage systems, for all steady-state wet coil tests (*i.e.,* the A and B tests), decrease $Q_c^k(T)$ by the quantity calculated in Equation 3.3–7 to this appendix and increase $\dot{E}_c^k(T)$ by the quantity calculated in Equation 3.3–8 to this appendix.

$$\text{Equation 3.3-7.} \quad \frac{1505\ Btu/h}{1000\ scfm} * \dot{V}_S, \text{ and}$$

$$\text{Equation 3.3-8.} \quad \frac{441\ W}{1000\ scfm} * \dot{V}_S$$

Where is the average measured indoor air volume rate expressed in units of cubic feet per minute of standard air (scfm).

TABLE 9—TEST OPERATING AND TEST CONDITION TOLERANCES FOR SECTION 3.3 STEADY-STATE WET COIL COOLING MODE TESTS AND SECTION 3.4 DRY COIL COOLING MODE TESTS

	Test operating tolerance [1]	Test condition tolerance [1]
Indoor dry-bulb, °F		
Entering temperature	2.0	0.5
Leaving temperature	2.0	
Indoor wet-bulb, °F		
Entering temperature	1.0	[2] 0.3
Leaving temperature	[2] 1.0	
Outdoor dry-bulb, °F		
Entering temperature	2.0	0.5
Leaving temperature	[3] 2.0	
Outdoor wet-bulb, °F		
Entering temperature	1.0	[4] 0.3
Leaving temperature	[3] 1.0	
External resistance to airflow, inches of water	0.05	[5] 0.02
Electrical voltage, % of reading	2.0	1.5
Nozzle pressure drop, % of reading	2.0	

[1] See section 1.2 of this appendix, Definitions.
[2] Only applies during wet coil tests; does not apply during steady-state, dry coil cooling mode tests.
[3] Only applies when using the outdoor air enthalpy method.
[4] Only applies during wet coil cooling mode tests where the unit rejects condensate to the outdoor coil.
[5] Only applies when testing non-ducted units.

* * * * *

3.5.1 Procedures When Testing Ducted Systems

The automatic controls that are installed in the test unit must govern the OFF/ON cycling of the air moving equipment on the indoor side (*i.e.,* the exhaust fan of the airflow measuring apparatus and the indoor blower of the test unit). For ducted coil-only systems rated based on using a fan time-delay relay, control the indoor coil airflow according to the OFF delay listed by the manufacturer in the certification report. For ducted units having a variable-speed indoor blower that has been disabled (and possibly removed), start and stop the indoor airflow at the same instances as if the fan were enabled. For all other ducted coil-only systems, cycle the indoor coil airflow in unison with the cycling of the compressor. If air damper boxes are used, close them on the inlet and outlet side during the OFF period. Airflow through the indoor coil should stop within 3 seconds after the automatic controls of the test unit de-energize (or if the airflow system has been disabled (and possibly removed), within 3 seconds after the automatic controls of the test unit *would have* de-energized) the indoor blower.

a. For mobile home and space-constrained ducted coil-only systems,

(1) For two-stage or variable-speed systems, for all cyclic dry-coil tests (*i.e.,* the D_1, D_2, and I_1 tests) decrease $q_{cyc,dry}$ by the quantity calculated in Equation 3.5–2 to this appendix and increase $e_{cyc,dry}$ by the quantity calculated in Equation 3.5–3 to this appendix.

$$\text{Equation 3.5-2} \quad \frac{(\mathrm{DFPC}_{MHSC} * 3.412)\,Btu/h}{1000\,scfm} * \dot{V}_S * [\tau_2 - \tau_1]$$

$$\text{Equation 3.5-3} \quad \frac{\mathrm{DFPC}_{MHSC} W}{1000\,scfm} * \dot{V}_S * [\tau_2 - \tau_1]$$

Where:

$\dot{V}_S$ is the average indoor air volume rate from the section 3.4 dry coil steady-state test and is expressed in units of cubic feet per minute of standard air (scfm),

DFPC_{MHSC} is the default fan power coefficient (watts) for mobile-home and space-constrained systems,

$$\mathrm{DFPC}_{MHSC} = 308 + \frac{(406 - 308) * (\%FLAVR - 75\%)}{100\% - 75\%}$$

And %FLAVR is the air volume rate used for the test, expressed as a percentage of the cooling full load air volume rate. For all tests specifying the full-load air volume rate (*e.g.,* the D_2 test), set %FLAVR to 100%. For tests that specify the cooling minimum air volume rate or cooling intermediate air volume rate (*i.e.,* the D_1 and I_1 tests) and for which the specified minimum or intermediate air volume rate is greater than or equal to 75 percent of the cooling full-load air volume rate and less than the cooling full-load air volume rate, set %FLAVR to the ratio of the specified air volume rate and the cooling full-load air volume rate, expressed as a percentage.

(2) For single-stage systems, for all cyclic dry-coil tests (*i.e.,* the D test), decrease $q_{cyc,dry}$ by the quantity calculated in Equation 3.5–4 to this appendix and increase $e_{cyc,dry}$ by the quantity calculated in Equation 3.5–5 to this appendix.

$$\text{Equation 3.5-4} \quad \frac{1385\ Btu/h}{1000\ scfm} * \dot{V}_S * [\tau_2 - \tau_1]$$

$$\text{Equation 3.5-5} \quad \frac{406\ W}{1000\ scfm} * \dot{V}_S * [\tau_2 - \tau_1]$$

b. For ducted, non-mobile, non-space-constrained home coil-only units,

(1) For two-stage or variable-speed systems, for all cyclic dry-coil tests (*i.e.,* the D_1, D_2, and I_1 tests) decrease $q_{cyc,dry}$ by the quantity calculated in Equation 3.5–6 to this appendix and increase $e_{cyc,dry}$ by the quantity calculated in Equation 3.5–7 to this appendix.

$$\text{Equation 3.5-6.} \quad \frac{(\mathrm{DFPC}_C * 3.412)\ Btu/h}{1000\ scfm} * \dot{V}_S * [\tau_2 - \tau_1]$$

$$\text{Equation 3.5-7.} \quad \frac{\mathrm{DFPC}_C\ W}{1000\ scfm} * \dot{V}_S * [\tau_2 - \tau_1]$$

Where:

$\dot{V}_S$ is the average indoor air volume rate from the section 3.4 dry coil steady-state test and is expressed in units of cubic feet per minute of standard air (scfm),

DFPC_C is the default fan power coefficient (watts) for non-mobile-home and non-space-constrained systems,

$$\mathrm{DFPC}_C = 335 + \frac{(441 - 335) * (\%FLAVR - 75\%)}{100\% - 75\%}$$

And %FLAVR is the air volume rate used for the test, expressed as a percentage of the cooling full load air volume rate. For all tests specifying the full-load air volume rate (*e.g.,* the D_2 test), set %FLAVR to 100%. For tests that specify the cooling minimum air volume rate or cooling intermediate air volume rate (*i.e.,* the D_1, and I_1 tests) and for which the specified minimum or intermediate air volume rate is greater than or equal to 75 percent of the cooling full-load air volume rate and less than the cooling full-load air volume rate, set %FLAVR to the ratio of the specified air volume rate and the cooling full-load air volume rate, expressed as a percentage.

(2) For single-stage systems, for all cyclic dry-coil tests (*i.e.,* the D test) decrease $q_{cyc,dry}$ by the quantity calculated in Equation 3.5–8 to this appendix and increase $e_{cyc,dry}$ by the quantity calculated in Equation 3.5–9 to this appendix.

$$\text{Equation 3.5-8.} \quad \frac{1505\ Btu/h}{1000\ scfm} * \dot{V}_S * [\tau_2 - \tau_1]$$

$$\text{Equation 3.5-9.} \quad \frac{441\ W}{1000\ scfm} * \dot{V}_S * [\tau_2 - \tau_1]$$

c. For units having a variable-speed indoor blower that is disabled during the cyclic test, decrease $q_{cyc,dry}$ and increase $e_{cyc,dry}$ based on: The product of $[\tau_2 - \tau_1]$ and the indoor blower power (in W) measured during or following the dry coil steady-state test; or,

* * * * *

3.6.1 Tests for a Heat Pump Having a Single-Speed Compressor and Fixed Heating Air Volume Rate

* * * * *

TABLE 11—HEATING MODE TEST CONDITIONS FOR UNITS HAVING A SINGLE-SPEED COMPRESSOR AND A FIXED-SPEED INDOOR BLOWER, A CONSTANT AIR VOLUME RATE INDOOR BLOWER, OR COIL-ONLY

Test description	Air entering indoor unit temperature (°F)		Air entering outdoor unit temperature (°F)		Heating air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb	
H1 test (required, steady)	70	60(max)	47	43	Heating Full-Load.[1]
H1C test (optional, cyclic)	70	60(max)	47	43	([2])
H2 test (required)	70	60(max)	35	33	Heating Full-Load.[1]
H3 test (required, steady)	70	60(max)	17	15	Heating Full-Load.[1]
H4 test (optional, steady)	70	60(max)	5	4(max)	Heating Full-Load.[1]

[1] Defined in section 3.1.4.4 of this appendix.

[2] Maintain the airflow nozzle(s) static pressure difference or velocity pressure during an ON period at the same pressure or velocity as measured during the H1 test.

* * * * *

3.6.2 Tests for a Heat Pump Having a Single-Speed Compressor and a Single Indoor Unit Having Either (1) a Variable-Speed, Variable-Air-Rate Indoor Blower Whose Capacity Modulation Correlates With Outdoor Dry Bulb Temperature or (2) Multiple Indoor Blowers

* * * * *

TABLE 12—HEATING MODE TEST CONDITIONS FOR UNITS WITH A SINGLE-SPEED COMPRESSOR THAT MEET THE SECTION 3.6.2 INDOOR UNIT REQUIREMENTS

Test description	Air entering indoor unit temperature (°F)		Air entering outdoor unit temperature (°F)		Heating air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb	
$H1_2$ test (required, steady)	70	$60^{(max)}$	47	43	Heating Full-Load.[1]
$H1_1$ test (required, steady)	70	$60^{(max)}$	47	43	Heating Minimum.[2]
$H1C_1$ test (optional, cyclic)	70	$60^{(max)}$	47	43	([3])
$H2_2$ test (required)	70	$60^{(max)}$	35	33	Heating Full-Load.[1]
$H2_1$ test (optional)	70	$60^{(max)}$	35	33	Heating Minimum.[2]
$H3_2$ test (required, steady)	70	$60^{(max)}$	17	15	Heating Full-Load.[1]
$H3_1$ test (required, steady)	70	$60^{(max)}$	17	15	Heating Minimum.[2]
$H4_2$ test (optional, steady)	70	$60^{(max)}$	5	$4^{(max)}$	Heating Full-Load.[1]

[1] Defined in section 3.1.4.4 of this appendix.
[2] Defined in section 3.1.4.5 of this appendix.
[3] Maintain the airflow nozzle(s) static pressure difference or velocity pressure during an ON period at the same pressure or velocity as measured during the $H1_1$ test.

* * * * *

3.6.3 Tests for a Heat Pump Having a Two-Capacity Compressor (see Section 1.2 of This Appendix, Definitions), Including Two-Capacity, Northern Heat Pumps (see Section 1.2 of This Appendix, Definitions)

* * * * *

TABLE 13—HEATING MODE TEST CONDITIONS FOR UNITS HAVING A TWO-CAPACITY COMPRESSOR

Test description	Air entering indoor unit temperature (°F)		Air entering outdoor unit temperature (°F)		Compressor capacity	Heating air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb		
$H0_1$ test (required, steady)	70	$60^{(max)}$	62	56.5	Low	Heating Minimum.[1]
$H1_2$ test (required, steady)	70	$60^{(max)}$	47	43	High	Heating Full-Load.[2]
$H1C_2$ test (optional,[7] cyclic)	70	$60^{(max)}$	47	43	High	([3])
$H1_1$ test (required, steady)	70	$60^{(max)}$	47	43	Low	Heating Minimum.[1]
$H1C_1$ test (optional, cyclic)	70	$60^{(max)}$	47	43	Low	([4])
$H2_2$ test (required)	70	$60^{(max)}$	35	33	High	Heating Full-Load.[2]
$H2_1$ test[5 6] (required)	70	$60^{(max)}$	35	33	Low	Heating Minimum.[1]
$H3_2$ test (required, steady)	70	$60^{(max)}$	17	15	High	Heating Full-Load.[2]
$H3_1$ test[5] (required, steady)	70	$60^{(max)}$	17	15	Low	Heating Minimum.[1]
$H4_2$ test (optional, steady)	70	$60^{(max)}$	5	$4^{(max)}$	High	Heating Full-Load.[2]

[1] Defined in section 3.1.4.5 of this appendix.
[2] Defined in section 3.1.4.4 of this appendix.
[3] Maintain the airflow nozzle(s) static pressure difference or velocity pressure during an ON period at the same pressure or velocity as measured during the $H1_2$ test.
[4] Maintain the airflow nozzle(s) static pressure difference or velocity pressure during an ON period at the same pressure or velocity as measured during the $H1_1$ test.
[5] Required only if the heat pump's performance when operating at low compressor capacity and outdoor temperatures less than 37°F is needed to complete HSPF2 calculations in section 4.2.3 of this appendix.
[6] If note #5 to this table applies, the equations for $Q_h^{k=1}(35)$ and $E_h^{k=1}(17)$ in section 3.6.3 of this appendix may be used in lieu of conducting the $H2_1$ test.
[7] Required only if the heat pump locks out low-capacity operation at lower outdoor temperatures.

* * * * *

3.6.4 Tests for a Heat Pump Having a Variable-Speed Compressor

3.6.4.1 Variable-Speed Compressor Other Than Non-Communicating Coil-Only Heat Pumps

a. Conduct one maximum temperature test ($H0_1$), two high temperature tests ($H1_N$ and $H1_1$), one frost accumulation test ($H2_V$), and one low temperature test ($H3_2$). Conducting one or more of the following tests is optional: an additional high temperature test ($H1_2$), an additional frost accumulation test ($H2_2$), and a very low temperature test ($H4_2$). Conduct the optional high temperature cyclic ($H1C_1$) test to determine the heating mode cyclic-degradation coefficient, C_D^h. If this optional test is conducted and yields a tested C_D^h that exceeds the default C_D^h or if the optional test is not conducted, assign C_D^h the default value of 0.25. Test conditions for the nine tests are specified in Table 14A to this appendix. The compressor shall operate for the $H1_2$, $H2_2$ and $H3_2$ Tests at the same heating full speed, measured by RPM or power input frequency (Hz), as the maximum speed at which the system controls would operate the compressor in normal operation in 17°F ambient temperature. The compressor shall operate for the $H1_N$ test at the maximum speed at which the system controls would operate the compressor in normal operation in 47°F ambient temperature. Additionally, for a cooling/heating heat pump, the compressor shall operate for the $H1_N$ test at a speed, measured by RPM or power input frequency (Hz), no lower than the speed used in the A_2 test if the tested $H1_N$ heating capacity is less than the tested A_2 cooling capacity. The compressor shall operate at the same heating minimum speed, measured by RPM or power input frequency (Hz), for the $H0_1$, $H1C_1$, and $H1_1$ Tests. Determine the heating intermediate compressor speed cited in Table 14A using the heating mode full and minimum compressors speeds and:

$$\text{Heating intermediate speed} = \text{Heating minimum speed} + \frac{\text{Heating full speed} - \text{Heating minimum speed}}{3}$$

Where a tolerance of plus 5 percent or the next higher inverter frequency step from that calculated is allowed.

b. If one of the high temperature tests ($H1_2$ or $H1_N$) is conducted using the same compressor speed (RPM or power input frequency) as the $H3_2$ test, set the 47°F capacity and power input values used for calculation of HSPF2 equal to the measured values for that test:

$\dot{Q}^{k=2}_{hcalc}(47) = \dot{Q}^{k=2}_{h}(47)$; $\dot{E}^{k=2}_{hcalc}(47) = \dot{E}^{k=2}_{h}(47)$

Where:

$\dot{Q}^{k=2}_{hcalc}(47)$ and $\dot{E}^{k=2}_{hcalc}(47)$ are the capacity and power input, respectively, representing full-speed operation at 47 °F for the HSPF2 calculations,

$\dot{Q}^{k=2}_{h}(47)$ is the capacity measured in the high temperature test ($H1_2$ or $H1_N$) that used the same compressor speed as the $H3_2$ test, and

$\dot{E}^{k=2}_{h}(47)$ is the power input measured in the high temperature test ($H1_2$ or $H1_N$) which used the same compressor speed as the $H3_2$ test.

Evaluate the quantities $\dot{Q}_h^{k=2}(47)$ and $\dot{E}_h^{k=2}(47)$ according to section 3.7 of this appendix.

Otherwise (if no high temperature test is conducted using the same speed (RPM or power input frequency) as the $H3_2$ test), calculate the 47 °F capacity and power input values used for calculation of HSPF2 as follows:

$\dot{Q}^{k=2}_{hcalc}(47) = \dot{Q}^{k=2}_{h}(17) * (1 + 30°F * CSF)$;

$\dot{E}^{k=2}_{hcalc}(47) = \dot{E}^{k=2}_{h}(17) * (1 + 30°F * PSF)$;

Where:

$\dot{Q}^{k=2}_{hcalc}(47)$ and $\dot{E}^{k=2}_{hcalc}(47)$ are the capacity and power input, respectively, representing full-speed operation at 47 °F for the HSPF2 calculations,

$\dot{Q}^{k=2}_{h}(17)$ is the capacity measured in the $H3_2$ test,

$\dot{E}^{k=2}_{h}(17)$ is the power input measured in the $H3_2$ test,

CSF is the capacity slope factor, equal to 0.0204/°F for split systems and 0.0262/°F for single-package systems, and

PSF is the Power Slope Factor, equal to 0.00455/°F.

c. If the $H2_2$ test is not done, use the following equations to approximate the capacity and electrical power at the $H2_2$ test conditions:

$\dot{Q}^{k=2}_{h}(35) = 0.90 * \{\dot{Q}^{k=2}_{h}(17) + 0.6 * [\dot{Q}^{k=2}_{hcalc}(47) - \dot{Q}^{k=2}_{h}(17)]\}$

$\dot{E}^{k=2}_{h}(35) = 0.985 * \{\dot{E}^{k=2}_{h}(17) + 0.6 * [\dot{E}^{k=2}_{hcalc}(47) - \dot{E}^{k=2}_{h}(17)]\}$

Where:

$\dot{Q}^{k=2}_{hcalc}(47)$ and $\dot{E}^{k=2}_{hcalc}(47)$ are the capacity and power input, respectively, representing full-speed operation at 47 °F for the HSPF2 calculations, calculated as described in paragraph b. of this section, and

$\dot{Q}^{k=2}_{h}(17)$ and $\dot{E}^{k=2}_{h}(17)$ are the capacity and power input measured in the $H3_2$ test.

d. Determine the quantities $\dot{Q}_h^{k=2}(17)$ and $\dot{E}_h^{k=2}(17)$ from the $H3_2$ test, determine the quantities $\dot{Q}_h^{k=2}(5)$ and $\dot{E}_h^{k=2}(5)$ from the $H4_2$ test, and evaluate all four according to section 3.10 of this appendix.

e. For multiple-split heat pumps (only), the following procedures supersede the above requirements. For all Table 14A of this appendix tests specified for a minimum compressor speed, turn off at least one indoor unit. The manufacturer shall designate the particular indoor unit(s) to be turned off. The manufacturer must also specify the compressor speed used for the Table 14A $H2_V$ test, a heating mode intermediate compressor speed that falls within ¼ and ¾ of the difference between the full and minimum heating mode speeds. The manufacturer should prescribe an intermediate speed that is expected to yield the highest COP for the given $H2_V$ test conditions and bracketed compressor speed range. The manufacturer can designate that one or more specific indoor units are turned off for the $H2_V$ test.

TABLE 14A—HEATING MODE TEST CONDITIONS FOR UNITS HAVING A VARIABLE-SPEED COMPRESSOR OTHER THAN VARIABLE-SPEED NON-COMMUNICATING COIL-ONLY HEAT PUMPS

Test description	Air entering indoor unit temperature (°F)		Air entering outdoor unit temperature (°F)		Compressor speed	Heating air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb		
$H0_1$ test (required, steady)	70	$60^{(max)}$	62	56.5	Heating Minimum	Heating Minimum.[1]
$H1_2$ test (optional, steady)	70	$60^{(max)}$	47	43	Heating Full[4]	Heating Full-Load.[3]
$H1_1$ test (required, steady)	70	$60^{(max)}$	47	43	Heating Minimum	Heating Minimum.[1]
$H1_N$ test (required, steady)	70	$60^{(max)}$	47	43	Heating Full[5]	Heating Nominal.[7]
$H1C_1$ test (optional, cyclic)	70	$60^{(max)}$	47	43	Heating Minimum	([2])
$H2_2$ test (optional)	70	$60^{(max)}$	35	33	Heating Full[4]	Heating Full-Load.[3]
$H2_V$ test (required)	70	$60^{(max)}$	35	33	Heating Intermediate	Heating Intermediate.[6]

TABLE 14A—HEATING MODE TEST CONDITIONS FOR UNITS HAVING A VARIABLE-SPEED COMPRESSOR OTHER THAN VARIABLE-SPEED NON-COMMUNICATING COIL-ONLY HEAT PUMPS—Continued

Test description	Air entering indoor unit temperature (°F)		Air entering outdoor unit temperature (°F)		Compressor speed	Heating air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb		
$H3_2$ test (required, steady)	70	60[(max)]	17	15	Heating Full[4]	Heating Full-Load.[3]
$H4_2$ test (optional, steady)	70	60[(max)]	5	4[(max)]	Heating Full[8]	Heating Full-Load.[3]

[1] Defined in section 3.1.4.5 of this appendix.
[2] Maintain the airflow nozzle(s) static pressure difference or velocity pressure during an ON period at the same pressure or velocity as measured during the $H1_1$ test.
[3] Defined in section 3.1.4.4 of this appendix.
[4] Maximum speed that the system controls would operate the compressor in normal operation in 17°F ambient temperature. The $H1_2$ test is not needed if the $H1_N$ test uses this same compressor speed.
[5] Maximum speed that the system controls would operate the compressor in normal operation in 47°F ambient temperature.
[6] Defined in section 3.1.4.6 of this appendix.
[7] Defined in section 3.1.4.7 of this appendix.
[8] Maximum speed that the system controls would operate the compressor in normal operation at 5°F ambient temperature.

3.6.4.2 Variable-Speed Compressor With Non-Communicating Coil-Only Heat Pumps

a. Conduct one maximum temperature test ($H0_1$), two high temperature tests ($H1_N$ and $H1_1$), two frost accumulation test ($H2_2$ and $H2_1$), and two low temperature tests ($H3_2$ and $H3_1$). Conducting one or both of the following tests is optional: an additional high temperature test ($H1_2$) and a very low temperature test ($H4_2$). Conduct the optional high temperature cyclic ($H1C_1$) test to determine the heating mode cyclic-degradation coefficient, $C_D{}^h$. If this optional test is conducted and yields a tested $C_D{}^h$ that exceeds the default $C_D{}^h$ or if the optional test is not conducted, assign $C_D{}^h$ the default value of 0.25. Test conditions for the ten tests are specified in Table 14B to this appendix. The compressor shall operate for the $H1_2$ and $H3_2$ tests at the same heating full speed, measured by RPM or power input frequency (Hz), as the maximum speed at which the system controls would operate the compressor in normal operation in 17 °F ambient temperature. The compressor shall operate for the $H1_N$ test at the maximum speed at which the system controls would operate the compressor in normal operation in 47 °F ambient temperature. Additionally, for a cooling/heating heat pump, the compressor shall operate for the $H1_N$ test at a speed, measured by RPM or power input frequency (Hz), no lower than the speed used in the A_2 test if the tested $H1_N$ heating capacity is less than the tested A_2 cooling capacity. The compressor shall operate at the same heating minimum speed, measured by RPM or power input frequency (Hz), for the $H0_1$, $H1C_1$, and $H1_1$ tests.

b. If one of the high temperature tests ($H1_2$ or $H1_N$) is conducted using the same compressor speed (RPM or power input frequency) as the $H3_2$ test, set the 47 °F capacity and power input values used for calculation of HSPF2 equal to the measured values for that test:

$$\dot{Q}^{k=2hcalc}(47) = \dot{Q}^{k=2h}(47) = \dot{E}^{k=2hcalc}(47) = \dot{E}^{k=2h}(47)$$

Where:

$\dot{Q}^{k=2hcalc}(47)$ and $\dot{E}^{k=2hcalc}(47)$ are the capacity and power input, respectively, representing full-speed operation at 47 °F for the HSPF2 calculations,

$\dot{Q}^{k=2}{}_h(47)$ is the capacity measured in the high temperature test ($H1_2$ or $H1_N$) which used the same compressor speed as the $H3_2$ test, and

$\dot{E}^{k=2}{}_h(47)$ is the power input measured in the high temperature test ($H1_2$ or $H1_N$) which used the same compressor speed as the $H3_2$ test.

Evaluate the quantities $\dot{Q}^{h=2}(47)$ and $\dot{E}^{k=2}(47)$ according to section 3.7 of this appendix.

Otherwise (if no high temperature test is conducted using the same speed (RPM or power input frequency) as the $H3_2$ test), calculate the 47 °F capacity and power input values used for calculation of HSPF2 as follows:

$$\dot{Q}^{k=2hcalc}(47) = \dot{Q}^{k=2h}(17) * (1 + 30\ °F\ CSF);$$

and

$$\dot{E}^{k=2hcalc}(47) = \dot{E}^{k=2h}(17) * (1 + 30\ °F\ PSF);$$ and

Where:

$\dot{Q}^{k=2hcalc}$ and $\dot{E}^{k=2hcalc}(47)$ are the capacity and power input, respectively, representing full-speed operation at 47 °F for the HSPF2 calculations,

$\dot{Q}^{k=2h}$ is the capacity measured in the $H3_2$ test,

$\dot{E}^{k=2h}(47)$ is the power input measured in the $H3_2$ test,

CSF is the capacity slope factor, equal to 0.0204/ °F for split systems, and

PSF is the Power Slope Factor, equal to 0.00455/ °F.

c. Determine the quantities $\dot{Q}^{k=2}{}_h(17)$ and $\dot{E}^{k=2}{}_h(5)$ from the $H3_2$ test, determine the quantities $\dot{Q}^{k=2}{}_h(5)$ and $\dot{E}^{k=2}{}_h(5)$ from the $H4_2$ test, and evaluate all four according to section 3.10 of this appendix.

TABLE 14B—HEATING MODE TEST CONDITIONS FOR VARIABLE-SPEED NON-COMMUNICATING COIL-ONLY HEAT PUMPS

Test description	Air entering indoor unit temperature (°F)		Air entering outdoor unit temperature (°F)		Compressor speed	Heating air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb		
$H0_1$ test (required, steady)	70	60 [(max)]	62	56.5	Heating Minimum	Heating Minimum.[1]
$H1_2$ test (optional, steady)	70	60 [(max)]	47	43	Heating Full[4]	Heating Full-Load.[3]
$H1_1$ test (required, steady)	70	60 [(max)]	47	43	Heating Minimum	Heating Minimum.[1]
$H1_N$ test (required, steady)	70	60 [(max)]	47	43	Heating Full[5]	Heating Full-Load.[3]
$H1C_1$ test (optional, cyclic)	70	60 [(max)]	47	43	Heating Minimum	([2])
$H2_2$ test (required)	70	60 [(max)]	35	33	Heating Full[6]	Heating Full-Load.[3]
$H2_1$ test (required)	70	60 [(max)]	35	33	Heating Minimum[7]	Heating Minimum.[1]
$H3_2$ test (required, steady)	70	60 [(max)]	17	15	Heating Full[4]	Heating Full-Load.[3]
$H3_1$ test (required, steady)	70	60 [(max)]	17	15	Heating Minimum[8]	Heating Minimum.[1]
$H4_2$ test (optional, steady)	70	60 [(max)]	5	4 [(max)]	Heating Full[9]	Heating Full-Load.[3]

[1] Defined in section 3.1.4.5 of this appendix.
[2] Maintain the airflow nozzle(s) static pressure difference or velocity pressure during an ON period at the same pressure or velocity as measured during the $H1_1$ test.
[3] Defined in section 3.1.4.4 of this appendix.
[4] Maximum speed that the system controls would operate the compressor in normal operation in 17 °F ambient temperature. The $H1_2$ test is not needed if the $H1_N$ test uses this same compressor speed.
[5] Maximum speed that the system controls would operate the compressor in normal operation in 47 °F ambient temperature.
[6] Maximum speed that the system controls would operate the compressor in normal operation in 35 °F ambient temperature.
[7] Minimum speed that the system controls would operate the compressor in normal operation in 35 °F ambient temperature.
[8] Minimum speed that the system controls would operate the compressor in normal operation in 17 °F ambient temperature.
[9] Maximum speed that the system controls would operate the compressor in normal operation in 5 °F ambient temperature.

* * * * *

3.6.6 Heating Mode Tests for Northern Heat Pumps With Triple-Capacity Compressors

* * * * *

TABLE 15—HEATING MODE TEST CONDITIONS FOR UNITS WITH A TRIPLE-CAPACITY COMPRESSOR

Test description	Air entering indoor unit (°F)		Air entering outdoor unit (°F)		Compressor capacity	Heating air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb		
$H0_1$ Test (required, steady)	70	60 (max)	62	56.5	Low	Heating Minimum.[1]
$H1_2$ (required, steady)	70	60 (max)	47	43	High	Heating Full-Load.[2]
$H1C_2$ Test (optional,[8] cyclic	70	60 (max)	47	43	High	([3])
$H1_1$ Test (required, steady)	70	60 (max)	47	43	Low	Heating Minimum.[1]
$H1C_1$ Test (optional, cyclic)	70	60 (max)	47	43	Low	([4])
$H2_3$ Test (optional, steady)	70	60 (max)	35	33	Booster	Heating Full-Load.[2]
$H2_2$ Test (required)	70	60 (max)	35	33	High	Heating Full-Load.[2]
$H2_1$ Test (required	70	60 (max)	35	33	Low	Heating Minimum.[1]
$H3_3$ Test (required, steady)	70	60 (max)	17	15	Booster	Heating Full-Load.[2]
$H3C_3$ Test[5 6] (optional, cyclic)	70	60 (max)	17	15	Booster	([7])
$H3_2$ Test (required, steady)	70	60 (max)	17	15	High	Heating Full-Load.[2]
$H3_1$ Test[5] (required, steady)	70	60 (max)	17	15	Low	Heating Minimum.[1]
$H4_3$ Test (required, steady)	70	60 (max)	5	4 (max)	Booster	Heating Full-Load.[2]

[1] Defined in section 3.1.4.5 of this appendix.
[2] Defined in section 3.1.4.4 of this appendix.
[3] Maintain the airflow nozzle(s) static pressure difference or velocity pressure during the ON period at the same pressure or velocity as measured during the $H1_2$ test.
[4] Maintain the airflow nozzle(s) static pressure difference or velocity pressure during the ON period at the same pressure or velocity as measured during the $H1_1$ test.
[5] Required only if the heat pump's performance when operating at low compressor capacity and outdoor temperatures less than 37 °F is needed to complete the HSPF2 calculations in section 4.2.6 of this appendix. .
[6] If note #5 to this table applies, the equations for $\dot{Q}^{k=1}_h(35)$ and $\dot{E}^{k=1}_h(17)$ in section 3.6.6 of this appendix may be used in lieu of conducting the $H2_1$ test.
[7] Maintain the airflow nozzle(s) static pressure difference or velocity pressure during the ON period at the same pressure or velocity as measured during the $H3_3$ test.
[8] Required only if the heat pump locks out low-capacity operation at lower outdoor temperatures

* * * * *

3.7 Test Procedures for Steady-State Maximum Temperature and High Temperature Heating Mode Tests (the $H0_1$, H1, $H1_2$, $H1_1$, and $H1_N$ tests)

* * * * *

c. For mobile home and space-constrained ducted coil-only system tests,

(1) For two-stage or variable-speed systems, for all steady-state maximum temperature and high temperature tests (*i.e.,* the $H0_1$, $H1_1$, $H1_2$, and $H1_N$ tests), increase $Q_c^k(T)$ by the quantity calculated in Equation 3.7–1 to this appendix and increase $\overline{\dot{E}_c}^k(T)$ by the quantity calculated in Equation 3.7–2 to this appendix.

$$\text{Equation 3.7-1} \quad \frac{(\text{DFPC}_{MHSC}*3.412)\ Btu/h}{1000\ scfm} * \dot{V}_S$$

$$\text{Equation 3.7-2} \quad \frac{\text{DFPC}_{MHSC}\ W}{1000\ scfm} * \dot{V}_S,$$

Where:

$DFPC_{MHSC}$ is the default fan power coefficient (watts) for mobile-home and space-constrained systems,

$$\text{DFPC}_{MHSC} = 308 + \frac{(406-308)*(\%FLAVR - 75\%)}{100\% - 75\%}$$

And %FLAVR is the air volume rate used for the test, expressed as a percentage of the cooling full load air volume rate. For all tests specifying the full-load air volume rate (*e.g.,* the $H1_2$ and $H1_N$ tests), set %FLAVR to 100%. For tests that specify the heating minimum air volume rate or heating intermediate air volume rate (*i.e.,* the $H0_1$ and $H1_1$ tests) and for which the specified minimum or intermediate air volume rate is greater than or equal to 75 percent of the cooling full-load air volume rate and less than the cooling full-load air volume rate, set %FLAVR to the ratio of the specified air volume rate and the cooling full-load air volume rate, expressed as a percentage.

(2) For single-stage systems, for all steady-state maximum temperature and high temperature tests (*i.e.,* the H1 test), increase $Q_c^k(T)$ by the quantity calculated in Equation 3.7–3 to this appendix and increase $E_c^k(T)$ by the quantity calculated in Equation 3.7–4 to this appendix.

$$\text{Equation 3.7-3} \quad \frac{1385\ Btu/h}{1000\ scfm} * \dot{V}_S$$

$$\text{Equation 3.7-4} \quad \frac{406\,W}{1000\,scfm} * \dot{V}_S.$$

Where $\dot{V}_S$ is the average measured indoor air volume rate expressed in units of cubic feet per minute of standard air (scfm).

d. For non-mobile, non-space-constrained home ducted coil-only system tests,

(1) For two-stage or variable-speed systems, for all steady-state maximum temperature and high temperature tests (*i.e.,* the $H0_1$, $H1_1$, $H1_2$, and $H1_N$ tests), increase $Q_c^k(T)$ by the quantity calculated in Equation 3.7–5 to this appendix and increase $E_c^k(T)$ by the quantity calculated in Equation 3.7–6 to this appendix.

$$\text{Equation 3.7-5} \quad \frac{(\mathrm{DFPC}_C * 3.412)\,Btu/h}{1000\,scfm} * \dot{V}_S$$

$$\text{Equation 3.7-6} \quad \frac{\mathrm{DFPC}_C\,W}{1000\,scfm} * \dot{V}_S,$$

Where:

$DFPC_C$ is the default fan power coefficient (watts) for non-mobile-home and non-space-constrained systems,

$$\mathrm{DFPC}_C = 335 + \frac{(441 - 335) * (\%FLAVR - 75\%)}{100\% - 75\%}$$

And %FLAVR is the air volume rate used for the test, expressed as a percentage of the cooling full load air volume rate. For all tests specifying the full-load air volume rate (*e.g.,* the $H1_2$ and $H1_N$ tests), set %FLAVR to 100%. For tests that specify the heating minimum air volume rate or heating intermediate air volume rate (*i.e.,* the $H0_1$ and $H1_1$ tests) and for which the specified minimum or intermediate air volume rate is greater than or equal to 75 percent of the cooling full-load air volume rate and less than the cooling full-load air volume rate, set %FLAVR to the ratio of the specified air volume rate and the cooling full-load air volume rate, expressed as a percentage.

(2) For single-stage systems, for all steady-state maximum temperature and high temperature tests (*i.e.,* the H1 test), increase $Q_c^k(T)$ by the quantity calculated in Equation 3.7–7 to this appendix and increase $E_c^k(T)$ by the quantity calculated in Equation 3.7–8 to this appendix.

$$\text{Equation 3.7-7} \quad \frac{1505\,Btu/h}{1000\,scfm} * \dot{V}_S$$

$$\text{Equation 3.7-8} \quad \frac{441\,W}{1000\,scfm} * \dot{V}_S.$$

Where $\dot{V}_S$ is the average measured indoor air volume rate expressed in units of cubic feet per minute of standard air (scfm).

* * * * *

3.8 Test Procedures for the Cyclic Heating Mode Tests (the $H0C_1$, H1C, $H1C_1$ and $H1C_2$ Tests).

* * * * *

b. For ducted coil-only system heat pumps (excluding the special case where a variable-speed fan is temporarily removed),

(1) For mobile home and space-constrained ducted coil-only systems,

(i) For two-stage or variable-speed systems, for all cyclic heating tests (*i.e.,* the $H1C_1$ and $H1C_2$ tests), increase q_{cyc} by the amount calculated using Equation 3.5–2 to this appendix. Additionally, increase e_{cyc} by the amount calculated using Equation 3.5–3 to this appendix.

(ii) For single-stage systems, for all cyclic heating tests (*i.e.,* the H1C and $H1C_1$ tests), increase q_{cyc} by the amount calculated using Equation 3.5–4 to this appendix. Additionally, increase e_{cyc} by the amount calculated using Equation 3.5–5 to this appendix.

(2) For non-mobile home and non-space-constrained ducted coil-only systems,

(i) For two-stage or variable-speed systems, for all cyclic heating tests (*i.e.,* the $H1C_1$ and $H1C_2$ tests), increase q_{cyc} by the amount calculated using Equation 3.5–6 to this appendix. Additionally, increase e_{cyc} by the amount calculated using Equation 3.5–7 to this appendix.

(ii) For single-stage systems, for all cyclic heating tests (*i.e.,* the H1C and $H1C_1$ tests), increase q_{cyc} by the amount calculated using Equation 3.5–8 to this appendix. Additionally, increase e_{cyc} by the amount calculated using Equation 3.5–9 to this appendix.

In making these calculations, use the average indoor air volume rate (V_s) determined from the section 3.7 of this appendix steady-state heating mode test conducted at the same test conditions.

* * * * *

3.9.1 Average Space Heating Capacity and Electrical Power Calculations

* * * * *

b. Evaluate average electrical power, $\dot{E}_h{}^k(35) = \frac{e_{def}(35)}{\Delta_{\tau_{FR}}}$, when expressed in units of watts, using:

(1) For mobile home and space-constrained ducted coil-only system tests,

(i) For two-stage or variable-speed systems, for all frost accumulation tests (*i.e.,* the $H2_1$, $H2_2$, and $H2_V$ tests), increase $Q_h{}^k(35)$ by the quantity calculated in Equation 3.9.1–1 to this appendix and increase $E_h{}^k(35)$ by the quantity calculated in Equation 3.9.1–2 to this appendix.

$$\text{Equation 3.9.1-1} \quad \frac{(\text{DFPC}_{MHSC} * 3.412)\ Btu/h}{1000\ scfm} * \dot{V}_S$$

$$\text{Equation 3.9.1-2} \quad \frac{\text{DFPC}_{MHSC}\ W}{1000\ scfm} * \dot{V}_S,$$

Where:

$DFPC_{MHSC}$ is the default fan power coefficient (watts) for mobile-home and space-constrained systems,

$$\text{DFPC}_{MHSC} = 308 + \frac{(406 - 308) * (\%FLAVR - 75\%)}{100\% - 75\%}$$

And %FLAVR is the air volume rate used for the test, expressed as a percentage of the cooling full load air volume rate. For all tests specifying the full-load air volume rate (*e.g.,* the $H2_2$ test), set %FLAVR to 100%. For tests that specify the heating minimum air volume rate or heating intermediate air volume rate (*i.e.,* the $H2_1$ and $H2_v$ tests) and for which the specified minimum or intermediate air volume rate is greater than or equal to 75 percent of the cooling full-load air volume rate and less than the cooling full-load air volume rate, set %FLAVR to the ratio of the specified air volume rate and the cooling full-load air volume rate, expressed as a percentage.

(ii) For single-stage systems, for all frost accumulation tests (*i.e.,* the H2 test), increase $Q_h{}^k(35)$ by the quantity calculated in Equation 3.9.1–3 to this appendix and increase $Q_h{}^k(35)$ by the quantity calculated in Equation 3.9.1–4 to this appendix.

$$\text{Equation 3.9.1-3} \quad \frac{1385\ Btu/h}{1000\ scfm} * \dot{V}_S$$

$$\text{Equation 3.9.1-4} \quad \frac{406\ W}{1000\ scfm} * \dot{V}_S.$$

Where V_s is the average measured indoor air volume rate expressed in units of cubic feet per minute of standard air (scfm).

(2) For non-mobile home and non-space-constrained ducted coil-only systems,

(i) For two-stage or variable-speed systems, for all frost accumulation tests (*i.e.,* the $H2_1$, $H2_2$, and $H2_V$ tests), increase $Q_h{}^k(35)$ by the quantity calculated in Equation 3.9.1–5 to this appendix and increase $E_h{}^k(35)$ by the quantity calculated in Equation 3.9.1–6 to this appendix.

$$\text{Equation 3.9.1-5} \quad \frac{(\text{DFPC}_C * 3.412)\ Btu/h}{1000\ scfm} * \dot{V}_S$$

$$\text{Equation 3.9.1-6} \quad \frac{\text{DFPC}_C\ W}{1000\ scfm} * \dot{V}_S,$$

Where:

$DFPC_C$ is the default fan power coefficient (watts) for non-mobile-home and non-space-constrained systems,

$$\text{DFPC}_C = 335 + \frac{(441 - 335) * (\%FLAVR - 75\%)}{100\% - 75\%}$$

And %FLAVR is the air volume rate used for the test, expressed as a percentage of the cooling full load air volume rate. For all tests specifying the full-load air volume rate (*e.g.,* the $H2_2$ test), set %FLAVR to 100%. For tests that specify the heating minimum air volume rate or heating intermediate air volume rate (*i.e.,* the $H2_1$ and $H2_v$ tests) and for which the specified minimum or intermediate air volume rate is greater than or equal to 75 percent of the cooling full-load air volume rate and less than the cooling full-load air volume rate, set %FLAVR to the ratio of the specified air volume rate and the cooling full-load air volume rate, expressed as a percentage.

(ii) For single-stage systems, for all frost accumulation tests (*i.e.,* the H2 test), increase $Q_h{}^k(35)$ by the quantity calculated in Equation 3.9.1–7 to this appendix and increase $E_h{}^k(35)$ by the quantity calculated in Equation 3.9.1–8 to this appendix.

Equation 3.9.1-7 $\frac{1505 ^{Btu}/_{h}}{1000\,scfm} * \dot{V}_S$, and

Equation 3.9.1-8 $\frac{441\,W}{1000\,scfm} * \dot{V}_S$.

Where V_s is the average measured indoor air volume rate expressed in units of cubic feet per minute of standard air (scfm).

* * * * *

4.1.4 SEER2 Calculations for an Air Conditioner or Heat Pump Having a Variable-Speed Compressor

Calculate SEER2 using Equation 4.1–1 to this appendix. Evaluate the space cooling capacity, $Q_c^{k=1}(T_j)$, and electrical power consumption, $E_c^{k=1}(T_j)$, of the test unit when operating at minimum compressor speed and outdoor temperature T_j. Use:

Equation 4.1.4-1 $\dot{Q}_c^{k=1}(T_j) = \dot{Q}_c^{k=1}(67) + \frac{\dot{Q}_c^{k=1}(82) - \dot{Q}_c^{k=1}(67)}{82-67} * (T_j - 67)$

Equation 4.1.4-2 $\dot{E}_c^{k=1}(T_j) = \dot{E}_c^{k=1}(67) + \frac{\dot{E}_c^{k=1}(82) - \dot{E}_c^{k=1}(67)}{82-67} * (T_j - 67)$

Where $\dot{Q}_c^{k=1}(82)$ and $\dot{E}_c^{k=1}(82)$ are determined from the B_1 test, $\dot{Q}_c^{k=1}(67)$ and $E_c^{k=1}(67)$ are determined from the F_1 test, and all four quantities are calculated as specified in section 3.3 of this appendix. Evaluate the space cooling capacity, $\dot{Q}_c^{k=2}(T_j)$, and electrical power consumption, $\dot{E}_c^{k=2}(T_j)$, of the test unit when operating at full compressor speed and outdoor temperature T_j. Use Equations 4.1.3–3 and 4.1.3–4 to this appendix, respectively, where $\dot{Q}_c^{k=2}(95)$ and $\dot{E}_c^{k=2}(95)$ are determined from the A_2 test, $\dot{Q}_c^{k=2}(82)$ and $\dot{E}_c^{k=2}(82)$ are determined from the B_2 test, and all four quantities are calculated as specified in section 3.3 of this appendix. For units other than variable-speed non-communicating coil-only air-conditioners or heat pumps, calculate the space cooling capacity, $\dot{Q}_c^{k=v}(T_j)$, and electrical power consumption, $\dot{E}_c^{k=v}(T_j)$, of the test unit when operating at outdoor temperature T_j and the intermediate compressor speed used during the section 3.2.4 (and Table 8) E_V test of this appendix using:

Equation 4.1.4-3 $\dot{Q}_c^{k=v}(T_j) = \dot{Q}_c^{k=v}(87) + M_Q * (T_j - 87)$

Equation 4.1.4-4 $\dot{E}_c^{k=v}(T_j) = \dot{E}_h^{k=v}(87) + M_E * (T_j - 87)$

Where $\dot{Q}_c^{k=v}(87)$ are determined from the E_V test and calculated as specified in section 3.3 of this appendix.

Approximate the slopes of the k=v intermediate speed cooling capacity and electrical power input curves, M_Q and M_E, as follows:

$$M_Q = \left[\frac{\dot{Q}_c^{k=1}(82) - \dot{Q}_c^{k=1}(67)}{82-67} * (1 - N_Q)\right] + \left[N_Q * \frac{\dot{Q}_c^{k=2}(95) - \dot{Q}_c^{k=2}(82)}{95-82}\right]$$

$$M_E = \left[\frac{\dot{E}_c^{k=1}(82) - \dot{E}_c^{k=1}(67)}{82-67} * (1 - N_E)\right] + \left[N_E * \frac{\dot{E}_c^{k=2}(95) - \dot{E}_c^{k=2}(82)}{95-82}\right]$$

Where:

$$N_Q = \frac{\dot{Q}_c^{k=v}(87) - \dot{Q}_c^{k=1}(87)}{\dot{Q}_c^{k=2}(87) - \dot{Q}_c^{k=1}(87)} \text{ and } N_E = \frac{\dot{E}_c^{k=v}(87) - \dot{E}_c^{k=1}(87)}{\dot{E}_c^{k=2}(87) - \dot{E}_c^{k=1}(87)}$$

Use Equations 4.1.4–1 and 4.1.4–2 to this appendix, respectively, to calculate $\dot{Q}_c^{k=1}(87)$ and $\dot{E}_c^{k=1}(87)$.

* * * * *

4.1.4.2.1 Units That Are Not Variable-Speed Non-Communicating Coil-Only Air Conditioners or Heat Pumps

If the unit operates at an intermediate compressor speed (k=i) in order to match the building cooling load at temperature T_j, $\dot{Q}_c^{k=1}(T_j) < BL(T_j) < \dot{Q}_c^{k=2}(T_j)$.

$$\frac{q_c(T_j)}{N} = \dot{Q}_c^{k=i}(T_j) * \frac{n_j}{N} \quad \frac{e_c(T_j)}{N} = \dot{E}_c^{k=i}(T_j) * \frac{n_j}{N}$$

Where:

$\dot{Q}_c^{k=i}(T_j)$ = $BL(T_j)$, the space cooling capacity delivered by the unit in matching the building load at temperature T_j, in Btu/h. The matching occurs with the unit operating at compressor speed k = i.

$$\dot{E}_c^{k=i}(T_j) = \frac{\dot{Q}_c^{k=i}(T_j)}{EER^{k=i}(T_j)}$$ the electrical power input required by the test unit when operating at a compressor speed of k = i and temperature T_j, in W.

$EER^{k=i}(T_j)$ = the steady-state energy efficiency ratio of the test unit when operating at a compressor speed of k = i and temperature T_j, Btu/h per W.

Obtain the fractional bin hours for the cooling season, n_j/N, from Table 19 of this section. For each temperature bin where the unit operates at an intermediate compressor speed, determine the energy efficiency ratio $EER^{k=i}(T_j)$ using the following equations:

For each temperature bin where $\dot{Q}_c^{k=1}(T_j) < BL(T_j) < \dot{Q}_c^{k=v}(T_j)$,

$$EER^{k=i}(T_j) = EER^{k=1}(T_j) + \frac{EER^{k=v}(T_j) - EER^{k=1}(T_j)}{Q^{k=v}(T_j) - Q^{k=1}(T_j)} * (BL(T_j) - Q^{k=1}(T_j))$$

For each temperature bin where $\dot{Q}_c^{k=v}(T_j) < BL(T_j) < \dot{Q}_c^{k=2}(T_j)$,

$$EER^{k=i}(T_j) = EER^{k=v}(T_j) + \frac{EER^{k=2}(T_j) - EER^{k=v}(T_j)}{Q^{k=2}(T_j) - Q^{k=v}(T_j)} * (BL(T_j) - Q^{k=v}(T_j))$$

Where:

$EER^{k=1}(T_j)$ is the steady-state energy efficiency ratio of the test unit when operating at minimum compressor speed and temperature Tj, in Btu/h per W, calculated using capacity $\dot{Q}_c^{k=1}(T_j)$ calculated using Equation 4.1.4–1 to this appendix and electrical power consumption $\dot{E}_c^{k=1}(T_j)$ calculated using Equation 4.1.4–2 to this appendix;

$EER^{k=v}(T_j)$ is the steady-state energy efficiency ratio of the test unit when operating at intermediate compressor speed and temperature Tj, in Btu/h per W, calculated using capacity $\dot{Q}_c^{k=v}(T_j)$ calculated using Equation 4.1.4–3 to this appendix and electrical power consumption $\dot{E}_c^{k=v}(T_j)$ calculated using Equation 4.1.4–4 to this appendix;

$EER^{k=2}(T_j)$ is the steady-state energy efficiency ratio of the test unit when operating at full compressor speed and temperature Tj, Btu/h per W, calculated using capacity $\dot{Q}_c^{k=2}(T_j)$ and electrical power consumption $\dot{E}_c^{k=2}(T_j)$, both calculated as described in section 4.1.4 of this appendix; and

$BL(T_j)$ is the building cooling load at temperature T_j, Btu/h.

4.1.4.2.2 Variable-Speed Non-Communicating Coil-Only Air Conditioners or Heat Pumps

If the unit alternates between high (k=2) and low (k=1) compressor capacity to satisfy the building cooling load at temperature T_j, $\dot{Q}_c^{k=1}(T_j) < BL(T_j) < \dot{Q}_c^{k=2}(T_j)$.

$$\frac{q_c(T_j)}{N} = [X^{k=1}(T_j) * \dot{Q}_c^{k=1}(T_j) + X^{k=2}(T_j) * \dot{Q}_c^{k=2}(T_j)] * \frac{n_j}{N}$$

$$\frac{e_c(T_j)}{N} = [X^{k=1}(T_j) * \dot{E}_c^{k=1}(T_j) + X^{k=2}(T_j) * \dot{E}_c^{k=2}(T_j)] * \frac{n_j}{N}$$

Where:

$$X^{k=1}(T_j) = \frac{\dot{Q}_c^{k=2}(T_j) - BL(T_j)}{\dot{Q}_c^{k=2}(T_j) - \dot{Q}_c^{k=1}(T_j)}$$ the cooling mode, low capacity load factor for

the cooling mode, low capacity load factor for temperature bin j (dimensionless); and $X^{k=2}(T_j) = 1 - X^{k=1}(T_j)$, the cooling mode, high capacity load factor for temperature bin j (demensionless).

Obtain the fractional bin hours for the cooling season, n_j/N, from Table 19 to this appendix. Obtain $\dot{Q}_c^{k=1}(T_j)$, $\dot{E}_c^{k=1}(T_j)$, $\dot{Q}_c^{k=2}(T_j)$, and $\dot{E}_c^{k=2}(T_j)$ as described in section 4.1.4 of this appendix.

* * * * *

4.2 Heating Seasonal Performance Factor 2 (HSPF2) Calculations

* * * * *

Evaluate the building heating load using:

Equation 4.2-2 $BL(T_j) = \frac{T_{zl}-T_j}{T_{zl}-5°F} * C * \dot{Q}_c(95°F)$

Where:

T_j = the outdoor bin temperature, °F;

T_{zl} = the zero-load temperature, °F, which varies by climate region according to Table 20 to this appendix;

C = slope (adjustment) factor, which varies by climate region according to Table 20 to this appendix. When calculating building load for a variable-speed compressor system, substitute C_{VS} for C;

$Q_c(95\ °F)$ = the cooling capacity at 95 °F determined from the A or A_2 test, Btu/h. For heating-only heat pump units, replace $Q_c(95\ °F)$ in Equation 4.2–2 with $Q_h(47\ °F)$;

$Q_h(47\ °F)$ = the heating capacity at 47 °F determined from the H1 test for units having a single-speed compressor, $H1_2$ for units having a two-capacity compressor, and $H1_N$ test for units having a variable-speed compressor, Btu/h.

* * * * *

4.2.3 Additional Steps for Calculating the HSPF2 of a Heat Pump Having a Two-Capacity Compressor

The calculation of the Equation 4.2–1 to this appendix quantities differ depending upon whether the heat pump would operate at low capacity (section 4.2.3.1 of this appendix), cycle between low and high capacity (section 4.2.3.2 of this appendix), or operate at high capacity (sections 4.2.3.3 and 4.2.3.4 of this appendix) in responding to the building load. For heat pumps that lock out low capacity operation at low outdoor temperatures, the outdoor temperature at which the unit locks out must be that specified by the manufacturer in the certification report so that the appropriate equations can be selected.

* * * * *

4.2.3.4 Heat Pump Must Operate Continuously at High (k=2) Compressor Capacity at Temperature T_j, $BL(T_j) \geq \dot{Q}_h^{k=2}(T_j)$

$$\frac{e_h(T_j)}{N} = \dot{E}_h^{k=2}(T_j) * \delta'(T_j) * \frac{n_j}{N}$$

$$\frac{RH(T_j)}{N} = \frac{BL(T_j) - [\dot{Q}_h^{k=2}(T_j) * \delta'(T_j)]}{3.413\frac{Btu}{Wh}} * \frac{n_j}{N}$$

Where:

$$\delta'(T_j) = \begin{cases} 0, & if\ T_j \leq T_{off}\ or\ \frac{\dot{Q}_h^{k=2}(T_j)}{3.413 * \dot{E}_h^{k=2}(T_j)} < 1 \\ \frac{1}{2}, & if\ T_{off} < T_j \leq T_{on}\ and\ \frac{\dot{Q}_h^{k=2}(T_j)}{3.413 * \dot{E}_h^{k=2}(T_j)} \geq 1 \\ 1, & if\ T_j > T_{on}\ and\ \frac{\dot{Q}_h^{k=2}(T_j)}{3.413 * \dot{E}_h^{k=2}(T_j)} \geq 1 \end{cases}$$

4.2.4 Additional Steps for Calculating the HSPF2 of a Heat Pump Having a Variable-Speed Compressor. Calculate HSPF2 Using Equation 4.2–1

* * * * *

a. Minimum Compressor Speed. For units other than variable-speed non-communicating coil-only heat pumps, evaluate the space heating capacity, $Q_h^{k=1}(T_j)$, and electrical power consumption, $E_h^{k=1}(T_j)$, of the heat pump when operating at minimum compressor speed and outdoor temperature T_j using:

Equation 4.2.4-1

$$\dot{Q}_h^{k=1}(T_j) = \dot{Q}_h^{k=1}(47) + \frac{\dot{Q}_h^{k=1}(62)-\dot{Q}_h^{k=1}(47)}{62-47} * (T_j - 47);\ \text{and}$$

Equation 4.2.4-2

$$\dot{E}_h^{k=1}(T_j) = \dot{E}_h^{k=1}(47) + \frac{\dot{E}_h^{k=1}(62) - \dot{E}_h^{k=1}(47)}{62-47} * (T_j - 47)$$

Where $Q_h^{k=1}(62)$ and $E_h^{k=1}(62)$ are determined from the $H0_1$ test, $Q_h^{k=1}(47)$ and $E_h^{k=1}(47)$ are determined from the $H1_1$ test, and all four quantities are calculated as specified in section 3.7 of this appendix.

For variable-speed non-communicating coil-only heat pumps, when T_j is greater than or equal to 47 °F, evaluate the space heating capacity, $\dot{Q}_h^{k=1}(T_j)$, and electrical power consumption, $\dot{E}_h^{k=1}(T_j)$, of the heat pump when operating at minimum compressor speed as described in Equations 4.2.4–1 and 4.2.4–2 to this appendix, respectively. When T_j is less than 47 °F, evaluate the space heating capacity, $\dot{Q}_h^{k=1}(T_j)$, and electrical power consumption, $\dot{E}_h^{k=1}(T_j)$ using:

Equation 4.2.4-3

$$\dot{Q}_h^{k=1}(T_j) = \begin{cases} \dot{Q}_h^{k=1}(35) + \frac{[\dot{Q}_h^{k=1}(47) - \dot{Q}_h^{k=1}(35)] * (T_j - 35)}{47 - 35}, & if\ 35\ °F \leq T_j < 47\ °F \\ \dot{Q}_h^{k=1}(17) + \frac{[\dot{Q}_h^{k=1}(35) - \dot{Q}_h^{k=1}(17)] * (T_j - 17)}{35 - 17}, & if\ 17\ °F \leq T_j < 35\ °F \\ \dot{Q}_h^{k=2}(T_j) * \left(\dot{Q}_h^{k=1}(17) / \dot{Q}_h^{k=2}(17)\right), & if\ T_j < 17\ °F \end{cases}$$

And

Equation 4.2.4-4

$$\dot{E}_h^{k=1}(T_j) = \begin{cases} \dot{E}_h^{k=1}(35) + \frac{[\dot{E}_h^{k=1}(47) - \dot{E}_h^{k=1}(35)] * (T_j - 35)}{47 - 35}, & if\ 35\ °F \leq T_j < 47\ °F \\ \dot{E}_h^{k=1}(17) + \frac{[\dot{E}_h^{k=1}(35) - \dot{E}_h^{k=1}(17)] * (T_j - 17)}{35 - 17}, & if\ 17\ °F \leq T_j < 35\ °F \\ \dot{E}_h^{k=2}(T_j) * \left(\dot{E}_h^{k=1}(17) / \dot{E}_h^{k=2}(17)\right), & if\ T_j < 17\ °F \end{cases}$$

Where $\dot{Q}_h^{k=1}(47)$ and $\dot{E}_h^{k=1}(47)$ are determined from the $H1_1$ test, and both quantities are calculated as specified in section 3.7 of this appendix; $\dot{Q}_h^{k=1}(35)$ and $\dot{E}_h^{k=1}(35)$ are determined from the $H2_1$ test, and are calculated as specified in section 3.9 of this appendix; $\dot{Q}_h^{k=1}(17)$ and $\dot{E}_h^{k=1}(17)$ are determined from the $H3_1$ test, and are calculated as specified in section 3.10 of this appendix; and $\dot{Q}_h^{k=2}(T_j)$ and $\dot{E}_h^{k=2}(T_j)$ are calculated as described in section 4.2.4.c or 4.2.4.d of this appendix, as appropriate.

b. Minimum Compressor Speed for Minimum-speed-limiting Variable-speed Heat Pumps. For units other than variable-speed non-communicating coil-only heat pumps, evaluate the space heating capacity, $\dot{Q}_h^{k=1}(T_j)$, and electrical power consumption, $\dot{E}_h^{k=1}(T_j)$, of the heat pump when operating at minimum compressor speed and outdoor temperature T_j using:

Equation 4.2.4-5

$$\dot{Q}_h^{k=1}(T_j) = \begin{cases} \dot{Q}_h^{k=1}(47) + \frac{[\dot{Q}_h^{k=1}(62) - \dot{Q}_h^{k=1}(47)] * (T_j - 47)}{62 - 47}, & if\ T_j \geq 47\ °F \\ \dot{Q}_h^{k=v}(35) + \frac{[\dot{Q}_h^{k=1}(47) - \dot{Q}_h^{k=v}(35)] * (T_j - 35)}{47 - 35}, & if\ 35\ °F \leq T_j < 47\ °F \\ \dot{Q}_h^{k=v}(T_j), & if\ T_j < 35\ °F \end{cases}$$

And

Equation 4.2.4-6

$$\dot{E}_h^{k=1}(T_j) = \begin{cases} \dot{E}_h^{k=1}(47) + \dfrac{\left[\dot{E}_h^{k=1}(62) - \dot{E}_h^{k=1}(47)\right] * (T_j - 47)}{62 - 47}, & if\ T_j \geq 47\ °F \\ \dot{E}_h^{k=v}(35) + \dfrac{\left[\dot{E}_h^{k=1}(47) - \dot{E}_h^{k=v}(35)\right] * (T_j - 35)}{47 - 35}, & if\ 35\ °F \leq T_j < 47\ °F \\ \dot{E}_h^{k=v}(T_j), & if\ T_j < 35\ °F \end{cases}$$

Where $\dot{Q}_h^{k=1}(62)$ and $\dot{E}_h^{k=1}(62)$ are determined from the $H0_1$ test, $\dot{Q}_h^{k=1}(47)$ and $\dot{E}_h^{k=1}(47)$ are determined from the $H1_1$ test, and all four quantities are calculated as specified in section 3.7 of this appendix; $\dot{Q}_h^{k=v}(35)$ and $\dot{E}_h^{k=v}(35)$ are determined from the $H2_v$ test and are calculated as specified in section 3.9 of this appendix; and $\dot{Q}_h^{k=v}(T_j)$ and $\dot{E}_h^{k=v}(T_j)$ are calculated using Equations 4.2.4–7 and 4.2.4–8 to this appendix, respectively.

For variable-speed non-communicating coil-only heat pumps, evaluate the space heating capacity, $\dot{Q}_h^{k=1}(T_j)$, and electrical power consumption, $\dot{E}_h^{k=1}(T_j)$, of the heat pump as described in section 4.2.4.a of this appendix, using Equations 4.2.4–1, 4.2.4–2, 4.2.4–3, and 4.2.4–4 to this appendix, as appropriate.

c. Full Compressor Speed for Heat Pumps for which the $H4_2$ test is not conducted. Evaluate the space heating capacity, $\dot{Q}_h^{k=2}(T_j)$, and electrical power consumption, $\dot{E}_h^{k=2}(T_j)$, of the heat pump when operating at full compressor speed and outdoor temperature T_j using:

$$\dot{Q}_h^{k=2}(T_j) = \begin{cases} \left\{\dot{Q}_h^{k=2}(17) + \dfrac{\left[\dot{Q}_{hcalc}^{k=2}(47) - \dot{Q}_h^{k=2}(17)\right] * (T_j - 17)}{47 - 17}\right\} * \left(\dfrac{\dot{Q}_h^{k=N}(47)}{\dot{Q}_{hcalc}^{k=2}(47)}\right), & if\ T_j \geq 45\ °F \\ \dot{Q}_h^{k=2}(17) + \dfrac{\left[\dot{Q}_h^{k=2}(35) - \dot{Q}_h^{k=2}(17)\right] * (T_j - 17)}{35 - 17}, & if\ 17\ °F \leq T_j < 45\ °F \\ \dot{Q}_h^{k=2}(17) + \dfrac{\left[\dot{Q}_{hcalc}^{k=2}(47) - \dot{Q}_h^{k=2}(17)\right] * (T_j - 17)}{47 - 17}, & if\ T_j < 17\ °F \end{cases}$$

And

$$\dot{E}_h^{k=2}(T_j) = \begin{cases} \left\{\dot{E}_h^{k=2}(17) + \dfrac{\left[\dot{E}_{hcalc}^{k=2}(47) - \dot{E}_h^{k=2}(17)\right] * (T_j - 17)}{47 - 17}\right\} * \left(\dfrac{\dot{E}_h^{k=N}(47)}{\dot{E}_{hcalc}^{k=2}(47)}\right), & if\ T_j \geq 45\ °F \\ \dot{E}_h^{k=2}(17) + \dfrac{\left[\dot{E}_h^{k=2}(35) - \dot{E}_h^{k=2}(17)\right] * (T_j - 17)}{35 - 17}, & if\ 17\ °F \leq T_j < 45\ °F \\ \dot{E}_h^{k=2}(17) + \dfrac{\left[\dot{E}_{hcalc}^{k=2}(47) - \dot{E}_h^{k=2}(17)\right] * (T_j - 17)}{47 - 17}, & if\ T_j < 17\ °F \end{cases}$$

Determine $\dot{Q}_h^{k=N}(47)$ and $\dot{E}_h^{k=N}(47)$ from the $H1_N$ test and the calculations specified in section 3.7 of this appendix. See section 3.6.4.b of this appendix regarding determination of the capacity $\dot{Q}_{hcalc}^{k=2}(47)$ and power input $\dot{E}_{hcacl}^{k=2}(47)$ used in the HSPF2 calculations to represent the $H1_2$ Test. Determine $\dot{Q}_h^{k=2}(35)$ and $\dot{E}_h^{k=2}(35)$ from the $H2_2$ test and the calculations specified in section 3.9 of this appendix or, if the $H2_2$ test is not conducted, by conducting the calculations specified in section 3.6.4 of this appendix. Determine $\dot{Q}_h^{k=2}(17)$ and $\dot{E}_h^{k=2}(17)$ from the $H3_2$ test and the methods specified in section 3.10 of this appendix.

* * * * *

e. Intermediate Compressor Speed. For units other than variable-speed non-communicating coil-only heat pumps, calculate the space heating capacity, $\dot{Q}_h^{k=v}(T_j)$, and electrical power consumption, $\dot{E}_h^{k=v}(T_j)$, of the heat pump when operating at outdoor temperature T_j and the intermediate compressor speed used during the $H2_V$ test in section 3.6.4 of this appendix using:

$$\text{Equation 4.2.4-7}\quad \dot{Q}_h^{k=v}(T_j) = \dot{Q}_h^{k=v}(35) + M_Q * (T_j - 35), \text{ and}$$

$$\text{Equation 4.2.4-8}\quad \dot{E}_h^{k=v}(T_j) = \dot{E}_h^{k=v}(35) + M_E * (T_j - 35)$$

Where $\dot{Q}_h^{k=v}(35)$ and $\dot{E}_h^{k=v}(35)$ are determined from the $H2_V$ test and calculated as specified in section 3.9 of this appendix. Approximate the slopes of the k=v intermediate speed heating capacity and electrical power input curves, M_Q and M_E, as follows:

$$M_Q = \left[\frac{\dot{Q}_h^{k=1}(62) - \dot{Q}_h^{k=1}(47)}{62-47} * (1 - N_Q)\right] + \left[N_Q * \frac{\dot{Q}_h^{k=2}(35) - \dot{Q}_h^{k=2}(17)}{35-17}\right]$$

$$M_E = \left[\frac{\dot{E}_h^{k=1}(62) - \dot{E}_h^{k=1}(47)}{62-47} * (1 - N_E)\right] + \left[N_E * \frac{\dot{E}_h^{k=2}(35) - \dot{E}_h^{k=2}(17)}{35-17}\right]$$

Where:

$$N_Q = \frac{\dot{Q}_h^{k=v}(35) - \dot{Q}_h^{k=1}(35)}{\dot{Q}_h^{k=2}(35) - \dot{Q}_h^{k=1}(35)} \text{ and } N_E = \frac{\dot{E}_h^{k=v}(35) - \dot{E}_h^{k=1}(35)}{\dot{E}_h^{k=2}(35) - \dot{E}_h^{k=1}(35)}$$

Use Equations 4.2.4–1 and 4.2.4–2 to this appendix, respectively, to calculate $\dot{Q}_h^{k=1}(35)$ and $\dot{E}_h^{k=1}(35)$, whether or not the heat pump is a minimum-speed-limiting variable-speed heat pump.

For variable-speed non-communicating coil-only heat pumps, there is no intermediate speed.

4.2.4.1 Steady-State Space Heating Capacity When Operating at Minimum Compressor Speed is Greater Than or Equal to the Building Heating Load at Temperature T_j, $\dot{Q}_h^{k=1}(T_j \geq BL(T_j)$.

Evaluate the Equation 4.2–1 to this appendix quantities:

$$\frac{RH(T_j)}{N} \quad \text{and} \quad \frac{e_h(T_j)}{N}$$

As specified in section 4.2.3.1 of this appendix. Except now use Equations 4.2.4–1 and 4.2.4–2 (for heat pumps that are not minimum-speed-limiting and are not variable-speed non-communicating coil-only heat pumps), Equations 4.2.4–1, 4.2.4–2, 4.2.4–3, and 4.2.4–4 as appropriate (for variable-speed non-communicating coil-only heat pumps), or Equations 4.2.4–5 and 4.2.4.-6 (for minimum-speed-limiting variable-speed heat pumps that are not variable-speed non-communicating coil-only heat pumps) to this appendix to evaluate $\dot{Q}_h^{k=1}(T_j)$ and $\dot{E}_h^{k=1}(T_j)$, respectively, and replace section 4.2.3.1 references to ''low capacity'' and section 3.6.3 of this appendix with ''minimum speed'' and section 3.6.4 of this appendix.

4.2.4.2 Heat Pump Operates at an Intermediate Compressor Speed (k = i) or, for a Variable-Speed Non-Communicating Coil-Only Heat Pump, Cycles Between High and Low Speeds, in Order to Match the Building Heating Load at a Temperature T_j, $\dot{Q}_h^{k=1}(T_j) < \dot{Q}BL(T_j) < \dot{Q}_h^{k=2}(T_j)$.

For units that are not variable-speed non-communicating coil-only heat pumps, calculate:

$$\frac{RH(T_j)}{N} \text{ using Equation 4.2.3-2 while evaluating } \frac{e_h(T_j)}{N} \text{ using,}$$

$$\frac{e_h(T_j)}{N} = \dot{E}_h^{k=i}(T_j) * \delta(T_j) * \frac{n_j}{N}$$

Where:

$$\dot{E}_h^{k=i}(T_j) = \frac{\dot{Q}_h^{k=i}(T_j)}{3.413\frac{Btu/h}{W} * COP^{k=i}(T_j)}$$

And $\delta(T_j)$ is evaluated using Equation 4.2.3–3, while:

$\dot{Q}_h^{k=i}(T_j) = BL(T_j)$, the space heating capacity delivered by the unit in matching the building load at temperature (T_j), in Btu/h. The matching occurs with the heat pump operating at compressor speed k=i, and

$COP^{k=i}(T_j)$ = the steady-state coefficient of performance of the heat pump when operating at compressor speed k=i and temperature T_j (dimensionless). For each temperature bin where the heat pump operates at an intermediate compressor speed, determine $COP^{k=i}(T_j)$ using the following equations,

For each temperature bin where $\dot{Q}_h^{k=1}(T_j) < BL(T_j) < \dot{Q}_h^{k=v}(T_j)$,

$$COP_h^{k=i}(T_j) = COP_h^{k=1}(T_j) + \frac{COP_h^{k=v}(T_j) - COP_h^{k=1}(T_j)}{Q_h^{k=v}(T_j) - Q_h^{k=1}(T_j)} * (BL(T_j) - Q_h^{k=1}(T_j))$$

For each temperature bin where $\dot{Q}_h^{k=v}(T_j) \leq BL(T_j) < \dot{Q}_h^{k=2}(T_j)$,

$$COP_h^{k=i}(T_j) = COP_h^{k=v}(T_j) + \frac{COP_h^{k=2}(T_j) - COP_h^{k=v}(T_j)}{Q_h^{k=2}(T_j) - Q_h^{k=v}(T_j)} * (BL(T_j) - Q_h^{k=v}(T_j))$$

Where:

$COP_h^{k=1}(T_j)$ is the steady-state coefficient of performance of the heat pump when operating at minimum compressor speed and temperature Tj, dimensionless, calculated using capacity $\dot{Q}_h^{k=1}(T_j)$ calculated using Equation 4.2.4–1 or 4.2.4–3 to this appendix and electrical power consumption $\dot{E}_h^{k=1}(T_j)$ calculated using Equation 4.2.4–2 or 4.2.4–4 to this appendix;

$COP_h^{k=v}(T_j)$ is the steady-state coefficient of performance of the heat pump when operating at intermediate compressor speed and temperature Tj, dimensionless, calculated using capacity $\dot{Q}_h^{k=v}(T_j)$ calculated using Equation 4.2.4–7 to this appendix and electrical power consumption $\dot{E}_h^{k=v}(T_j)$ calculated using Equation 4.2.4–8 to this appendix;

$COP_h^{k=2}(T_j)$ is the steady-state coefficient of performance of the heat pump when operating at full compressor speed and temperature Tj (dimensionless), calculated using capacity $\dot{Q}_h^{k=2}(T_j)$ and electrical power consumption $\dot{E}_h^{k=2}(T_j)$, both calculated as described in section 4.2.4 of this appendix; and

$BL(T_j)$ is the building heating load at temperature T_j, in Btu/h.

For variable-speed non-communicating heat pumps, calculate $\frac{RH(T_j)}{N}$ and $\frac{e_h(T_j)}{N}$ as described in section 4.2.3.2 of this appendix with the understanding that $\dot{Q}_h^{k=2}(T_j)$ and $\dot{E}_h^{k=2}(T_j)$ correspond to full compressor speed operation, $\dot{Q}_h^{k=1}(T_j)$ and $\dot{E}_h^{k=1}(T_j)$ correspond to minimum compressor speed operation, and all four quantities are derived from the results of the specified section 3.6.4 tests of this appendix.

* * * * *

[FR Doc. 2022–22257 Filed 10–24–22; 8:45 am]

BILLING CODE 6450–01–P