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Energy Conservation Program for Consumer Products: Test Procedure for Residential Central Air Conditioners and Heat Pumps; Proposed Rule

DEPARTMENT OF ENERGY

10 CFR Part 430

[Docket No. EERE–2009–BT–TP–0004]

RIN 1904–AB94

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

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

ACTION: Notice of proposed rulemaking and public meeting.

SUMMARY: The U.S. Department of Energy (DOE) proposes amendments to its test procedure for residential central air conditioners and heat pumps. The proposed amendments would add requirements for the calculation of sensible heat ratio, incorporate a method to evaluate off mode power consumption, and add parameters for establishing regional measures of energy efficiency. DOE will hold a public meeting to receive and discuss comments on the proposal.

DATES: DOE will hold a public meeting in Washington, DC on Friday, June 11, 2010 from 9 a.m. to 4 p.m. The purpose of the meeting is to receive comments and to help DOE understand potential issues associated with this proposed rulemaking. DOE must receive requests to speak at the meeting before 4 p.m. Friday, June 4, 2010. DOE must receive a signed original and an electronic copy of statements to be given at the public meeting before 4 p.m. Friday, June 4, 2010.

DOE will accept comments, data, and other information regarding this notice of proposed rulemaking (NOPR) before or after the public meeting, but no later than August 16, 2010. See section V., "Public Participation," of this NOPR for details.

ADDRESSES: The public meeting will be held at the U.S. Department of Energy, Forrestal Building, Room 8E–089. You may submit comments, identified by docket number EERE–2009–BT–TP–0004 and/or Regulation Identifier Number (RIN) 1904–AB94, by any of the following methods:

- *Federal eRulemaking Portal http://www.regulations.gov.:* Follow the instructions for submitting comments.
- *E-mail: RCAC-HP-2009-TP-0004@ee.doe.gov.* Include the docket number EERE–2009–BT–TP–0004 and/or RIN number 1904–AB94 in the subject line of the message.
- *Postal Mail:* Ms. Brenda Edwards, U.S. Department of Energy, Building Technologies Program, Mailstop EE–2J, 1000 Independence Avenue, SW., Washington, DC 20585–0121. Please submit one signed paper original.
- *Hand Delivery/Courier:* Ms. Brenda Edwards, U.S. Department of Energy, Building Technologies Program, 6th Floor, 950 L'Enfant Plaza, SW., Washington, DC 20024. Telephone: (202) 586–2945. Please submit one signed paper original.

Instructions: All submissions must include the agency name and docket number or RIN for this rulemaking. For detailed instructions on submitting comments and additional information on the rulemaking process, see section V., "Public Participation," of this document.

Docket: For access to the docket to read background documents or comments received, visit the U.S. Department of Energy, 6th Floor, 950 L'Enfant Plaza, SW., Washington, DC 20024, (202) 586–2945, between 9 a.m. and 4 p.m., Monday through Friday, except Federal holidays. Please call Ms. Brenda Edwards at (202) 586–2945 for additional information regarding visiting the Resource Room. Please note: DOE's Freedom of Information Reading Room (Forrestal Building, Room 1E–190) no longer houses rulemaking materials.

FOR FURTHER INFORMATION CONTACT: Mr. Wes Anderson, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Program, EE–2J, 1000 Independence Avenue, SW., Washington, DC 20585–0121. Telephone: (202) 586–7335. E-mail: *Wes.Anderson@ee.doe.gov.*

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SUPPLEMENTARY INFORMATION:

I. Authority and Background

A. Authority

Title III of the Energy Policy and Conservation Act (42 U.S.C. 6291 *et seq.;* EPCA or the Act) sets forth a variety of provisions designed to improve energy efficiency. Part A of Title III (42 U.S.C. 6291–6309) establishes the "Energy Conservation Program for Consumer Products Other Than Automobiles." (This part was originally titled Part B; however, it was redesignated Part A in the United States Code for editorial reasons.) The program covers consumer products and certain commercial products (collectively "covered products"), including residential central air conditioners and heat pumps having rated cooling capacities less than 65,000 British thermal units/hour (Btu/h). (42 U.S.C. 6291(1)–(2), (21) and 6292(a)(3))

Under the Act, the overall program consists of testing, labeling, and Federal energy conservation standards. Manufacturers of covered products must use the test procedures prescribed under EPCA to measure energy efficiency, to certify to DOE that products comply with EPCA's energy conservation standards, and for representing the energy efficiency of their products. Similarly, DOE must use these test procedures when determining whether the equipment complies with energy conservation standards adopted pursuant to EPCA.

Section 323 of EPCA (42 U.S.C. 6293) sets forth generally applicable criteria and procedures for DOE's adoption and amendment of such test procedures. For example, the Act states that "[a]ny test procedures prescribed or amended under this section shall 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, as determined by the Secretary [of Energy], and shall not be unduly burdensome to conduct." (42 U.S.C. 6293(b)(3)) DOE's existing test procedures for central air conditioners and heat pumps adopted pursuant to these provisions appear under Title 10 of the Code of Federal Regulations (CFR) part 430, subpart B, appendix M ("Uniform Test Method for Measuring the Energy Consumption of Central Air Conditioners and Heat Pumps").

Further, if any rulemaking amends a test procedure, DOE must determine "to what extent, if any, the proposed test procedure would alter the measured energy efficiency * * * of any covered product as determined under the existing test procedure." (42 U.S.C. 6293(e)(1)) If it determines that the amended test procedure would alter the measured efficiency of a covered product, DOE must amend the applicable energy conservation standard accordingly. (42 U.S.C. 6293(e)(2)) The amendments proposed in today's rulemaking will not alter the measured efficiency, as represented in the regulating metrics of SEER and HSPF. Thus, today's proposed test procedure changes can be adopted without amending the standards for SEER and HSPF.

On December 19, 2007, the President signed the Energy Independence and Security Act of 2007 (EISA 2007; Pub. L. 110–140), which contains numerous amendments to EPCA. Section 310 of EISA 2007 established that the Department's test procedures for all covered products must account for standby and off mode energy consumption. (42 U.S.C. 6295(gg)(2)(A)) DOE must modify the test procedures to integrate such energy consumption into the energy descriptor(s) for each product, unless the Secretary determines that "(i) the current test procedures for a covered product already fully account for and incorporate the standby mode and off mode energy consumption of the covered product; or (ii) such an integrated test procedure is technically infeasible * * * in which case the Secretary shall prescribe a separate standby mode and off mode energy use test for the covered product, if technically feasible. (42 U.S.C. 6295 (gg)(2)(A)) In addition, section 306(a) of EISA 2007 amended EPCA section 325(o)(6) to consider one or two regional standards for central air conditioners and heat pumps (among other products) in addition to a base national standard. (42 U.S.C. 6295(o)(6)(B)) EPCA 325(o)(6)(C)(i) requires that DOE consider only regions made up of contiguous States. (42 U.S.C. 6295(o)(6)(C)(i)) Accordingly, today's proposed test procedure rulemaking includes additions that specifically address sections 306 and 310 of EISA 2007.

B. Background

Most portions of the existing test procedure for central air conditioners and heat pumps were originally published as a final rule in the **Federal Register** on December 27, 1979. 44 FR 76700. DOE modified the test procedure on March 14, 1988, to expand coverage to variable-speed central air conditioners and heat pumps, to address testing of split non-ducted units, and to change the method for crediting heat pumps that provide a demand defrost capability. 53 FR 8304.

The next revision of the central air conditioners and heat pumps test procedure was published as a final rule on October 11, 2005, and became effective on April 10, 2006. 70 FR 59122. The October 2005 final rule provided a much needed updating to reference current standards, adopted improved measurement capabilities, and presented more detail on how to conduct the laboratory testing. The 2005 final rule also expanded coverage for equipment features previously not covered (*e.g.,* two-capacity northern heat pumps, heat comfort controllers, triple-split systems, etc.). During this revision process, the test procedure was significantly reorganized in an effort to improve its readability.

On July 20, 2006, DOE published a proposed rule to consider additional changes to the test procedure in response to issues interested parties submitted before the October 2005 publication of the final rule. 71 FR 41320. DOE determined that it was appropriate to consider additional modifications to the test procedure for the following reasons: (1) To implement test procedure revisions for new energy conservation standards for small-duct, high-velocity (SDHV) systems; (2) to address test procedure waivers for multi-split systems; and (3) to address interested parties' concerns about sampling and rating after new energy conservation standards became effective on January 23, 2006. (10 CFR 432.32(c)(2)) DOE issued a final rule adopting relevant amendments to the central air conditioner and heat pump test procedures on October 22, 2007, which became effective on April 21, 2008. 72 FR 59906. This latter final rule was published before EISA's implementation on December 19, 2007; therefore, the test procedures did not incorporate the requirements in sections 306 and 310 of EISA 2007.

While making changes necessary to comply with the amendments in EISA 2007, DOE is considering additional changes to the test procedure that were identified after finalizing the prior rulemaking.

II. Summary of the Proposed Rule

DOE proposes amendments to its test procedure for residential central air conditioners and heat pumps. The amendments would add calculations for determination of sensible heat ratio (SHR), would incorporate a method to evaluate off mode power consumption, and would add parameters for establishing regional measures of energy efficiency.

In addition to statutory requirements for amended test procedures, EISA 2007 has three separate provisions regarding the inclusion of standby mode and off mode energy use in any energy conservation standard that have bearing on the current test procedure rulemaking. First, test procedure amendments to include standby mode and off mode energy consumption shall not be used to determine compliance with standards established prior to the adoption of such test procedure amendments. (42 U.S.C. 6295(gg)(2)(C)) Second, standby mode and off mode energy use must be included into a single amended or new standard for a covered product adopted in a final rule after July 1, 2010. Finally, a separate standard for standby mode and off mode energy consumption is required if a single amended or new standard is not feasible. (42 U.S.C. 6295(gg)(3)(B))

In order to accommodate the above-mentioned first provision, DOE clarifies that today's proposed amended test procedure would not alter the measure of energy efficiency used in existing energy conservation standards; therefore, this proposal would neither affect a manufacturer's ability to demonstrate compliance with previously established standards nor require retesting and rerating of existing units that are already certified. These amended test procedures would become effective, in terms of adoption into the CFR, 30 days after the date of publication in the **Federal Register** of the final rule in this test procedure rulemaking. However, DOE is proposing added language to the regulations codified in the CFR that would state that any added procedures and calculations for determining off mode energy consumption and regional cooling mode performance being proposed in order to satisfy the relevant provisions of EISA 2007 need not be performed at this time to determine compliance with the current energy conservation standards. Subsequently, and consistent with the second provision above, manufacturers would be required to use the amended test procedures' off mode and regional cooling mode provisions to demonstrate compliance with DOE's energy conservation standards on the effective date of a final rule establishing amended energy conservation standards for these products that address off mode energy consumption and/or regional cooling mode performance, at which time the limiting statement in the DOE test procedure would be revised or removed. Further clarification would also be provided that as of 180 days after publication of a test procedure final rule, any representations as to the off mode energy consumption and regional cooling mode performance of the products that are the subject of this rulemaking would need to be based upon results generated under the applicable provisions of this test procedure. (42 U.S.C. 6293(c)(2)) A separate standard for off-mode energy consumption is required if a single amended or new standard is not feasible. (42 U.S.C. 6295(gg)(3)(B))

III. Discussion

The current standards rulemaking preliminary analysis for residential central air conditioners and heat pumps is ready for stakeholder review and comment. This preliminary analysis follows the first step in the standards rulemaking process, the release of the framework document (*http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/cac_framework.pdf*) and the subsequent June 12, 2008 public meeting. At and following this latter meeting, stakeholder comments were received, some of which apply to today's proposed test procedure.

In formulating today's notice of proposed rulemaking (NOPR), DOE considered these test procedure related comments and, where appropriate, proposed changes to the test procedure. Moreover, DOE responses to stakeholder comments are provided in the following subject areas:

1. Test Procedure Schedule
2. Bench Testing of Third Party coils
3. Defaults for Fan Power
4. Changes to External Static Pressure Values
5. Fan Time Delay Relays
6. Inverter-Driven Compressors
7. Addition of Calculation for Sensible Heat Ratio
8. Regional Rating Procedure
9. Address Testing Inconsistencies for Ductless Mini- and Multi-Splits
10. Standby Power Consumption and Measurement

Section III. A. provides a more in-depth discussion on those comments that questioned or disagreed with DOE's positions in the framework document.

Section III. B. provides a summary of the proposed changes to the test procedure, including

1. Modify the definition of "tested combination" for residential multi-split systems
2. Add Alternative Minimum External Static Pressure Requirements for Testing Ducted Multi-Split Systems
3. Clarify that Optional Tests May Be Conducted Without Forfeiting Use of the Default Value(s)
4. Allow a Wider Tolerance on Air Volume Rate to Yield More Repeatable Laboratory Setups
5. Change the Magnitude of the Test Operating Tolerance Specified for the External Resistance to Airflow and the Nozzle Pressure Drop
6. Modify Third-Party Testing Requirements when Charging the Test Unit
7. Clarify Unit Testing Installation Instruction and Address Manufacturer and Third-Party Testing Laboratory Interactions
8. When Determining the Cyclic Degradation Coefficient C_D, Correct the Indoor-Side Temperature Sensors Used During the Cyclic Test to Align with the Temperature Sensors Used During the Companion Steady-State Test, If Applicable
9. Clarify Inputs for the Demand Defrost Credit Equation
10. Add Calculations for Sensible Heat Ratio
11. Incorporate Changes to Cover Testing and Rating of Ducted Systems Having More than One Indoor Blower
12. Add Changes To Cover Triple-Capacity, Northern Heat Pumps.
13. Specify Requirements for the Low-Voltage Transformer Used when Testing Coil-Only Air Conditioners and Heat Pumps and Require Metering of All Sources of Energy Consumption During All Tests
14. Add Testing Procedures and Calculations for Off Mode Energy Consumption
15. Add Parameters for Establishing Regional Standards

As part of today's rulemaking, DOE provides the specific proposed changes to 10 CFR part 430, subpart B, appendix M, "Uniform Test Method for Measuring the Energy Consumption of Central Air Conditioners and Heat Pumps."

A. Framework Comment Summary and DOE Responses

A notation in the form "Southern Company Systems (SCS), No. 13 at p. 105" identifies a written comment DOE has received and has included in the docket of this rulemaking. This particular notation refers to a comment (1) by the Southern Company Systems (SCS); (2) in document number 13 in the docket of this rulemaking; and (3) appearing on page 105 of document number 13.

1. Test Procedure Schedule

Several interested parties commented that DOE should consider the timeline necessary when modifying this test procedure, and how the publication of the test procedure coincides with publication of the revised standard. (Southern Company Systems (SCS), No. 13 at p. 105; Air-Conditioning, Heating and Refrigeration Institute (AHRI), No. 13 at p. 116; the American Council for an Energy Efficient Economy (ACEEE), No. 13 at p. 117; Trane, No. 13 at p. 123)

DOE is coordinating the publication timelines of both the test procedure and the amended standard. The test procedure NOPR will be open for public comments. DOE will then address those comments and publish a final test procedure rule. The associated standard will proceed concurrently with the test procedure rulemaking to maximize the time interval between the test procedure final rule and the revised energy standards final rule.

2. Bench Testing of Third-Party Coils

The Northeast Energy Efficiency Partnerships (NEEP) comment stated that test procedures should require laboratory/bench testing for independent coil manufacturers' (ICM) indoor units. (NEEP, No. 37 at p. 3) NEEP includes representatives from the Connecticut Office of Policy and Management, New Hampshire Office of Energy and Planning, Efficiency Maine, and Department of Energy Resources for the Commonwealth of Massachusetts.

As amended, EPCA makes all residential central air conditioners and heat pumps sold in the United States subject to specific testing, rating, minimum efficiency, and labeling requirements. These requirements apply to complete systems, including those split systems where the outdoor components are provided by one manufacturer, while the indoor components are provided by a separate manufacturer. The typical two-manufacturer split system is where the indoor unit is provided by an ICM and the outdoor unit is provided by an original equipment manufacturer (OEM). Because the ICM wants to advertise the performance of its indoor coils with various OEM outdoor units, the ICM is responsible for obtaining the system seasonal energy efficiency ratio (SEER) and heating seasonal performance factor (HSPF) ratings according to DOE requirements. In obtaining these ratings, the ICM can either test complete systems or use a DOE-approved alternative rating method (ARM) to calculate the rating. Approval of the ARM requires laboratory test results for complete systems, but inputs to the ARM may or may not require testing of just the indoor unit. (10 CFR 430.24)

Although DOE does not have the authority to regulate a component of an air conditioner or heat pump system, it does regulate the complete systems. The system ratings published by ICMs must be obtained in accordance with DOE requirements summarized above.

3. Defaults for Fan Power

A Joint Comment stated that the present rating method does not credit advanced air handler designs adequately because the default value is much lower than the average air handler energy use observed in the field. (Joint Comment, No. 25 at pp. 4, 6–7) According to the Joint Comment, a low default value for fan power reduces the incentive to improve fan efficiency. The Joint Comment includes representatives from ACEEE, Appliance Standards Awareness Project (ASAP), the California Energy Commission (CEC), the Northwest Power and Conservation Council (NPCC), and the Western Cooling Efficiency Center (WCEC).

Proctor Engineering Group (Proctor) stated that the inside coil fan energy needs to represent the median values from actual installations, and also provided input on the methodology for evaluating fan power based on air volume rate and equipment tonnage. (Proctor, No. 38 at p. 1)

NEEP stated that testing should be required for motors in actual operation and that the procedure should include provisions for testing while air handler fans are running. (NEEP, No. 37 at p. 3)

Split-system ducted air conditioners and heat pumps are primarily designed for two different applications. These applications depend on whether the air conditioner or heat pump is installed with a hot-air furnace and share a common duct system. Air conditioners and heat pumps not designed for installation with a hot-air furnace must contain a blower to circulate air through the indoor coil and ductwork. Systems that include the integral or modular indoor blower are typically referred to as blower-coil units. Coil-only units—air conditioners and heat pumps designed for installation with a hot-air furnace—rely on the furnace blower to circulate air through the indoor coil, ductwork, and the furnace section when the compressor and outdoor fan are operating.

The Joint Comment pertains to coil-only units, so discussion in the following paragraphs is limited to those products. This comment does not apply to blower-coil units within the test procedure because there is no required default assumption for the average air handler. With regard to the NEEP comment, the ratings for blower coil units already reflect the performance of the system's particular indoor blower. When blower coils are tested, the indoor blower operates, and its performance is accounted for in the measured system capacity and power consumption values and ultimately in SEER and HSPF.

A coil-only air conditioner or heat pump can be installed with a multitude of new and existing furnaces. The key considerations for matching a coil-only unit with a furnace are (1) the furnace blower's ability to provide the necessary air volume rate for the system; and (2) whether the outlet flange dimensions of the furnace are compatible with the inlet flanges on the indoor coil-only section of the air conditioner or heat pump. Another factor for field application is whether the overall height (length) of the furnace and coil-only indoor section will fit into the available building space.

The SEER and HSPF ratings represent the seasonal efficiencies of a complete, functioning air conditioner or heat pump system. However, coil-only split systems in laboratory testing are incomplete because a hot-air furnace is not part of the setup. Instead of the furnace blower, the exhaust fan in the test facility pulls air through the indoor unit of the coil-only system. The exhaust fan is located downstream of the test unit's indoor section, outlet instrumentation, and air volume measurement station. When the hot-air furnace and blower are removed from testing, the associated power consumption and measured cooling or heating capacity are adjusted to account for the hypothetical hot-air furnace blower. The Joint Comment asserted that the test procedure default value is too low and should require additional real-time blower testing. Proctor Engineering Group agreed and offered an alternative default equation based on data collected from actual installations.

Given the variety of furnaces within which a coil-only unit may be installed, the range of blower sizes and associated efficiency of a complete installed system are unknown. As a result, there are several options for calculating the assumed power and heat contributions for the hypothetical hot-air furnace blower. To obtain a SEER (and for heat pumps, an HSPF) rating for each coil-only split system, the hot-air furnace blower receives a default value. According to the DOE test procedure, the hypothetical hot-air furnace blower contribution is expressed in terms of power (watts) and heat (Btu/h) per unit of air volume rate (in this case, 1,000 standard cubic feet per minute [scfm]).

Since it was issued in 1979, the DOE test procedure for central air conditioners and heat pumps has used the same default fan power and heat for rating coil-only air conditioners and heat pumps: 365 watts per 1,000 scfm and 1,250 Btu/h per 1,000 scfm. These default values result in the adjustment range from approximately 220 watts (750 Btu/h) for a 1.5-ton unit to approximately 730 watts (2,500 Btu/h) for a 5-ton unit.

The default value does not indicate the efficiency of blowers in furnaces; it simply provides a means of comparing products on a complete system basis. The long-standing default values represent a typical furnace blower while not being overly conservative. Changing the default values would shift the SEER and HSPF ratings, but the ranking among most comparably sized equipment would change minimally, if at all. DOE evaluated the worst-case scenario: multiple units with the same SEER calculated using the existing fan power and heat defaults, but with degradation coefficients (C_D) varying from 0.01 and 0.25, and capacities differing up to 10 percent. If the SEER calculation uses a higher default like 500 watts per 1,000 scfm (1,700 Btu/h per 1,000 scfm), the new SEER ratings would all decrease but lie within a range that spans less than 0.20 points (on the SEER rating scale). The minimal impact on the ranking lessens the need for better defaults. To determine whether higher default values better represent actual installations, DOE must address three questions:

• What data can accurately represent the typical installation?

• What coordination will ensure that blower coils and coil-only units are evaluated on a common basis?

• Should poor duct systems affect equipment ratings?

DOE expects that addressing these questions will require additional data collection, analysis, and input from interested parties. With minimal impact on altering the relative ranking among competing products combined with the need to answer the above questions, DOE chose not to propose alternative default values for the power and heat contribution of the hypothetical furnace blower used when calculating the SEER and HSPF for coil-only air conditioners and heat pumps.

4. Changes to External Static Pressure Values

A Joint Comment stated that the current assumed inches of water column (in wc) values are lower than those typically found in the field and unrealistically deemphasize the importance of fan efficiency as a part of overall system effectiveness. (Joint Comment, No. 25 at pp. 4, 6) The discrepancy often leads to less airflow in a field application, which generally improves latent (at the expense of sensible) capacity.

The Joint Utility Comment suggested that new test conditions for external static pressure and default fan power should be consistent with current field research findings. (Joint Utility Comment, No. 30 at pp. 1, 21) The Joint Utility Comment includes representatives from Pacific Gas and Electric Company (PG&E), Southern California Edison, Sempra Energy Utilities (Southern California Gas Company and San Diego Gas and Electric Company; hereafter "Sempra"), Sacramento Municipal Utility District, the Nevada Power Company, and Sierra Pacific Power.

DOE received a number of comments requesting that the minimum external static pressure levels be increased. (Florida Solar Energy Center (FSEC), No. 31 at p. 4; Sempra, No. 13 at p. 121; SCS, No. 39 at p. 2) Additionally, Proctor Engineering Group (Proctor) provided a formula for estimating the static pressure based on the rated cfm/ton (Proctor, No. 38 at p. 2).

Some split system and all single-package system air conditioners and heat pumps are sold with integral indoor blowers. Split systems with integral indoor blowers (*i.e.,* blower-coil units) may be designed for ducted or non-ducted installation. The integral indoor blower may be located either upstream (push-through configuration) or downstream (draw-through configuration) of the indoor refrigerant-to-air heat coil.

To mimic a field installation, single-package and blower-coil split air conditioners and heat pumps are laboratory tested with installed components to include the most restrictive filter(s), supplementary heating coils, and other equipment specified as part of the unit. The DOE test procedure allows testing of a ducted unit without an indoor air filter but requires a compensatory increase of 0.08 in wc for the minimum external static pressure requirement. Otherwise, the test procedure requires that the unit be installed and configured in accordance with the manufacturer's instructions.

The DOE test procedure requires that a minimum external static pressure be equaled or exceeded during the wet-coil cooling mode test. If this requirement is not met initially, the configuration of the indoor unit is incrementally changed (*e.g.,* switched to the next highest speed tap), and the wet-coil test is repeated until the measured external static pressure meets or surpasses the applicable DOE test procedure minimum value.

Since its issuance in 1980, the DOE test procedure for central air conditioners and heat pumps has used the same set of minimum external static pressure values (except for SDHV systems): 0.10 in wc for systems with a rated cooling capacity less than or equal to 28,800 Btu/h, 0.15 in wc for 29,000 to 42,500 Btu/h, and 0.20 in wc for 43,000 to 64,500 Btu/h. The laboratory static pressure measurement tries to account for the supply and return home or building duct system unit flow resistance.

Limited field testing reports and the general decline in the quality of installed duct systems (in part from the proliferation of the flexible duct) would support an increase in the minimum external static pressure. Efforts by building trades and code compliance communities to improve the quality of installed duct systems would support smaller increases in the minimum statics prescribed in the DOE test procedure. More field data would be helpful but would likely never be acquired to the level needed to provide a definitive basis for selecting new minimums. The greater impact of higher minimum external static pressures will be on lowering the SEER and HSPF of all units equally. Lacking a basis to propose new values or reference a consensus standard where alternatives to the current minimums are established, DOE chose not to propose an alternative to the existing minimum values as part of today's NOPR.

5. Fan Time Delay Relays

FSEC and SCS commented that the fan time delay relays should be disabled for the SEER test procedure. (FSEC, No. 31 at p. 3; SCS, No. 39 at p. 2)

Many air conditioners and heat pumps employ a fan-off delay feature on the indoor blower. This delay, which is usually active for both the cooling and heating modes, is used to extract stored energy from the indoor coil immediately after the compressor has cycled off. The indoor blower typically continues to operate for 45 to 90 seconds after the compressor cycles off.

The DOE test procedure seeks to evaluate the performance of central air conditioners and heat pumps without making the process overly burdensome or expensive. The test procedure includes optional cyclic tests used to quantify the degradation in performance from the system cycling (predominantly in field installation) compared with operating continuously (as in most laboratory tests). During these cyclic tests, the fan-off delay feature is not disabled. The evaluation thus accounts for an incremental increase in total delivered capacity at the expense of increased electrical energy consumption in extending the indoor blower operation.

Disabling the fan time delay from central air conditioners and heat pumps during the cooling season will prevent re-evaporation of moisture on the indoor coil and in the condensation pan. Substantial re-evaporation can occur if the indoor blower continues for an extended period after compressor shutoff. Because of this evaporative mechanism, continuous fan operation is discouraged during the cooling season. However, DOE is not aware of definitive data that show significant re-evaporation during short fan-off delays. Part of the data void is due to the challenge of measuring rapidly changing values (humidity and temperature) during the relatively short fan-off delay period. Because of this difficulty, the cyclic cooling mode test, used in establishing the SEER, is conducted at an indoor wet bulb (wb) temperature that results in a dry coil. This also explains why this test cannot be used to address the concern about re-evaporation.

In a related comment, Proctor recommended conducting the cooling mode cyclic tests with the indoor conditions set to the same values used for the steady-state tests, 80 degrees Fahrenheit (°F) dry bulb (db)/67 °F wb (Proctor, No. 38 at p. 2). Proctor stated that such a change to wet-coil cooling mode cyclic tests is well within the reach of today's measurement technologies.

DOE needs additional information to quantify the potential benefits of converting from dry-coil to wet-coil cyclic testing. DOE must evaluate any potential benefits relative to any laboratory upgrades that would be needed to achieve acceptably accurate and repeatable results across the industry, and the impact of changing the time required to run a cyclic test. DOE seeks data and information that would aid efforts to quantify the relative performance impact and associated expense of laboratory upgrades in combination with achievable measurement uncertainty. Until more is known about the impact of changing from the long-standing dry-coil tests to a wet-coil cyclic test, DOE has tentatively decided not to modify this test procedure to convert to wet-coil cyclic testing.

6. Inverter-Driven Compressors

Mitsubishi Electric and Electronics USA, Inc. (MEUS) commented that new systems incorporating inverter-driven compressor technology require a modification to the test procedure. (MEUS, No. 13 at p. 19)

Since 1988, the DOE test procedure has covered air conditioners and heat pumps with variable-speed compressors, single indoor units, and single outdoor units. The October 2007 final rule extended coverage to variable-speed multi-split systems. 72 FR 59906. Before DOE can offer a more substantive evaluation of the comment, DOE will need specific examples, including laboratory data, of how the test procedure fails to capture the performance characteristics of an air conditioner or heat pump that uses "new inverter-driven compressor technology."

7. Addition of Calculation for Sensible Heat Ratio

The Joint Comment contended that the latent heat removal capability of CAC equipment should be measured under typical operating conditions, as opposed to high temperature conditions, and should be certified for all models sold in hot and humid climates. (Joint Comment, No. 25 at p. 4) FSEC expressed similar views and suggested that the latent heat ratio should be measured under different test conditions for single speed and multi-speed equipment. (FSEC, No. 31 at p. 2) Ice Energy suggested that the dehumidification capability of CAC equipment under hot and humid conditions be included in the standard, and any regional standard for the Southeast region should address this issue. (Ice Energy, No. 33 at p. 3) On the other hand, the Edison Electric Institute (EEI) wants dehumidification capability to be included in the standards for all regions. (EEI, No. 20 at p. 4) SCS stated that for hot and humid climates, a higher dehumidification capacity should be incorporated in the standard. (SCS, No. 13 at p. 42) SCS also stated that any regional air conditioning standard should provide for minimum dehumidification performance that should be measured at normal operating conditions and not at a higher temperature like 95 °F. (SCS, No. 39 at p. 1) The Joint Utilities Comment stated that DOE should require that all units be certified and rated for SHR at 82 °F ambient db temperature. (Joint Comment, No. 30 at pp. 1, 21) Proctor stated that the rating for humid climates should include information about what portion of the capacity is latent. (Proctor, No. 38 at p. 2)

DOE proposes including the calculation for the SHR within the revised DOE test procedure. (10 CFR part 430, subpart B, appendix M, revised section 3.3c and proposed section 4.5) The Federal Trade Commission (FTC) could then consider incorporating this information in labels for these products.

8. Regional Rating Procedure

DOE received some comments that were supportive and others that were neutral on the development of regional ratings. The Joint Comment noted that DOE already applies regional rating methods in the current test procedure for residential central air conditioners and heat pumps. (Joint Comment, No. 25 at pp. 3–4) It further noted that adoption of regional rating methods might allow DOE to set standards of comparable stringency, but using different rating conditions. (Joint Comment, No. 25 at p. 8) Ice Energy stated that the test protocol should be comprehensive and should span outdoor ambient conditions over the complete range of expected operating conditions. (Ice Energy, No. 33 at p. 3) FSEC stated that DOE should develop new cooling season bin temperature profiles using 2008 typical meteorological year (TMY) data from the National Renewable Energy Laboratory (NREL). (FSEC, No. 31 at pp. 3–4) The National Rural Electric Cooperative Association (NRECA) commented that DOE should evaluate whether its test procedures account for the vast differences in ambient humidity levels in different regions. The air conditioner and heat pump standards should also take into account the effects of humidity on different regional standards. (NRECA, No. 35 at p. 1)

A second Joint Comment (Joint Comment 2) from the National Resources Defense Council, National Consumer Law Center, Inc., and Enterprise stated that DOE should strengthen the SEER test procedure to provide a more robust measure of actual performance in varying conditions in different regions. (Joint Comment 2, No. 36 at p. 2) PG&E noted that DOE needs to reevaluate test procedures to determine the performance of this equipment in the various climate zones. (PG&E, No. 13 at p. 116) EEI suggested that the test procedure be updated to account for ambient conditions in hot-dry and hot-humid climates. (EEI, No. 20 at p. 3) Proctor commented that the temperature bins used for the rating calculation are not representative of the hotter portions of the United States and provided data representative of specific hot climates. Proctor also commented that the ratings for dry climates should be based only on the sensible capacities measured in the test, and suggested that the sensible capacities and latent capacities, as well as the appropriate watt draws, be measured in the existing 115 °F test. Further, the results of that test should be used in conjunction with any intermediate tests to establish the relationship between the energy efficiency ratio (EER) and outdoor temperature. Proctor also suggested that in defining regions, DOE start with examination of the existing DOE climate map (currently used in the DOE Building Energy Codes Program), which defines dry and humid regions of the United States. (Proctor, No. 38 at pp. 1, 2) SCS also commented that measuring performance at 115 °F would allow the design of temperature bin profiles that better reflect the actual climate of the desert Southwest. SCS supports the concept of a regional rating that reflects actual weather conditions, stating that for a "hot-dry" regional standard, setting the performance rating at 115 °F would be of great value to consumers and would not put an unreasonable burden on manufacturers. (SCS, No. 39 at p. 2) SCS stated, however, that it is neutral at this time on whether a hot-humid regional standard should be established, due to uncertainties about changes in test procedures, future design options manufacturers could use to reach higher efficiency, of the ability of local jurisdictions to limit use of equipment with poor dehumidification performance, and changes in consumer repair versus replacement or substitute behavior due to higher standards. (SCS, No. 39 at pp. 2, 3, 4)

Regarding the comments that favor region-specific cooling mode performance evaluations, DOE proposes changes that will allow the calculation of a region-specific SEER. (10 CFR 430, subpart B, appendix M, proposed section 2.2e and revised sections 3.2.1, 3.2.2.1, 3.2.3, and 3.2.4) The calculation parameters that permit this proposed region-specific SEER are the fractional bin hour distribution and the outdoor design temperature. DOE proposes modifying the indoor wet bulb temperature as part of additional required and optional testing. (10 CFR part 430, subpart B, appendix M, revised sections 3.2.1 (table 3A), 3.2.2.1 (table 4A), and 3.2.2 (table 5A)) These test procedure proposed changes will complement efforts to evaluate the merit of a regional standard for a cooling-dominated region with dry climate. DOE believes that similar changes are not needed for cooling-dominated States with humid climates. The current indoor side entering wet-bulb test condition of 67 °F, fractional bin-hour distribution, and outdoor design temperature sufficiently represent the conditions for a humid climate. Calculation of the SHR from such existing tests, however, is proposed in today's NOPR to quantify the product's dehumidification capabilities.

Section 306(a) of EISA amended section 325(o) of EPCA to require that regions defined for the purposes of regional standards are required to be composed of contiguous States. (42 U.S.C. 6295(o)(6)(C)(i)) In addition, individual States shall be placed only into a single region. (42 U.S.C. 6295(o)(6)(C)(iii)) DOE is proposing an alternative regional efficiency metric, a region-specific SEER (SEER–HD) for a four-State region consisting of Arizona, California, Nevada, and New Mexico. The proposed SEER–HD reflects equipment performance in this region.

DOE does not endorse the recommendation to add testing at 115 °F outdoor temperature. A linear fit of data collected from the cooling mode tests at 82 °F and 95 °F can sufficiently estimate capacity and power consumption at 105 °F, 110 °F, and even 115 °F. Interested parties have not provided, and DOE has not identified, examples where a SEER rating or the proposed region-specific SEER was statistically different as a result of being evaluated based on laboratory data at 115 °F as opposed to 95 °F.

In other related comments, ACEEE asked how DOE would capture and evaluate the efficiency of continuous ventilation for regional standards, as it is provided and used in a reasonable fraction of houses. (ACEEE, No. 13 at p. 138) Sempra indicated that the test protocols should be able to accommodate technologies other than air-cooled expansion unitary equipment. Sempra also commented that DOE should consider using the time value of energy in the new test procedures. (Sempra, No. 13 at p. 121) WCEC contended that certain changes in the test procedures could result in energy savings: (1) A 24-hour test protocol that can measure and characterize the energy and peak demand implications of control and thermal storage technologies; (2) a test protocol that provides different types of evaporative-cooled equipment with directly comparable SEER ratings; and (3) a test protocol that seriously addresses installation and performance-longevity issues. (WCEC, No. 41 at p. 2) ACEEE stated that DOE could use an alternative rating route to deal with enhanced dehumidification products. (ACEEE, No. 13 at p. 154)

Regarding installation and performance longevity issues, DOE does not have the authority to implement new performance metrics for characterizing such features at this time. Presently, the only metrics available for representing performance are SEER and HSPF. These are seasonal performance metrics and are not useful for characterizing installation issues, performance longevity, or quantifying performance at peak demand.

DOE notes that while there may be value in defining a test procedure that can provide consistent, comparable rating of alternative cooling systems, including evaporative cooling technologies and technologies incorporating thermal storage, such expansion of the test procedure is beyond the scope of this rulemaking. This rulemaking seeks to address changes mandated in EISA and otherwise improve upon coverage of comparatively conventional air conditioners and heat pumps. Determining additions and changes needed to allow testing and rating of thermal storage technologies, for example, is a formidable task, one that requires significant investigation. Such an investigation is difficult to pursue until such equipment is readily available as a commercial product.

9. Address Testing Inconsistencies for Ductless Mini- and Multi-Splits

Two interested parties commented that there are inconsistencies within the central air conditioning test procedure for mini- and multi-split systems. (MEUS, No. 13 at p. 21 and 22; Daikin, No. 28 at p. 6)

The proposed changes to items 1 through 3 of Appendix M, cover test procedure changes addressing inconsistencies for ductless mini- and multi-splits. In response to the comments, DOE proposes three changes to the test procedure to address these inconsistencies: (1) Modify the definition of tested combination for multi-split systems. DOE proposes to use the term "nominal cooling capacity" within the definition of "tested combination" (proposed change to 10 CFR 430, subpart A, section 430.2, Definitions, Tested Combination) and to simplify the requirements for multi-split systems with cooling capacities of

24,000 Btu/h or lower; (2) add an alternative minimum static pressure requirement for use when testing ducted multi-split systems (10 CFR 430, subpart B, appendix M, proposed table 2); (3) clarify within the test procedure that optional testing may be conducted without forfeiting the use of default values (10 CFR 430, subpart B, appendix M, proposed section 3.6.4d).

10. Standby Power Consumption and Measurement

Interested parties submitted comments refuting the need to revise the test procedure to consider standby power consumption when EISA does not explicitly call for its revision, and noting that standby power consumption is already addressed in the standard. (AHRI, No. 13 at p. 105; Sempra, No. 13 at p. 133; Energy Solutions, No. 13 at p. 108; Emerson, No. 13 at p. 111) Some contended that the test procedure's accounting of standby power consumption is adequate and does not require modification. (Trane, No. 16 at p. 3; Carrier Corporation (Carrier), No. 18 at p. 1; ASAP, No. 13 at p. 114; MEUS, No. 19 at p. 1; AHRI, No. 24 at p. 2). Trane and Carrier representatives both stated that the standby power consumption calculation is already captured in the degradation coefficient, C_D calculation. (Trane, No. 16 at p. 3; Carrier, No. 18 at p. 1)

SEER reflects all modes of climate control energy consumption that occur during the cooling season, as HSPF does for the heating season. SEER does not capture the time that an air conditioner could be energized but idle during the non-cooling season. Similarly, the current test procedure does not capture energy consumed by a heat pump during the non-cooling and non-heating seasons. These are the shoulder seasons that occur between the cooling and heating seasons and can be quantified by converting the cooling and heating load hours for any location into actual hours. In each case, the actual site or region-specific cooling and heating season hours always sum to less than 8,760. To calculate annual energy consumption or annual operating cost, all 8,760 hours of the year must be accounted for. Until now, these annual quantities have been based on energy consumption of fewer than 8,760 hours. The DOE test procedure must account for the idle mode energy consumption of the air conditioner and heat pump during the shoulder seasons and the idle mode energy consumption of an air conditioner during the heating season.

Several interested parties commented that although the current standard does address standby power consumption, standby and off mode power need to be better defined. (Joint Comment, No. 25 at p. 6; CFM Equipment Distributors, No. 13 at p. 129; Lennox, No. 13 at pp. 113, 134; Carrier, No. 13 at p. 113; the Unico System, No. 13 at p. 129; Trane, No. 13 at pp. 130, 131, 136; PG&E, No. 13 at pp. 132, 137; General Electric, No. 13 at p. 135; EEI, No. 20 at p. 5; ASAP, No. 13 at p. 132)

DOE concurs with the commenters. The definitions of standby and off mode as provided in EPCA section 325(gg) were amended by section 310 of EISA and are purposely generic so that they can apply to all covered products. (42 U.S.C. 6295(gg)(1)(A)(iii), (42 U.S.C. 6295(gg)(1)(A)(ii), respectively) EPCA section 325 allows DOE to redefine these definitions, including off mode, as part of this rulemaking. (42 U.S.C. 6295(gg)(1)(B)) The proposed definition is as follows:

The term "off mode" means:

(1) For air conditioners, all times during the non-cooling season of an air conditioner. This mode includes the "shoulder seasons" between the cooling and heating seasons when the unit provides no cooling to the building and the entire heating season, when the unit is idle. The air conditioner is assumed to be connected to its main power source at all times during the off mode; and

(2) For heat pumps, all times during the non-cooling and non-heating seasons of a heat pump. This mode includes the "shoulder seasons" between the cooling and heating seasons when the unit provides neither heating nor cooling to the building. The heat pump is assumed to be connected to its main power source at all times during the off mode.

DOE requests comments on this proposed definition (10 CFR, subpart B, appendix M, proposed section 1.48).

B. Summary of the Test Procedure Revisions

Today's proposed rule contains the following proposed changes to the test procedure in 10 CFR part 430, subpart B, appendix M.

1. Modify the Definition of "Tested Combination" for Residential Multi-Split Systems

DOE procedures require testing a complete system, not just its components. For multi-split systems, each model of outdoor unit may be installed with numerous indoor unit combinations. Systems may differ in the number of connected indoor units, their physical type (*e.g.,* wall-mounted versus ceiling cassette, ducted versus non-ducted), and individual capacities.

As part of the October 2007 final rule, multi-split units with rated cooling capacities less than 65,000 Btu/h were newly covered in the DOE central air conditioner and heat pump test procedure. As part of this coverage, manufacturers are required to test each model of a multi-split outdoor unit with at least one set of non-ducted (and at least one set of ducted, if applicable) indoor units. DOE placed limits on the set of indoor units selected to meet this testing requirement for each multi-split outdoor unit. These limits are prescribed in 10 CFR 430.2 definition for "tested combination." During the previous test procedure rulemaking, DOE refined the "tested combination" definition from the version published in the July 20, 2006 NOPR to the version published in the October 2007 final rule. After implementing the new test procedures, manufacturers of multi-split systems requested additional changes.

In its May 27, 2008 letter to DOE, the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) recommended three changes to the "tested combination" definition. First, AHRI supported changing specific references to "capacity" and "nominal capacity" to "nominal cooling capacity." AHRI argued that "this correction is necessary to clarify that the test procedures are based on the cooling (rather than heating) capacity of the equipment and to recognize that the nominal means the cooling capacity of the system at 95 °F ambient, 80/67 °F indoor conditions."

Second, AHRI requested that the requirement preventing the use of an indoor unit having a nominal cooling capacity that exceeds 50 percent of the nominal cooling capacity of the outdoor unit be waived for outdoor units with a nominal cooling capacity of 24,000 Btu/h or lower. AHRI noted that it is not always possible to meet this requirement, especially because of the additional DOE requirement that the nominal cooling capacities of the indoor units, when summed, must fall between 95 and 105 percent of the outdoor unit's nominal capacity. AHRI gave the example of an outdoor unit rated for 20,000 Btu/h that is designed to be used with indoor units having nominal capacities of 9,000 and 12,000 Btu/h. In this case, the only combination that meets the 95 to 105 percent indoor-outdoor capacity criteria is where two indoor units are used, one having a capacity of 12,000 Btu/h and one having a capacity of 9,000 Btu/h. The current definition for tested combination, however, does not allow this combination because the 12,000 Btu/h indoor unit exceeds the 50 percent limit on the capacity of the indoor unit to the capacity of the outdoor unit.

AHRI's final suggested change pertains to multi-split systems with nominal capacities greater than 150,000

Btu/h. The current limit of five indoor units to complete the system is often insufficient for the required 95 to 105 percent match with the outdoor unit. As AHRI stated in its letter, AHRI recognizes that "this capacity is beyond the cooling capacity limit of 65,000 Btu/h * * * but many manufacturers have been granted waivers in which this tested combination definition applies."

DOE concurs with two of the three changes AHRI requested. DOE proposes to adopt the wording "nominal cooling capacity" within the definition of "tested combination." (10 CFR 430.2) DOE will also waive the restriction that no indoor unit shall have a nominal cooling capacity exceeding 50 percent of the outdoor unit's nominal cooling capacity for multi-split systems having a nominal cooling capacity of 24,000 Btu/h or less. (10 CFR 430.2(2)(iii)) Additionally, DOE proposes to modify the definition for "tested combination" to indicate that the allowed range for the indoor to outdoor capacity percentages is 95 to 105 percent, inclusive. (10 CFR 430.2(2)(ii) The current wording calls for the match to be "between" (*i.e.,* not "including") these bounds. Especially with the above switch to using "nominal cooling capacity," specifying a set of indoor units that yields an indoor to outdoor capacity percentage of either 95 or 105 percent increases should be allowed.

With regard to the third change requested by AHRI, DOE will not establish a different limit on the number of indoor units used when testing multi-split systems with nominal capacities greater than 150,000 Btu/h because these systems are outside the scope of this residential test procedure rulemaking.

2. Add Alternative Minimum External Static Pressure Requirements for Testing Ducted Multi-Split Systems

Since the inception of DOE central air conditioner and heat pump test procedures, the majority of covered products have used a single indoor unit designed to work with a multi-branch duct system to distribute air within a building. This system imposes an additional load (quantified as external static pressure (ESP)) on the indoor blower as it distributes and returns air to and from the conditioned space.

When a system is laboratory tested according to the DOE test procedure, airflow resistance imposed on the blower by external attachments is measured when the indoor blower and the laboratory's airflow measurement apparatus maintain the manufacturer-specified air volume rate. To constitute a valid setup for ducted indoor units, this external resistance measurement must equal or exceed a value—the minimum ESP expressed in wc—specified in the DOE test procedure. The minimum ESP value depends on one of three minimum rated cooling capacities of the tested system: 0.1 in wc for units up to 28,800 Btu/h, 0.15 in wc for units between 29,000 and 42,500 Btu/h, and 0.2 in wc for units 43,000 Btu/h and above. These minimums were adopted from industry standards that were in place when the test procedure was developed and that have remained unchanged.

The majority of multi-split systems use non-ducted indoor units. In laboratory testing following the DOE test procedure, these free discharge units are tested with an ESP of 0 in wc. Multi-splits are also offered where one or more of the indoor units is ducted. Compared with conventional ducted units, indoor unit ducting for multi-splits is shorter and used on the return or supply, or both.

In its May 27, 2008 letter, AHRI stated that "many ductless manufacturers have 'ducted' indoor units that are intended for a minimum (less than a few feet) or no duct runs and as a result have a rated external static pressure capability of less than 0.1 ESP and usually around 0.02 ESP." AHRI recommended a mechanism and language for addressing this issue in the DOE test procedure. Specifically, AHRI suggested that DOE amend its test procedure by adding the following footnote to Table 2 of Appendix M (shown as Table III.1 below): "If the manufacturer's rated external static pressure is less than 0.10 in wc (25 Pascals (Pa)), then the indoor unit should be tested at that rated external static pressure."

TABLE III.1—MINIMUM EXTERNAL STATIC PRESSURE FOR DUCTED SYSTEMS TESTED WITH AN INDOOR FAN INSTALLED *

Rated cooling or heating capacity ** *Btu/h*	Minimum External Resistance † *in wc*	
	SDHV Systems ††	All other systems
≤ 28,800	1.10	0.10
29,000 to 42,500	1.15	0.15
43,000 ≥	1.20	0.20

* Source: Table 2 from 10 CFR 430, modified for today's NOPR.

** For air conditioners and heat pumps, this is the value the manufacturer cites in published literature for the unit's capacity when operated at the *A* or A_2 test conditions. For heating-only heat pumps, this is the value the manufacturer cites in published literature for the unit's capacity when operated at the *H1* or $H1_2$ test conditions.

† For ducted units tested without an air filter installed, increase the applicable tabular value by 0.08 in wc.

†† See definition 1.35 to determine if equipment qualifies as an SDHV system. If a closed-loop air-enthalpy test apparatus is used on the indoor side, limit the resistance to airflow on the inlet side of the indoor blower coil to a maximum of 0.1 in wc. Impose the balance of airflow resistance on the outlet side of the indoor blower.

In the field, ducted multi-split systems are installed using lower pressure duct systems than are typically used to install a conventional ducted central air conditioner or heat pump. Consequently, DOE recognizes that ducted multi-split systems should not be subject to the same minimum ESP requirements as conventional central systems. Specifying appropriate minimums, however, is difficult.

One problem with the language AHRI proposed is that a manufacturer could choose an unrealistically low value for the rated external static pressure. Because this would likely be a secondary concern (if not completely overlooked) when a system is selected, the manufacturer lacks an incentive to choose a representative rating. Additionally, because the manufacturer is not allowed to select the minimum external static pressure when testing a conventional unit, allowing the manufacturer to select the minimum when testing a ducted multi-split systems would create an unjustifiable inconsistency.

DOE considered three related factors before formulating an alternative to the AHRI proposal. First, the following approach appears in the Draft International Standard (DIS) ballot of

ISO Standard 15402, "Multi-Split System Air Conditioners and Air-to-Air Heat Pumps: Testing and Rating for Performance."

This ESP shall be greater than the minimum value given in Table 1 but not greater than 80% of the maximum external static pressure specified by the manufacturer. * * * If the maximum ESP of the unit is lower than the minimum ESP given in Table 1, then the airflow rate is lowered to achieve an ESP equal to 80% of the maximum ESP of the manufacturer. In case this ESP is lower than 25 Pa, the unit can be considered as a free delivery unit.

Where the ISO approach ties the tested minimum external static pressure to a manufacturer published maximum value while approximating the smallest indoor units as non-ducted, the two other inputs suggest that the current test procedure requirements are manageable. Specifically, manufacturers of single indoor blower coil units that use short ducts —sometimes referred to as "furred down or ceiling mounted air handling units"—have never requested that DOE lower the minimum static pressure requirements. Further, DOE has received no evidence showing that any multi-split indoor unit could not achieve the applicable DOE minimum external static pressure when delivering its air volume rate.

DOE proposes an approach that does not require publication of the maximum external static pressure. For the systems meeting the definition of "multiple-split air conditioner and heat pumps" in the test procedure (10 CFR part 430, subpart B, appendix M, section 1.30), DOE proposes a new set of minimum external static pressures. The proposed minimums will be listed in table 2 of appendix M of the test procedure, along with the current values for SDHV and all other systems. The proposed values are 0.03 in wc for units through 28,800 Btu/h, 0.05 in wc for units between 29,000 and 42,500 Btu/h, and 0.07 in wc for units 43,000 Btu/h and above. The proposed minimums seek to capture the relative differences between a conventional central ducted system and one with the shorter ducts of a typical multi-split system installation. Because ducts add resistance, DOE will not adopt the ISO approach of testing the smallest systems at zero static pressure. For multi-split systems, the applicable minimum external static pressure will be assigned based on the nominal/rated cooling capacity of the outdoor unit. A static pressure equal to or higher that this minimum will be achieved in each outlet duct upstream of the point where they connect to the common plenum that leads to the test room's airflow measuring apparatus. In addition to ducted multi-split systems, DOE proposes applying this new set of minimum external static pressures to ducted mini-splits or 1-to-1 systems where the indoor air handler is a ducted furred down/ceiling-mounted unit. To limit the 1-to-1 products that qualify for the lower minimum static pressures, the single indoor unit must not exceed specified dimensions (*e.g.,* no more than 11 in high and less than 24 in deep), the indoor unit must use a single slab coil that is perpendicular to the flow stream, and the system's rated capacity must not exceed 39,000 Btu/h.

DOE requests comment from interested parties on the proposed lower external static pressure levels for certain equipment as described above and on the proposed language for ensuring that these levels are used only for testing the intended products: ducted multi-splits, ducted mini-splits, and ducted furred down/ceiling mounted one-to-one units.

3. Clarify That Optional Tests May Be Conducted Without Forfeiting Use of the Default Value(s)

In the DOE test procedure, the manufacturer has two options for obtaining a required parameter within the SEER or HSPF calculation algorithm: (1) Run one or two additional tests to obtain the necessary data; or (2) use a "default value," which may be fixed or derived from an approximating equation. For certain frost accumulation tests, the DOE test procedure gives the manufacturer the option of conducting the test or using default equations to determine the pump's power consumption and space heating capacity at 35 °F outdoor temperature and at the designated compressor capacity. The test procedure is not clear whether defaults are forfeited if the manufacturer conducts the optional laboratory test. This matter is clarified here.

As stated in the DOE test procedure (10 CFR part 430, subpart B, appendix M, sections 3.2.1, 3.2.2.1, and 3.2.3), the manufacturer may run the optional test(s) for determining a cyclic degradation coefficient but still use the default if it is lower than the tested value. DOE proposes allowing manufacturers to run the optional test(s), with the understanding that they can still use the default value if it is more favorable for optional frost accumulation tests. Specifically, the manufacturer may use the power consumption and heating capacity values derived from conducting the optional frost accumulation test or the values calculated using the default equations, whichever set contributes to a higher Region IV HSPF based on the minimum design heating requirement.

4. Allow a Wider Tolerance on Air Volume Rate To Yield More Repeatable Laboratory Setups

A goal of the DOE test procedure is specifying a consistent equipment configuration to obtain repeatable laboratory test results. For example, the indoor blower of a particular model should be consistently set to the same blower speed setting for a given test configuration. More generally, the blower speed setting should be the same when performing the same test on all units of the same equipment model.

As part of the equipment setup requirements for most blower-coil units, the testing entity (*e.g.,* manufacturer or third party) turns on both the indoor unit blower and the test facility exhaust fan. The exhaust fan and/or an airflow damper are adjusted until the manufacturer-specified indoor air volume rate is obtained. If the measured external static pressure equals or exceeds the test procedure specified minimum value, testing proceeds without adjustment to the indoor unit configuration.

If the measured external static pressure is below the DOE minimum, the setup requires additional effort. The first step is to reduce the air volume rate until the measured external static pressure equals the DOE minimum. As currently specified in the test procedure, if the measured external static pressure does not equal the DOE minimum by the time the air volume rate has been reduced to 95 percent of the rated value, then the indoor unit blower is turned off, and the indoor unit's setup is adjusted to the next highest speed setting.

The above setup procedure will typically result in the indoor blower-coil set to the same speed setting for testing all units of the same model. In essence, the procedure handles the inherent variability in the external static pressure and air volume rate produced and measured for multiple equipment setups. This variability is due to manufacturing tolerances and lab measurement uncertainties.

In its May 27, 2008 letter, AHRI requested that the 5-percent tolerance on air volume rate be increased to 10 percent. In addition, AHRI recommended that the language for the indoor blower coil setup procedure be refined to recognize that some incremental setting changes may affect more than fan speed. AHRI gives the example that "some speed tap settings may equate to a specific duration of fan delay whereas other settings may translate to no fan delay." To address this issue, AHRI recommends that DOE make incremental changes to the indoor blower setting among settings that provide similar operating features.

AHRI offers two reasons in its May 27, 2008 letter for supporting a greater tolerance on air volume rate during the initial setup process: The expanding use of constant torque motors for central air conditioners and heat pumps blower coils, and the effect of barometric pressure. AHRI states that "for a given speed tap, the air volume rate achieved using a constant torque motor is comparatively more variable; also the change in power draw as a function of an incremental change in the speed tap is also comparatively greater so the impact on efficiency will be more pronounced." Barometric pressure affects air density and the water vapor content for a given db/wb combination. Thus, barometric pressure affects capacity through both the air volume rate and the enthalpy change of the air. As referenced in the AHRI letter, barometric pressure effects are especially important, as most manufacturers' in-house testing is conducted at a lower elevation and typically higher barometric pressure than at the industry's primary independent certification testing facility.

In response to AHRI's May 27, 2008 letter, DOE proposes to increase the tolerance on air volume rate from 5 to 10 percent. In addition, DOE proposes to adopt AHRI's recommendation to refine the indoor blower coil setup procedure to recognize that some incremental changes to the setting may affect more than the fan speed. DOE used computer modeling and laboratory data to determine that a 10 percent difference in air volume rate will cause total capacity to decrease between 1.3 to 2 percent, while having the total system power consumption fall between 1 to 1.8 percent for a minimally compliant system. Because capacity and power impacts are similar, the EER and SEER impacts are less. SEER is projected to decrease between 0.2 and 0.4 percent. Thus, this proposed change has the potential to affect the measured capacity such that it may make it more difficult to meet the industry certification program's 95 percent capacity tolerance. The impact on the DOE regulated descriptor of SEER, however, is well within the measurement uncertainty, even for the limiting case of a 10-percent departure.

DOE requests data and comments from interested parties on the impact of the change from 5 to 10 percent tolerance on air volume rate.

5. Change the Magnitude of the Test Operating Tolerance Specified for the External Resistance to Airflow and the Nozzle Pressure Drop

The DOE test procedure specifies both test operating and condition tolerances. Test operating tolerances indicate the maximum range that a parameter may vary during the data collection interval. For any given test, operating tolerances are specified for a few different parameters. For each parameter, the difference between the highest and lowest instantaneous measurement for the data collection interval must not exceed the specified operating tolerance in order to constitute a valid test.

The test operating tolerance for external resistance to airflow is 0.05 in wc. The test operating tolerance for nozzle pressure drop is 2.0 percent. Both tolerances, which apply for all cooling and heating tests were included in industry standards (*e.g.,* ASHRAE Standard 37) that pre-date the first publication of the DOE central air conditioner and heat pump test procedure. The DOE test procedure adopted the two tolerances at its inception and has not changed it. For current industry standards, the tolerances appear in the 2009 version of ASHRAE Standard 37.

The two test operating tolerances are often exceeded when an electronic pressure transducer is used to measure differential pressure instantaneously. The likelihood of exceeding the tolerance increases with higher sampling rates and when testing indoor blowers whose controls actively regulate operation of the blower's motor. One example is a blower with a variable-speed motor designed to maintain the air volume rate regardless of the airflow resistance. In contrast, these test operating tolerances are usually satisfied if the differential pressures are measured using liquid manometers. The fluid provides mechanical damping that tends to stabilize readings.

DOE proposes to loosen the existing tolerances from 0.05 to 0.12 in wc for the test operating tolerance assigned to the external resistance to airflow and from 2.0 percent to 8.0 percent for the nozzle pressure drop tolerance because the pressure fluctuations are real (10 CFR, subpart B, appendix M, revised tables 7, 8, 13, 14 and 15). The proposed changes in the magnitude of the tolerances are based on limited data obtained from laboratory testing of a variable-speed, constant air-volume-rate blower using electronic pressure transducers with a 5-second sampling rate. This data indicated that the current tolerances could rarely be achieved when using and electronic pressure transducer instead of a liquid manometer. Matching or remaining within the proposed tolerances, by comparison, was far more achievable.

At this stage, DOE proposes amended values for the two tolerances rather than their complete elimination because they still help assure data is taken during a period of relatively steady operation. Additional steps, however, may be warranted. For example, a prescribed algorithm for identifying outliers and/or establishing minimum intervals over which all instantaneous measurements are averaged (*e.g.,* minutely averages) may also be needed to strike the necessary balance between defining test tolerances that promote repeatable test results while not extending test times. Another option may be to introduce a mechanical means for damping the high frequency pressure fluctuations that are fed to the electronic pressure transducer to mimic a liquid manometer. Such damping would be acceptable because the measurements would still reveal whether the flow was steady or trending higher or lower.

DOE seeks comments from interested parties about the proposal to increase the test operating tolerance for the external resistance to airflow from 0.05 to 0.12 in wc and increase the test operating tolerance for the nozzle pressure drop from 2.0 percent to 8.0 percent. In addition, comments on alternative or additional steps to assure the capacity and electrical power data are collected over a 30-minute period of consistent operation are encouraged.

6. Modify Third-Party Testing Requirements When Charging the Test Unit

DOE proposes to revise section 2.2.5, "Additional refrigerant charging requirements," of the test procedure. Most of the proposed revisions originate from the requirements listed in section 9.8.1.1 of the 2008 ARI General Operations Manual for AHRI Certification Programs. DOE adopted the current language in section 2.2.5 of the DOE test procedure in the October 2005 final rule. The section 2.2.5 text covers details not addressed in the test procedure prior to the October 2005 rule, such as charging instructions that differ for field installations versus laboratory testing and the procedure for manufacturers and third-party testing entities to resolve questions on charging a particular system. In the months following publication of that rule, AHRI members reconsidered refrigerant charging, mainly within the context of implementing its third-party certification program. During the August

23, 2006 public meeting, Rheem Manufacturing Company shared AHRI's view of key shortcomings. These include provisions in section 2.2.5 regarding available options when a unit is charged and tested by a third party. These provisions failed to disallow charge manipulation during the testing process (*e.g.,* different charging criteria for the cooling mode tests versus the heating mode tests).

AHRI provided language from the current version of the AHRI General Operations Manual so that all or part of it may be considered for incorporation into the DOE test procedure. The specific AHRI text of interest is as follows:

9.8.1.1 *Test Sample Refrigerant Charge.* All test samples will be charged in accordance with the following instructions and those provided in the manufacturers' Installation and Operational (I/O) Manuals.

Determine refrigerant charge at the Standard Rating Condition in accordance with instructions from I/O Manual. For a given specified range for superheat, sub-cooling, or refrigerant pressure, the average of the range shall be used to determine the refrigerant charge. If multiple instructions are given, the manufacturer will be asked to sign off on the preferred method.

The testing laboratory will then add or subtract the correct amount of refrigerant to achieve the pre-determined superheat, sub-cooling, or refrigerant pressure. This single charge will then be used to conduct all cooling cycle and heating cycle tests.

Once the correct refrigerant charge is determined, the test will run until completion without interruption.

DOE proposes to adopt selected elements of the above AHRI procedures. (10 CFR part 430, subpart B, appendix M, section 2.2.5) The proposed changes promote consistency with current AHRI certification practices, including explicitly disallowing charge manipulation once the initial charging procedure is completed, while differing on the approach of addressing cases where a manufacturer either provides no instructions or provides more than one set of charging instructions. In particular, DOE chose not to implement a "sign off" option as AHRI uses because the proposed approach of specifically addressing the setup procedure in these two special cases is effective and less burdensome.

7. Clarify Unit Testing Installation Instruction and Address Manufacturer and Third-Party Testing Laboratory Interactions

DOE proposes to add language to section 2.2 of the test procedure. The additions seek to clarify installation instructions and, when third-party testing is conducted, to clarify that interaction with the manufacturer is allowed.

The AHRI Certification Program and the DOE test procedure focus on different aspects of the rating process. The AHRI program conducts verification testing of full production of randomly sampled units taken from the manufacturer's inventory. By comparison, the DOE test procedure is typically conducted before a new model of air conditioner or heat pump is introduced into the market. Therefore, testing is usually performed on first production or pre-production units, each of which meets the requirement in 10 CFR 430.24 that testing be done on "units which are production units, or are representative of production units." When testing pre-production units, the installation instructions are not packaged with the unit or perhaps not even finalized. DOE proposes adding language on how to handle such cases. (appendix M, revised section 2.2) Some of the restrictions on interactions between third-party testing laboratories and manufacturers, imposed as part of the AHRI Certification Program, do not apply to the DOE test procedure. One example is AHRI's General Operations Manual requirement that "only laboratory personnel shall install test units." The policy is useful to AHRI because certification testing checks DOE ratings. AHRI does not want individual manufacturers to slow the testing process or reveal information about a competitor. On the other hand, DOE will not prohibit a manufacturer from interacting with a third-party testing laboratory if the latter is contracted to perform work similar to in-house manufacturers. (10 CFR part 430, subpart B, appendix M, revised section 2.2a) In the event of a DOE enforcement action, DOE places no restrictions on manufacturer involvement as long as the test unit installation and laboratory testing are conducted in complete compliance with all other requirements in the DOE test procedure. The highest order of these other requirements is to install the unit according "the manufacturer's installation instructions," as stated in section 8.2 of ASHRAE Standard 37, where the first source for those instructions is the published literature that comes packaged with the unit.

This second issue on the allowed interactions between third-party testing laboratory and the manufacturer was addressed in a previous rulemaking (70 FR 59122) but only as it pertained to the specific installation step of refrigerant charging (section 2.2.5 of the test procedure). Because the interaction applies to the entire installation process, DOE proposes to address the issue in section 2.2 and, as a result, existing section 2.2.5 language on this topic is proposed for deletion.

8. When Determining the Cyclic Degradation Coefficient C_D, Correct the Indoor-Side Temperature Sensors Used During the Cyclic Test to Align With the Temperature Sensors Used During the Companion Steady-State Test, If Applicable

In the DOE test procedure, the results from two optional dry-coil cooling mode tests—one steady-state, one cyclic—provide the inputs to calculate cooling mode cyclic degradation coefficient(s), C^c_D. For the heating mode, the results from one of the required steady-state tests plus the results from an optional cyclic test are used to calculate the heating mode cyclic degradation coefficient, C^h_D. In all cases, the two tests for calculating a cyclic degradation coefficient are conducted consecutively, with the steady-state test conducted first.

Both the steady-state (10 CFR part 430, subpart B, appendix M, sections 3.4 and 3.7) and cyclic (10 CFR part 430, subpart B, appendix M, sections 3.5 and 3.8) C_D tests require calculating the change in the db temperature on the indoor side. To complete these measurements, the laboratory test setup includes redundant sets of temperature sensors and associated instrumentation. In many cases, one set of temperature sensors provides the primary measurement of the change in db temperature for all steady-state tests, while the second set provides the same primary measurement for all transient tests, including the cyclic C_D test. Using two sets of temperature sensors allows highly accurate measurements during the steady-state test; comparatively less accurate but necessarily faster-responding measurements are achieved during the transient tests. The DOE test procedure refers to ASHRAE Standard 41.1–1986 (RA 2001) for recommendations and requirements on making these temperature measurements.

Cyclic degradation coefficients are used to obtain a relationship between part-load factor (PLF) and the percent on-time of the unit. PLF is a ratio of the cyclic to the steady-state EER. The consecutive C_D tests are used to obtain one point on the PLF versus percent on-time plot. Because the results of the consecutive C_D tests define a ratio, the preferred testing approach is to limit differences between the two tests. Using one set of instrumentation to measure the change in the db air temperature entering and leaving the indoor unit during the steady-state C_D test and a different set for the companion cyclic C_D test is a source of potential bias.

To avoid conflict, DOE may require that the same temperature measurement instrumentation be used for both consecutive C_D tests. The Standards Project Committee revising ASHRAE Standard 116, "Methods of Testing for Rating Seasonal Efficiency of Unitary Air Conditioners and Heat Pumps," considered this alternative but chose to make it a recommendation, not a requirement (see clause 5.1.4 of ASHRAE Standard 116–1995R, "Method of Testing for Rating Seasonal Efficiency of Unitary Air Conditioners and Heat Pumps," First Public Review draft). A second option is to correlate the instrumentation used for the primary measurement of the temperature difference of the cyclic C_D test to that used for the primary measurement during the steady-state C_D test. Some industry members have implemented this correlation approach and found that it improves repeatability.

DOE proposes to require a correlation step for testing laboratories that use different instrumentation to measure the change in the db temperature of the air entering and leaving the indoor unit during the steady-state C_D test versus the cyclic C_D test. This correlation step is conducted during the steady-state C_D test. During the test, both sets of instrumentation—those sensors providing the primary measurement during the steady-state (set SS) and during the cyclic (set CYC) tests—measure the indoor-side air db temperature difference. For both sets of instrumentation, measurements made at equal intervals that span 5 minutes or less determine the temperature difference. Once the 30-minute data collection period begins for the steady-state C_D test, an average temperature difference is calculated based on the sets SS and CYC instrumentation after a minimum of 7 data samples and 6 minutes or more. The average temperature differences are then used to calculate the C_D correlation factor, F_{CD}:

$$F_{CD} = \Delta T(\text{Set SS})/\Delta T(\text{Set CYC})$$

An updated F_{CD} value shall be recalculated every minute or after each data sample, whichever occurs later. In addition, each recalculated ratio shall be based on the same number of data samples and same elapsed time as used for the first F_{CD}. For the example case of a sampling rate of 1 minute or less, the first F_{CD} shall be based on data collected from elapsed time of 0 to 6 minutes, the second from 1 to 7 minutes, the third from 2 to 8 minutes, and so on.

Upper and lower limits are proposed for F_{CD} to provide a uniform basis as to how much the two temperature measurements may deviate. The proposed allowable range of F_{CD} is 0.94 to 1.06. Laboratories that sample at a rate of every minute or less can evaluate the first F_{CD} as soon as 6 minutes after the start of the normal 30-minute data collection period. If this first or any subsequent value of F_{CD} is outside the proposed application range of 0.94 to 1.06, then the testing laboratory can make a decision to abort the test in advance of completing the 30-minute data collection period. By comparison, if a 5-minute sample rate is used, F_{CD} falling within the allowed range will remain unknown until the 30-minute data collection period is completed. In this case, up to 24 minutes of laboratory testing time may be lost from a longer wait to evaluate compliance.

If the value of F_{CD} at the conclusion of the 30-minute period (saved F_{CD}) falls outside the range of 1.0 ± 0.6, then the test sequence must be terminated, and steps taken to improve the agreement between the sets SS and CYC instrumentation. Calibration of one or both sets of instrumentation in accordance with ASHRAE Standard 41.1 may be necessary. Once the remedial steps are complete, the steady-state C_D test shall be repeated. For cases within the accepted range, the saved F_{CD} shall thereafter be used during the cyclic C_D test to adjust the indoor-side temperature difference or a time-integrated value of the same determined using the set CYC instrumentation. For example, with respect to section 3.5 of Appendix M, the equation for the integrated, indoor-side air temperature difference will be written as follows:

$$\Gamma = F_{CD} \int_{\tau_1}^{\tau_2} \left[T_{a1}(\tau) - T_{a2}(\tau) \right] d\tau$$

The value of F_{CD} shall be used only to adjust the set CYC temperature difference measurement from the cyclic C_D test that immediately follows the steady-state C_D test that yields the correlation factor. The F_{CD} determined and applied for one set of consecutive C_D tests shall not be used to adjust the set CYC temperature difference measured during a second cyclic C_D test or during a frost accumulation test.

DOE proposes to decrease the minimum sampling rate of the db temperature difference from the current value of every 10 minutes to every 5 minutes to obtain a more representative value of F_{CD}. As an extension of this modification, DOE proposes to change the long-standing minimum sampling rate for all steady-state tests from 10 to 5 minutes. The 10-minute sampling interval rate allows time for some measurements to be hand-recorded. Improved test quality and results, advances in electronic instrumentation, and the low cost of computer-based versus manual recording justify the minimum sampling rate change.

DOE seeks comments from interested parties on the introduction and calculation of the cyclic degradation correlation factor. DOE also seeks comments on the change in sampling rate from 10 to 5 minutes.

9. Clarify Inputs for the Demand Defrost Credit Equation

The demand defrost credit (F_{def}) is a direct multiplier within the HSPF calculation Eq. 4.2–1 in the DOE test procedure. The factor provides nominal credit for heat pumps with a demand defrost control system. Systems that meet DOE requirements in test procedure definition 1.21, "demand defrost control system," qualify for this credit. The multiplier has a value between 1.00 and 1.03, which is a 0 to 3 percent increase in the HSPF rating. The credit is evaluated using the following equation from section 3.9.2 of the DOE test procedure:

$$F_{def} = 1 + 0.03 \times \left[1 - \frac{\Delta\tau_{def} - 1.5}{\Delta\tau_{\max} - 1.5} \right]$$

Where:

$\Delta\tau_{def}$ = time between defrost terminations (in hours) or 1.5, whichever is greater, and

$\Delta\tau_{max}$ = maximum time between defrosts as allowed by the controls (in hours) or 12, whichever is less.

The demand defrost credit was incorporated into the test procedure during the rulemaking completed in March 1988 and has remained unchanged. 53 FR 8319. DOE mistakenly overlooked inputs to this equation during the most recent test procedure final rulemaking, in which DOE shortened the maximum duration of all frost accumulation tests from 12 to 6 hours. DOE has since considered two options for calculating the credit: (1) Update the evaluation of $\Delta\tau_{max}$ to read "maximum time between defrosts as allowed by the controls (in hours) or 6 hours, whichever is less;" and (2) reinforce that the current form of the equation still applies and, when a defrost cycle is not completed before the maximum time, assign $\Delta\tau_{def}$ the value of 6 hours. DOE proposes to adopt this second option in today's notice.

As discussed in the October 2007 final rule, the change from a maximum test duration of 12 to 6 hours rarely affected testing; when it did, there was a negligible impact on the calculation of the average heating capacity and power consumption at a 35 °F outdoor temperature. The main reason for changing the maximum limit to 6 hours was to reduce the test burden when frost did not build on the outdoor coil. The frost accumulation tests at low-capacity for two-capacity heat pumps and at the intermediate compressor speed for variable-speed units are the two leading cases where this revision may help reduce that burden. Since the institution of this change, DOE has not received any comments or information about the effects on heating capacity or power.

Shortening the maximum duration of the frost accumulation test affects heat pumps that would otherwise conduct a defrost after 6 but before 12 hours in two ways. First, as recognized during the October 2007 final rule process, such heat pumps benefit slightly from not having a defrost cycle factored into their average heating capacity calculation. Second, they earn a higher demand defrost credit than they would have earned previously. As a worst case (*e.g.,* unit's demand defrost controls actuate at 11.999 hours while the unit's maximum duration is 12 hours or more), the approximated demand defrost credit is now 1.017 compared to the "true" value of 1.000.

In summary, the proposed rule includes additional language clarifying that manufacturers must assign $\Delta\tau_{def}$ the value of 6 hours if this limit is reached during a frost accumulation test and the heat pump has not completed a defrost cycle. A sentence is also added to indicate that the manufacturer must provide the value of $\Delta\tau_{max}$.

DOE seeks comments from interested parties on this proposal for calculating the demand defrost credit (F_{def}) for cases where the Frost Accumulation Test is terminated because the heat pump does not initiate a defrost within the maximum allowed 6-hour heating interval.

10. Add Calculations for Sensible Heat Ratio

SHR is a parameter that indicates the relative contributions of the air conditioner's or heat pump's cooling output that reduces the db temperature of the air (*i.e.,* sensible cooling) to the cooling output that reduces the moisture content in the air (*i.e.,* latent cooling). The parameter is calculated by dividing the sensible cooling capacity by the total cooling capacity. Total cooling capacity is the sum of the sensible and latent cooling capacities. For example, an SHR of 0.75 indicates that 75 percent of the cooling is sensible and 25 percent is latent.

The DOE test procedure considers total building cooling loads and total cooling equipment capacities as part of the SEER calculation. The cooling load and capacity are not divided into their sensible and latent components. Based on historical data, equipment SHRs have remained relatively unchanged as equipment SEER ratings have increased. In addition, cooling equipment has historically provided a reasonable match to the sensible and latent loads of the building or residence. However, better insulation of homes and small commercial buildings has helped reduce sensible building loads. Particularly in more humid climates, this reduction in the sensible building load can make the latent building load more prominent.

SHR differences among equipment having approximately the same SEER have always existed. For example, 2001 Amrane, Hourahan, and Potts data reported in the January 2003 *ASHRAE Journal* (pp. 28–31) show SHR values that vary by at least 0.10 for a given SEER value. When humidity control is a concern, consumers and their contractors may wish to know the SHRs of different units to make a more informed decision.

The measurements required to calculate the SHR from a DOE wet-coil cooling mode test are taken as part of the DOE test procedure. In fact, manufacturers and independent testing laboratories routinely determine SHR. DOE proposes to add the SHR calculation to its test procedure to endorse the calculation and its continued use explicitly. (10 CFR part 430, subpart B, appendix M, revised section 3.3c and proposed section 4.5)

11. Incorporate Changes to Cover Testing and Rating of Ducted Systems Having More Than One Indoor Blower

The majority of residential central air conditioners and heat pumps employ a single blower and a single refrigerant-to-air coil. Typical multi- and some mini-splits use more than one indoor unit, with the indoor units using one blower and one coil. However, a newer type of residential central system that uses more indoor blowers than indoor coils does not follow this one-to-one blower-to-coil ratio.

The multi-blower design facilitates zoning when the system responds to more than one thermostat. Associated with the zoning feature are capacity modulation and variations in electrical power consumption. The first and more limited means of affecting capacity and power use is controlling the number of indoor blowers that are turned on and, where applicable, altering the blower's speed (if equipped with a multi-stage or variable-speed motor). The second and broader means of affecting power consumption occurs in systems that use a single outdoor unit equipped with a two-stage compressor or in systems consisting of two outdoor units, each having single-speed compressors.

DOE proposes modifications to cover the testing and rating of systems using a multi-blower indoor unit. These systems will be treated as if all zones depend on outdoor temperature such that they respond to the same load profile as a single-zone system. DOE test procedure algorithms for covering two-capacity units and systems having a single-speed compressor with a variable-air-volume rate indoor blower would provide the basis for the algorithms that address systems with a multi-blower indoor unit (10 CFR 430, subpart B, appendix M, revised sections 2.2.3, 2.4.1, 3.1.4.1.1, 3.1.4.2, 3.1.4.4.2, 3.1.4.5, 3.2.2, 3.2.2.1, and 3.6.2; proposed sections 3.2.6, 3.6.7, 4.1.5, and 4.2.7; and revised tables 4 and 10).

On August 28, 2008, DOE published a decision and order granting a waiver from the DOE Residential Central Air Conditioner and Heat Pump Test Procedure for a line of multi-blower indoor units that may be combined with one single-speed heat pump outdoor unit, one two-capacity heat pump outdoor unit, or two separate single-speed heat pump outdoor units. 73 FR 50787–50797. For the two separate single-speed outdoor units, the chosen indoor coil contains two independent refrigeration circuits, each fed by one of the outdoor units.

The above-referenced waiver covers products that use two to eight indoor blowers with a single- or dual-circuit indoor coil. To simplify the testing and rating algorithm, DOE structured the waiver so that each system was evaluated with all and with half of the indoor blowers operating. DOE did not consider any other potential blower combinations. For systems offering compressor modulation, a high-stage compressor operation was evaluated only when all blowers were on, and the low-stage was evaluated with half the blowers on.

DOE proposes to amend the test procedure to allow the coverage of systems that use a multi-blower indoor unit to address the same type of equipment covered by the test procedure waiver granted to Cascade Group, LLC.

12. Add Changes To Cover Triple-Capacity, Northern Heat Pumps

On February 5, 2010, DOE granted Hallowell International a waiver from the DOE test procedure on how to test and rate its line of boosted compression heat pumps. (24 FR 6014–6018) These heat pumps offer three stages of compressor capacity when heating, with the third stage being designed to provide greater heating capacity at the lowest outdoor temperatures. The approved waiver contained additional laboratory tests and calculations steps that were specific to obtaining an HSPF rating for the Hallowell heat pumps. No changes to the DOE test procedure were required to evaluate the SEER for these heat pumps. The test procedure sections covering two-capacity systems when operating in a cooling mode are applicable for the Hallowell heat pumps.

Proposed test procedure amendments are offered as part of this rulemaking to cover heat pumps that provide three levels or stages of heating capacity like the Hallowell units. The proposals seek to cover the more generic case of such technology.. The proposal includes, additional laboratory testing to capture the effect on both capacity and power of the additional stage of heating operations.. The proposed building load assigned by HSPF calculations requires evaluation based on the application in which high-stage compressor capacity for heating exceeds that for cooling. Finally, the proposed coverage accounts for controls that lock out one or two heating mode capacity levels at any given outdoor temperature. Once these proposals are incorporated into the test procedure, the need for a waiver will be eliminated and the requirements will apply to all manufacturers who offer equipment with this technology.

DOE proposes adding two required steady-state tests to quantify the heating capacity and power consumption characteristics of the third stage of heating. One test would be conducted at the existing outdoor temperature test condition of 17 °F db/15 °F wb temperature ($H3_3$). The second test would be at a new outdoor test condition ($H4_3$), 2 °F db/1 °F wb. This proposed outdoor temperature condition is slightly higher than the 0 °F db/−2 °F wb condition proposed by Hallowell and cited in the approved waiver. The alternative condition is proposed with the intent of specifying a test condition that is marginally more achievable for testing laboratories. Finally, two optional tests are proposed, a Frost Accumulation Test and a cyclic test with the heat pump operating at its third or boosted compression stage (10 CFR part 430, subpart B, appendix M, proposed section 3.6.6).

DOE is proposing equations for calculating the capacity and electrical power consumption of the heat pump as a function of the outdoor temperature when operating at its highest stage of compressor capacity. As part of the proposal, the heating building load used in the HSPF calculation, would also be based on the capacity measured during the *H1* test condition (47 °F db/43 °F wb outdoor temperatures). The compressor would operate at the same speed or stage as in the (A_2) cooling mode test at 95 °F outdoor db. The HSPF calculation algorithm would be an extension of the approach currently used in the DOE test procedure for two-capacity heat pumps. The active stages of heating capacity available for each bin temperature calculation would be based on the control logic of the unit (10 CFR part 430, subpart B, appendix M, proposed section 4.2.6).

DOE seeks comments from interested parties on the inclusion of test procedure amendments to cover heat pumps that offer three stages of compressor capacity when heating.

13. Specify Requirements for the Low-Voltage Transformer Used when Testing Coil-Only Air Conditioners and Heat Pumps and Require Metering of All Sources of Energy Consumption During All Tests

The transformer that powers the low-voltage components of a field-installed hot-air furnace and add-on (coil-only) air conditioner or heat pump resides in the furnace. A coil-only air conditioner or heat pump with a hot-air furnace is not typically laboratory tested. As a result, the DOE test procedure does not specify the low-voltage source of power for the compressor contactor, control boards, and most heat pump reversing valves. Because the test procedure does not stipulate metering requirements, the associated power consumption is typically unmetered, which makes the choice of the transformer used inconsequential. A 100 volt amp (VA) transformer powered by a 230 V input works as well as a 40 VA model powered by a 115 V input.

Because coil-only equipment mainly competes against like equipment, not accounting for low-voltage components' power consumption in the past was not a glaring deficiency as the comparable impact on SEER and HSPF ratings. However, in seeking to account for all modes and sources of energy consumption as per section 310 of EISA 2007, DOE proposes that the energy consumption of low-voltage components of coil-only systems be measured and included in the applicable rating descriptors. DOE anticipates needing to specify a VA rating for the transformer used for laboratory testing, while requiring that the input voltage be the same as that provided to the outdoor unit (*e.g.,* 230 V).

An indoor wall thermostat is not typically used for laboratory testing of a central air conditioner or heat pump. For this rulemaking, DOE considered but decided against assigning a default power value to account for the absence of the wall thermostat. Some thermostats use no power or are battery powered. If a low-voltage-powered electronic thermostat is used, its power consumption is often low, usually less than a watt or two. In most cases, an air conditioner or heat pump can be installed in a system that includes a variety of wall thermostats. It is not possible to know the type of thermostat that will be used or its power consumption.

For testing coil-only air conditioners and heat pumps, DOE proposes that the power consumption of the low-voltage system components be metered. Additionally, the transformer would be rated to provide 24 V, have a load rating of either 40 or 50 VA, and would be designed to operate with a primary input of 230 V, single phase, 60 hertz. The transformer may be powered by the same source as the outdoor unit or a separate 230 V source. The key requirement is that the instrument measuring the transformer's power consumption during the off mode power or any other test must do so within the prescribed measurement accuracy.

14. Add Testing Procedures and Calculations for Off Mode Energy Consumption

SEER is a seasonal descriptor that accounts for all (modes of) energy consumption that occurs during the cooling season, including times when the air conditioner or heat pump is cycled off because the building thermostat is satisfied. HSPF is a seasonal descriptor for heat pumps that accounts for all (modes of) energy consumption during the heating season. The current test procedure does not cover the energy consumption of an air conditioner during the heating season when the unit is typically turned off at the thermostat but its controls and protective devices remain energized. The current test procedure also does not account for a complete 8,760-hour year as part of the annual cost calculation. As documented in appendix A of ASHRAE Standard 137–2009, "Method of Testing for Efficiency of Space-Conditioning/ Water Heating Appliances that Include a Desuperheater Water Heater," the combination of the location-specific cooling and heating load hours used in the annual cost calculation is less than 8,760. The missing hours correspond to the intervals during which space conditioning is not required because the outdoor temperature is moderate, as during the shoulder seasons that occur between the cooling and heating seasons. Neither SEER nor HSPF account for energy consumed during the shoulder seasons.

To provide a means for more clearly accounting for the energy consumption during the shoulder seasons and, for air conditioners, the energy consumption during the heating season, DOE proposes to define that such times occur when the air conditioner or heat pump is in an "off mode." DOE proposes the following definition.

The term "off mode" means:

(1) For air conditioners, all times during the non-cooling season of an air conditioner. This mode includes the "shoulder seasons" between the cooling and heating seasons when the unit provides neither heating nor cooling to the building plus the entire heating season, when the unit is idle. The air conditioner is assumed to remain connected to its main power source at all times during the off mode; and

(2) For heat pumps, all times during the non-cooling and non-heating seasons of a heat pump. This mode includes the "shoulder seasons" between the cooling and heating seasons when the unit provides neither heating nor cooling to the building. The heat pump is assumed to remain connected to its main power source at all times during the off mode.

Notably, the above proposed definition differs from the one provided in section 310 of EISA 2007, which amended section 325(gg)(1)(A) of EPCA. (42 U.S.C. 6295(gg)(1)(A)) This section of EPCA applies to a wide range of covered products, and as a result, the definitions for off-mode, active mode, and standby mode are relatively general in order to address all possible energy consuming modes. Rather than introduce alternative definitions for all of these modes within the central air conditioner and heat pump test procedure, DOE proposes modifying only the definition for off-mode as part of this rulemaking.

DOE proposes new laboratory tests and a separate calculation algorithm for estimating the energy consumption during the off-mode season. The new tests and calculations are used to determine an average power consumption for the collective shoulder seasons and, for air conditioners, an average power consumption during the heating season. The shoulder season's off-mode power consumption will be designated as *P1,* which affects both air conditioner and heat pump energy usage. The heating season off-mode power consumption will be designated as *P2,* which only affects air conditioner energy usage.

(10 CFR part 430, subpart B, appendix M, proposed section 3.13)

DOE has determined that it is not technically feasible to integrate off-mode energy use into the SEER and HSPF metrics because they are both seasonal descriptors. These seasonal descriptors should not be used to account for the out-of-season of off-mode energy consumption—i.e., the energy consumed during the shoulder seasons and during the heating season. To do so would alter the basis of SEER and HSPF. The basis for the integrated SEER for an air conditioner would be annual performance, while the basis for the integrated SEER and HSPF for a heat pump would be part-year performance. Annual and part-year bases for SEER and HSPF are inconsistent with the definitions of these regulating metrics. Moreover, the difference in bases, annual for the air conditioner versus part-year for the heat pump, disallows the use of the integrated SEER for comparing an air conditioner to a heat pump. Therefore, to maintain the technical integrity of SEER and HSPF and to account for off-mode (off season) energy consumption, DOE has developed a separate algorithm to calculate the off-mode (off season) energy consumption.

The proposed *P1* and *P2* parameters are used to evaluate the off-mode energy consumption for any generalized climatic region or specific location.

The shoulder season average off-mode power *P1* (for air conditioners and heat pumps) would be multiplied by the appropriate shoulder season hours to obtain the energy consumed during the collective shoulder seasons. For air conditioners during the heating season, the average off-mode power *P2* would be multiplied by the applicable heating season hours to obtain the energy consumed. The calculation of an air conditioner's annual energy consumption and annual operating cost would include both the shoulder season energy consumption and the energy consumed during the heating season. For heat pumps, the energy consumption during the shoulder seasons would be included in the calculation of the annual energy consumption and annual operating cost.

As part of today's notice, DOE provides the actual hours associated with cooling, heating, and the collective shoulder seasons for six generalized climatic regions currently defined in the test procedure. DOE also includes actual hours that correspond to the 1,000 cooling load and the 2,080 heating load hours referenced in 10 CFR 430.23(m), "Test procedures for the measurement of energy and water consumption—central air conditioners and heat pumps," as the representative average use cycles. Additionally, DOE provides equations for calculating the actual hours for the cooling, heating, and collective shoulder seasons corresponding to any cooling and heating load hour combination.

As noted above, it is not technically feasible to use SEER and HSPF to account for the off-mode energy use. SEER and HSPF are the seasonal performance descriptors for the cooling and heating seasons, respectively. Moreover, such changes would have a deleterious impact on the manufacturer and confuse the consumer. Air conditioners and heat pumps would no longer be comparable and their energy efficiency values would only apply to similar climactic regions (*i.e.* one specific combination of cooling season hours, heating season hours, and shoulder season hours). If these energy efficiency values were integrated, SEER would be different in Maine than in Florida for similar air conditioner design. Therefore, additional precautions would be required to make sure the manufacturer only labels the units with a "locally integrated" SEER when selling a unit. This new complexity would require the consumer to have a technically pertinent knowledge to make an informed purchasing decision.

DOE seeks comments from interested parties about off-mode power consumption, its definition, and how DOE proposes to add it to the test procedure.

15. Add Parameters for Establishing Regional Standards

Implementation of regional standards for central air conditioners and heat pumps is allowed if justified. (42 U.S.C. 6295(o)(6)(D)(i)) Before DOE can establish regional standards it must fulfill two statutory requirements: (1) That the establishment of additional regional standards will produce significant energy savings in comparison to establishing only a single national standard; and (2) that the additional regional standards are economically justified. DOE has considered regional standards from two perspectives: (1) Using the existing SEER and/or HSPF rating but setting the regional standard higher than the national standard; and (2) evaluating the regional SEER and/or HSPF using a different algorithm and establishing a standard based on this region-specific SEER and/or HSPF. As part of its standards rulemaking, DOE is considering the merits of both alternatives. Notably, DOE does not have authority to use a performance metric other than SEER and HSPF to quantify performance, either as part of a national rating or as part of a regional rating. EER and COP, for example, cannot be used.

To consider a standard based on a region-specific SEER and/or HSPF, DOE must implement changes to the test procedure. Proposed test procedure changes are itemized below. These proposed changes were formulated based on the framework specified in EISA 2007 and from the results of the preliminary analysis conducted as part of the standards rulemaking. For that framework, section 306 of EISA 2007 permits DOE to establish up to two regional standards for cooling products in addition to the national standard. (42 U.S.C. 6295(o)(6)(B)) Further, individual States shall be placed only into a single region. (42 U.S.C. 6295(o)(6)(C)(iii)) In response, DOE has tentatively decided to limit its consideration of regional standards to cooling-dominated contiguous States and, in addition, to focus only on a region-specific SEER, not HSPF. The natural division of the cooling-dominated region is an east-west partitioning where the eastern region generically qualifies as having a hot, humid climate, where the western region may be generically categorized as hot and dry.

SEER, which has and will continue to be used to establish the national standard, is evaluated based on indoor test conditions of 80 °F db/67 °F wb. These conditions would be suitable to evaluate performance when the equipment is applied in the proposed hot-humid region. As a result, test procedure changes are not necessary to complement a potential hot-humid regional standard. As currently planned, any hot-humid regional standard would be based on the current SEER algorithm. The final SEER assigned to the hot-humid regional standard, however, could be higher than the value assigned for the national standard.

As for the proposed hot-dry region, DOE identified States that could be included in this region. These States and the basis for their selection is described in the technical support document (TSD) prepared as part of the development of the residential central air conditioners and heat pumps standards. For this region, DOE is considering the option of establishing a regional SEER standard based on a region-specific SEER rating (*i.e.,* SEER or SEER Hot-Dry (SEER–HD)). The subsections that follow discuss test procedure elements that offer mechanisms for capturing equipment performance in a climate that differs from the average climate represented in the national SEER rating. Until DOE finalizes the list of States in the targeted region, some numbers and inputs are subject to change.

a. Use a Bin Method for Single-Speed SEER Calculations for the Hot-Dry Region and National Rating

The bin calculation structure currently used in the DOE test procedure for calculating the SEER of two-capacity and variable-speed systems accounts for the effects of outdoor db temperature (including a shift in the frequency of occurrence), the equipment sizing criteria, and an alternative building load profile. The bin calculation method allows a mechanism to evaluate the relative impact of installing an air conditioner or heat pump in different climates, including a hot climate.

The simple short-cut equation provided in the DOE test procedure for rating most single-speed systems typically yields a SEER value that is close to the SEER value obtained using the temperature bin method; *i.e.,* if the fractional bin hour distribution, the sizing criteria, and the building load line algorithm are the national average values. As deviations to this specific case are introduced, however, the bin calculated SEER will change accordingly while the short-cut SEER will remain unchanged and equal to the value that results from the calculations in 10 CFR part 430, subpart B, appendix M, section 4.1.1. Thus, the current short-cut SEER method cannot be used if any calculation parameter changes.

Three potentially differentiating parameters of the proposed hot-dry region are the addition of operating hours at bin temperatures above the current maximum of 102 °F, an appreciable redistribution in the percentage of hours occurring in each 5 °F outdoor temperature bin, and a different outdoor design temperature. To account for the dryness of the region, in addition, cooling capacity and electrical power can be based on performance achieved when operating with comparatively drier indoor conditions. Because of these projected departures, DOE proposes a bin calculation method for evaluating the region-specific SEER for all types of systems, including those units having a single-speed compressor.

The proposed SEER–HD temperature bin method will use a single set of new fractional bin hours representative of the applicable contiguous States. A revised outdoor design temperature would be used in defining the building load for each temperature bin. The zero-load balance point will remain at 65 °F, and the assumed oversizing would remain at 10 percent. The assumed linear relationship between outdoor db temperature and building load would also remain. The performance of the air conditioner or heat pump as a function of outdoor db temperature would be based on operating at indoor ambient conditions comparatively drier than those used for the national rating.

With the planned institution of a bin calculation method for all systems when determining the SEER–HD, DOE proposes to eliminate the use of the short-cut method for all single-speed systems when determining the national SEER, replacing it with the bin calculation algorithm on which the short-cut method is based. The benefits of this proposed transition include consistency between rating fixed speed and modulating systems, an increase in the potential impact of the *A* Test relative to the *B* Test, avoidance of potential confusion about the validity and basis of the short-cut method, elimination of concerns that the short-cut method often yields a slightly higher SEER than the bin method for current equipment, and consistency between the calculation of the national SEER and regional SEER–HD (10 CFR part 430, subpart B, appendix M, revised sections 4.1 and 4.1.1).

b. Add New Hot-Dry Region Bin Data

An important component for implementing a new SEER–HD rating is defining a representative set of outdoor temperature data for the cooling season. This data set is the fractional bin hours assigned to each 5 °F temperature bin. Using TMY2 weather data combined with the calculated building load for each temperature bin (based on using the ASHRAE 1 percent design dry-bulb temperature for specific location in place of the 95 °F used in the DOE test procedure), DOE generated cooling load profiles for cities within those States being considered as part of the hot-dry region. Using population-based weighting factors for each TMY location, DOE calculated a population-averaged annual cooling load profile and a corresponding fractional bin hour distribution.

Table III.2 lists the proposed cooling season fractional bin hour distribution for the hot-dry region under the column heading SEER–HD (for basis of this table, see chapter 7 of the preliminary TSD of the central air conditioner standards rulemaking). For comparison, the current DOE test procedure cooling season fractional bin hour distribution is shown along with the cooling load profiles calculated from each bin hour distribution. To three decimal places, the cooling season fractional bin hours for the SEER–HD in the 110 to 114 °F temperature bin is shown as 0.000; however, the actual bin hour fraction, 0.0002, resulted in a 0.001 annual cooling load fraction as shown in the rightmost column. DOE requests comments on the chart below.

TABLE III.2—PROPOSED FOUR-STATE HOT-DRY REGION: ARIZONA, CALIFORNIA, NEW MEXICO, NEVADA

Temperature °F	Cooling season fractional bin hours		Resulting cooling load profile	
	DOE PT.430	SEER–HD	DOE PT.430	SEER–HD
65–69	0.214	0.477	0.036	0.115
70–74	0.231	0.208	0.137	0.175
75–79	0.216	0.119	0.220	0.172
80–84	0.161	0.086	0.232	0.176
85–89	0.104	0.047	0.194	0.124
90–94	0.052	0.027	0.119	0.088
95–99	0.018	0.021	0.049	0.082
100–104	0.004	0.011	0.013	0.050
105–109	0.000	0.004	0.000	0.018
110–114	0.000	0.000	0.000	0.001

c. Add Optional Testing at the *A* and *B* Test Conditions With the Unit in a Hot-Dry Region Setup

Bin calculations account for how the air conditioner or heat pump's total cooling capacity and electrical power consumption change with outdoor temperature (and, for modulating systems, with the compressor's capacity or speed). During the cooling season for the proposed hot-dry region, the air conditioner or heat pump will operate mostly when comparatively less latent cooling is needed. By comparison, the performance data from the currently required laboratory tests (Tests *A* and *B* for single-speed systems) correspond to indoor test conditions that result in a fully wetted coil and a significant amount of latent cooling (typically 20 to 30 percent of the total capacity). The electrical power consumption and EER of a system operating with a fully wetted coil also differ slightly from the values obtained from operating with a partially wetted or dry coil.

In addition to evaluating the SEER–HD using the same performance data used to calculate the national SEER, at least two other options are available: specify hot-dry, steady-state cooling mode tests (where indoor conditions are representative of such an installation), or test at the same indoor conditions currently specified for the dry-coil tests used to determine the cooling mode cyclic degradation coefficient(s).

To determine the potential impact that the indoor conditions (wb temperature) may have on the new SEER–HD rating, DOE conducted sample calculations for the bracketing cases. A unit with a tested national SEER of 13.6 would earn a SEER–HD of 13 using the 80 °F/67 °F data and a SEER–HD of 11 using the dry-coil data. The first drop reflects the effects of the fractional bin hour distribution and a different outdoor design temperature for the hot-dry region. The second drop captures the impact of using dry- instead of wet-coil data. The magnitude of the latter drop persuaded DOE to explore a different option. Acknowledging the greater test burden, DOE seeks to specify conditions more representative of a hot-dry region installation.

Lacking any contrary data or comments supporting an indoor db temperature for the hot-dry region tests greater than the 80 °F db temperature used for standard SEER tests, DOE proposes to use the 80 °F db temperature to minimize the increased test burden. For the companion wb test condition, DOE considered four values: 63 °F, 64 °F, 64.5 °F, and 65 °F. These candidate wb temperatures were selected based upon published reports of field data collected in California drier climate zones, a review of indoor test conditions selected for hot-dry testing by private and university researchers, and the practical aspect of differentiating from the current test condition of 67 °F wb temperature (Proctor Engineering Group, Ltd., "Hot Dry Climate Air Conditioner [HDAC] Proof of Concept [POC]—Final 3-Ton Laboratory Test Analysis Report," Draft Report, July 13, 2006 and Southern California Edison, Proctor Engineering Group Ltd., and Bevilacqua-Knight, Inc., "Energy Performance of Hot, Dry Optimized Air-Conditioning Systems," PIER Final Project Report, CEC–500–2008–056, July 2008). DOE today proposes to use an indoor wb temperature of 64 °F because it lies at the midpoint of the considered range.

The effect of outdoor temperature on cooling capacity and power consumption can be approximated by a linear fit when calculating the national SEER using a bin method. As such, DOE prefers testing at two different outdoor temperatures, with all other operating parameters constant. Ideally, the two temperatures should provide a range of application to maximize interpolation values and minimize extrapolation. The national SEER test pair of 82 °F and 95 °F approach the specified criterion for singlespeed units, for the high capacity of two-capacity units, and for the maximum speed of variable-speed systems. The test pair of 67 °F and 82 °F for the low capacity performance of two-capacity units and for the minimum speed performance of variable-speed systems provide the same utility.

Because of the availability of the national SEER wet-coil test data, the need to minimize the test burden, and the fact that the performance ratings only apply to the hot-dry regional climate, DOE seeks to minimize the number of new required tests. Therefore, DOE proposes a combination of required and optional tests. Instead of conducting optional tests, DOE proposes using simplified approximating equations to capture the change in performance as the outdoor temperature changes.

As proposed, single-speed systems will have a single required SEER–HD test, which will occur at an outdoor temperature of 95 °F and be designated "the *AD* Test." Systems having a modulating capability will have two required tests: one (AD_2) occurring at a 95 °F outdoor temperature with the unit operating at high capacity or maximum speed, and the other (BD_1) occurring at a 82 °F outdoor temperature with the unit operating at low capacity or minimum compressor speed. Before conducting the first SEER–HD tests, the system shall be (re)configured, as applicable, in accordance with any published instructions from the manufacturer that pertain to installations in a hot-dry region.

As proposed, single-speed systems will have a single optional SEER–HD test (*BD*) that would occur at an outdoor temperature of 82 °F. Systems with a modulating capability would have two optional tests: one (BD_2) occurring at a 82 °F outdoor temperature with the unit operating at high capacity or maximum compressor speed, and the other (FD_1) occurring at a 67 °F outdoor temperature with the unit operating at low capacity or minimum compressor speed. These optional tests provide the additional data necessary to determine how the cooling capacity and power consumption change with outdoor temperature.

Instead of conducting the optional test(s), manufacturers can use the capacity and power data collected from the national SEER cooling mode tests conducted using 80 °F db/67 °F wb as the indoor entering air conditions to approximate how the hot-dry region capacity and power consumption change with outdoor temperature for a given compressor capacity. Specifically, the slope of the capacity (or power consumption) versus outdoor temperature relationship for the comparable 80 °F db/67 °F wb tests will be scaled by multiplying the ratio of the capacity (or power consumption) determined from the SEER–HD test by the capacity (power consumption) determined from the national SEER test conducted at the same outdoor temperature. Using a single-speed system as an example, the slope based on the *A* and *B* Tests is multiplied by the ratio of the *AD* Test capacity (or power consumption) to the *A* Test capacity (or power consumption).

For approximating the capacity and power consumption dependency with outdoor temperature, DOE proposes global adjustment factors to assist in obtaining a conservative SEER–HD. Applying the approximated slope, estimated capacities for temperatures above the single-test temperature point will be over-predicted, while capacities for temperatures below will be under-predicted. Given the proposed required tests for the hot-dry region, the calculated weighted energy consumption for temperature bins below the required test temperature (*e.g.,* 95 °F) should be higher than the bin-weighted total energy consumed for temperature bins above the test temperature. Conversely, the total bin-weighted cooling delivered for temperature bins less than the test temperature should exceed the cooling contribution from temperature bins above the test temperature. As a result, a conservative rating would be achieved if the capacity at the lower temperatures is under-predicted and the power consumption at these temperatures is over-predicted. To determine the under-prediction of capacity, the magnitude of the negative slope for the approximated capacity versus temperature relationship should be reduced slightly. DOE proposes a capacity slope adjustment factor of 0.95. Similarly, the magnitude of the positive slope for the approximated power consumption versus temperature relationship should be reduced slightly. DOE proposes a power consumption slope adjustment factor of 0.95. These adjustment factors are assigned based on the goal of safeguarding against the default equations yielding a higher SEER–HD than the tested values. DOE specifically requests data showing whether the magnitudes of these adjustment factors should be changed.

Collectively, the approximation approach that includes the proposed adjustment factors should yield a SEER–HD equal to or slightly less than the SEER–HD determined from the optional test(s). DOE wants the approximation to provide a conservative rating, which will avoid over-predicting the actual value. When the optional testing is conducted but yields a poorer outcome, a manufacturer shall not be penalized for having conducted the optional SEER tests. If the SEER–HD determined using the approximations defined above is higher than the SEER–HD determined using the data from the optional test(s), the manufacturer may use the higher value. (10 CFR part 430, subpart B, appendix M, revised sections 3.6.2, 3.6.3, and 3.6.4)

DOE considered additional options for modifying the laboratory testing to differentiate equipment installed in a hot-dry region. For example, DOE considered setting higher minimum external static pressure requirements for the required and optional SEER–HD laboratory tests, as some interested parties have advocated increasing the current minimums. DOE elected not to change these minimums as part of the SEER–HD tests to maximize consistency between the SEER–HD and national SEER tests. This consistency is necessary given the above-described method for approximating the relationship between cooling capacity (power consumption) and outdoor temperature for the hot-dry condition. DOE also considered ways to account for an extended indoor fan time delay mode designed to re-evaporate condensate trapped on the coil or lying in the pan. Because the current C_D tests are dry-coil tests, DOE was unable to conceive of a change that would permit measurement of such an evaporative cooling (latent recovery) mechanism if employed in the field.

d. Add a New Equation for Building Load Line in the Hot-Dry Region

As part of the evaluation of the newly proposed region-specific performance rating, SEER–HD, DOE must establish a building load line for the SEER–HD (just as used for evaluating the national SEER):

$$BL\left(T_j\right) = \frac{\left(T_j - T_{ZB}\right)}{\left(T_{OD} - T_{ZB}\right)} \times \frac{\dot{Q}^k_{c,HD}\left(T_{OD}\right)}{F_{OS}}$$

Where:

T_j = the bin temperature,

T_{ZB} = the zero load balance point,

T_{OD} = the outdoor design temperature,

$\dot{Q}^k_{c,HD}$ (T_{OD}) = the unit's capacity at the design outdoor temperature, and

F_{OS} = the oversizing factor.

As with the calculation of the national SEER, the building load is assumed to vary linearly with outdoor temperature. Other parameters common to the two building load calculations are the zero load balance point, the outdoor design temperature, and the oversizing factor: 65 °F, 95 °F and 10 percent (*i.e.,* F_{OS} = 1.1), respectively. As for the 95 °F outdoor design temperature, DOE arrived at it by calculating the population-weighted average of the ASHRAE Handbook 1 percent design dry-bulb temperature for multiple cities located within the proposed hot-dry region. DOE recognizes that across the hot-dry region there are significant differences in cooling design conditions by location but has proposed 95 °F for establishing the load line.

DOE requests comments from interested parties on the introduction of regional standards, the use of the bin method for determining regional and national SEER, the proposed hot-dry regional bin data, and the addition of required and optional testing in a hot-dry region setup.

16. Add References to ASHRAE 116–1995 (RA 2005) for Equations That Calculate SEER and HSPF for Variable-Speed Systems

DOE proposes to reference specific language and equations within ASHRAE Standard 116–1995 (RA 2005) that provide greater detail in determining the three balance point temperatures needed when calculating the SEER of an air conditioner or heat pump having a variable-speed compressor. DOE proposes to do the same for the HSPF variable-speed algorithm.

The DOE test procedure does not include the equations used for calculating the outdoor temperatures at which the unit's cooling or heating capacity matches the building's cooling or heating load when operating at minimum, intermediate, or maximum compressor speeds. (Intermediate speed is used for laboratory testing.) The DOE test procedure defines these three outdoor temperatures and how they are evaluated. ASHRAE Standard 116–1995 (RA 2005) provides explicit equations for calculating the three outdoor temperatures for cooling and the three outdoor temperatures for heating. Referencing this standard within the DOE test procedure is worthwhile, as it may be especially helpful for those new to either test procedures or testing and rating variable-speed products.

DOE proposes adding a sentence within test procedure sections 4.1.4.2 and 4.2.4.2 to reference the applicable sections of the ASHRAE Standard that provide the exact equations, along with explanatory text and figures.

DOE seeks comments on this proposal.

17. Update Test Procedure References to the Current Standards of AHRI and ASHRAE

Since the October 2007 final rule, ARI has merged with the Gas Appliance Manufacturers Association to become AHRI. References to ARI within Appendix M need to be updated accordingly, as documented below.

IV. Regulatory Review

A. Review Under Executive Order 12866

Today's regulatory action is not a "significant regulatory action" under Executive Order (E.O.) 12866, "Regulatory Planning and Review." 58 FR 51735 (October 4, 1993). Accordingly, this action was not subject to review by the Office of Management and Budget under the Executive Order.

B. Review Under the National Environmental Policy Act of 1969

In this proposed rule, DOE proposes amendments to test procedures that may be used to implement future energy conservation standards for central air conditioners. These amendments will not affect the quality or distribution of energy usage and, therefore, will not result in any environmental impacts. 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 (NEPA) (42 U.S.C. 4321 *et seq.*) and the Department's implementing regulations at 10 CFR part 1021. More specifically, this rule is covered by the Categorical Exclusion in paragraph A5, to subpart D, 10 CFR part 1021. Accordingly, neither an environmental assessment nor an environmental impact statement is required.

C. Review Under the Regulatory Flexibility Act

The Regulatory Flexibility Act (5 U.S.C. 601 *et seq.*) requires preparation of an initial regulatory flexibility analysis (IRFA) for any rule that by law must be proposed for public comment, unless the agency certifies that the rule, if promulgated, will not have a significant economic impact on a substantial number of small entities. As required by E.O. 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 rulemaking process. 68 FR 7990. DOE has made its procedures and policies available on the Office of the General Counsel's Web site (*http://www.gc.doe.gov*).

DOE reviewed today's proposed rule, which would amend the test procedures for residential central air conditioners and heat pumps, under the provisions of the Regulatory Flexibility Act and the procedures and policies published on February 19, 2003. DOE tentatively concludes and certifies that the proposed rule, if adopted, would not result in a significant impact on a substantial number of small entities. The factual basis for this certification is set forth below.

As defined by the Small Business Administration (SBA) for the Air-Conditioning and Warm Air Heating Equipment manufacturing industry, small businesses are manufacturing enterprises with 750 employees or fewer. DOE used the small business size standards published on January 31, 1996, as amended, by the SBA to determine whether any small entities would be required to comply with the rule. 61 FR 3286, January 31, 1996, as amended at 67 FR 3045, January 23, 2002 and at 69 FR 29203, May 21, 2004; see also 65 FR 30836, 30850 (May 15, 2000), as amended at 65 FR 53533, 53545 (September 5, 2000). The size standards are codified at 13 CFR part 121. The standards are listed by North American Industry Classification System (NAICS) code and industry description and are available at *http://www.sba.gov/idc/groups/public/documents/sba_homepage/serv_sstd_tablepdf.pdf*.

Residential central air conditioner and heat pump equipment manufacturing is classified under NAICS 333415, "Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing." 70 FR 12395 (March 11, 2005). DOE reviewed AHRI's listing of residential central air conditioner and heat pump equipment manufacturer members and surveyed the industry to develop a list of domestic manufacturers. As a result of this review, DOE identified 22 manufacturers of residential central air conditioners and heat pumps, of which 15 would be considered small manufacturers with a total of approximately 3 percent of the market sales. DOE seeks comment on its estimate of the number of small entities that may be impacted by the proposed test procedure.

Potential impacts of the proposed test procedures on all manufacturers, including small businesses, come from impacts associated with the cost of proposed additional testing. DOE estimates the incremental cost of the proposed additional tests described in 10 CFR part 430, subpart B, appendix M (revised sections 3.1, 4.3.1, and 4.3.2; and proposed sections 3.13 and 4.2.7) to be an increase of $1,000 to $1,500 per unit tested. This estimate is based on private testing services quoted on behalf of DOE in the last two years for central air conditioners and heat pumps. Typical costs for running the cooling tests appear to be approximately $5,000. DOE estimated that the additional activities required by the revised test procedure would introduce a 20 to 30 percent increase in testing time resulting in approximately $1,000 to $1,500 additional cost. The largest additional cost would be associated with conducting steady-state cooling mode tests and the dry climate tests (for SEER–HD).

Because the incremental cost of running the extra tests is the same for all manufacturers, DOE believes that all manufacturers would incur comparable costs for testing of individual basic models as a result of the proposed test procedures. DOE expects that small manufacturers will incur less testing expense compared with larger manufacturers as a result of the proposed testing requirements because they have fewer basic models and thus require proportionally less testing when compared with large manufacturers that have many basic models. DOE recognizes, however, that smaller manufacturers may have less capital available over which to spread the increased costs of testing.

DOE compared the cost of the testing to the total value added by the manufacturers to determine whether the impact of the proposed test procedure amendments is significant. The value added represents the net economic value that a business creates when it takes manufacturing inputs (*e.g.* materials) and turns them into manufacturing outputs (*e.g.* manufactured goods). Specifically as defined by the U.S. Census, the value added statistic is calculated as the total value of shipments (products manufactured plus receipts for services rendered) minus the cost of materials, supplies, containers, fuel, purchased electricity, and contract work expenses.

DOE analyzed the impact on the smallest manufacturers of central air conditioners and heat pumps because these manufacturers would likely be the most vulnerable to cost increases. DOE calculated the additional testing expense as a percentage of the average value added statistic for the five individual firms in the 25 to 49 employee size category in NAICS 333415 as reported by the U.S. Census (U.S. Bureau of the Census, American Factfinder, 2002 Economic Census, Manufacturing, Industry Series, Industry Statistics by Employment Size) *http://factfinder.census.gov/servlet/EconSectorServlet?_lang=en&ds_name=EC0200A1&_SectorId=31&_ts=288639767147*>). The average annual value for manufacturers in this size range from the census data was 1.26 million dollars in 2001$, per the 2002 Economic Census, or approximately 1.52 million dollars per year in 2009$ after adjusting for inflation using the implicit price deflator for gross domestic product (U.S. Department of Commerce Bureau of Economic Analysis *http://www.bea.gov/national/nipaweb/SelectTable.asp*).

DOE also examined the average value added statistic provided by census for all manufacturers with less than 500 employees in this NAICS classification as the most representative value from the 2002 Economic Census data of the CAC manufacturers with less than 750 employees that are considered small businesses by the SBA (15 manufacturers). The average annual value added statistic for all small manufacturers with less than 500 employees was 7.88 million dollars (2009$).

Given this data, and assuming the high-end estimate of $1,500 for the additional testing costs, DOE concluded that the additional costs for testing of a single basic model product under the proposed requirements would be approximately 0.1% of annual value added for the five smallest firms, and approximately 0.02% of the average annual value added for all small CAC manufacturers (15 firms). DOE estimates that testing of basic models may not have to be updated more than once every five years, and therefore the average incremental burden of testing one basic model may be one fifth of these values when the cost is spread over several years.

DOE requires that only the highest sales volume split system combinations be lab tested (10 CFR 430.24(m)). The majority of air conditioners and heat pumps offered by a manufacturer are typically split systems that are not required to be lab tested but can be certified using an alternative rating method which does not require DOE testing of these units. DOE reviewed the available data for five of the smallest manufacturers to estimate the incremental testing cost burden for those small firms that might experience the greatest relative burden from the revised test procedures. These manufacturers had an average of 10 models requiring testing (AHRI Directory of Certified Product Performance *http://www.ahridirectory.org/ahridirectory/pages/home.aspx*), while large manufacturers will have well over a hundred such models. The additional testing cost for final certification for 10 models was estimated at $15,000. Meanwhile these certifications would be expected to last the product life, estimated to be at least five years based on the time frame established in EPCA for DOE review of CAC efficiency standards. This test burden is therefore estimated to be approximately 0.2% of the estimated five-year value added for the smallest five manufacturers. DOE believes that these costs are not significant given other, much more significant costs that the small manufacturers of central air conditioners and heat pumps incur in the course of doing business. DOE seeks comment on its estimate of the impact of the proposed test procedure amendments on small entities and its conclusion that this impact is not significant.

Accordingly, as stated above, DOE tentatively concludes and certifies that this proposed rule would not have a significant economic impact on a substantial number of small entities. Accordingly, DOE has not prepared an IRFA for this rulemaking. DOE will provide its certification and supporting statement of factual basis to the Chief Counsel for Advocacy of the SBA for review under 5 U.S.C. 605(b).

D. Review Under the Paperwork Reduction Act

This rule contains a collection-of-information requirement subject to the Paperwork Reduction Act (PRA) and which has been approved by OMB under control number 1910–1400. Public reporting burden for the collection of test information and maintenance of records on regulated residential central air conditioners and heat pumps based on the certification and reporting requirements is estimated to average 30 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. Send comments regarding this burden estimate, or any other aspect of this data collection, including suggestions for reducing the burden, to DOE (see **ADDRESSES**) and by e-mail to *Christine_Kymn@omb.eop.gov*.

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.

E. Review Under the Unfunded Mandates Reform Act of 1995

Title II of the Unfunded Mandates Reform Act of 1995 (UMRA; Pub. L. 104–4, codified at 2 U.S.C. 1501 *et seq.*) requires each Federal agency to assess the effects of Federal regulatory actions on State, local, and Tribal governments and the private sector. For proposed regulatory actions likely to result in a rule that may cause expenditures 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 estimates of 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. (This policy is also available at *http://www.gc.doe.gov.*) Today's proposed 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.

F. 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 proposed rule that may affect family well-being. Today's proposed rule would not have any impact on the autonomy or integrity of the family as an institution. Accordingly, DOE has concluded that it is unnecessary to prepare a Family Policymaking Assessment.

G. Review Under Executive Order 13132

Executive Order 13132, "Federalism," 64 FR 43255 (August 10, 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 assess carefully 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 today's proposed rule and has determined that it does not preempt State law and does 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 today's proposed rule. States can petition DOE for a waiver of such preemption to the extent, and based on criteria, set forth in EPCA. (42 U.S.C. 6297) No further action is required by E.O. 13132.

H. Review Under Executive Order 12988

With respect to the review of existing regulations and the promulgation of new regulations, section 3(a) of E.O. 12988, "Civil Justice Reform" (61 FR 4729, February 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 E.O. 12988 specifically requires that Executive agencies make every reasonable effort so 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 E.O. 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, the proposed rule meets the relevant standards of E.O. 12988.

I. Review Under the 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 information quality guidelines established by each agency pursuant to general OMB guidelines. The OMB's guidelines were published at 67 FR 8452 (February 22, 2002), and DOE's guidelines were published at 67 FR 62446 (October 7, 2002). DOE has reviewed today's proposed rule under the OMB and DOE guidelines and has concluded that it is consistent with applicable policies in those guidelines.

J. 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 the Office of Information and Regulatory Affairs (OIRA), Office of Management and Budget, a Statement of Energy Effects for any proposed 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 E.O. 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 proposed significant energy action, the agency must give a detailed statement of any adverse effects on energy supply, distribution, or use should the proposal be implemented, and of reasonable alternatives to the action and their expected benefits on energy supply, distribution, and use. Today's regulatory action would not have a significant adverse effect on the supply, distribution, or use of energy and, therefore, it is not a significant energy action. Accordingly, DOE has not prepared a Statement of Energy Effects.

K. Review Under Executive Order 12630

DOE has determined, under E.O. 12630, "Governmental Actions and Interference with Constitutionally Protected Property Rights," 53 FR 8859 (March 15, 1988), that this proposed regulation, if promulgated as a final rule, would not result in any takings that might require compensation under the Fifth Amendment to the U.S. Constitution.

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

Under section 301 of the Department of Energy Organization Act (Pub. L. 95–91), 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. When a proposed rule contains or involves use of commercial standards, the rulemaking must inform the public of the use and background of such standards. 15 U.S.C. 788 Section 32.

The proposed rule incorporates testing methods contained in the following commercial standards: (1) ASHRAE Standard 23–2005, "Methods of Testing for Rating Positive Displacement Refrigerant Compressors and Condensing Units;" (2) ASHRAE Standard 37–2005, "Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment," sections 7.3.3.1, 7.3.3.3, 7.3.4.1, 7.3.4.3, 7.4, 8.2, 8.2.5, and Table 3; (3) ASHRAE Standard 41.1–1986 (RA 2006), "Standard Method for Temperature Measurement," sections 4, 5, 6, 9, 10, and 11; (4) ASHRAE 41.6–1994 (RA 2006), "Standard Method for Measurement of Moist Air Properties," sections 5 and 8; (5) ASHRAE 41.9–2000 (RA 2006), "Calorimeter Test Methods for Mass Flow Measurements of Volatile Refrigerants;" (6) ASHRAE Standard 116–1995 (RA 2005), "Methods of Testing for Rating Seasonal Efficiency of Unitary Air Conditioners and Heat Pumps," section 10.2.4; (7) ANSI/AMCA 210–07 (ANSI/ASHRAE 51–07), "Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating," Figures 2A and 12; and (8) AHRI Standard 210/240–2008 "Standard for Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment," sections 6.1.3.2, 6.1.3.4, and 6.1.3.5 and Figures D1, D2, and D4. DOE has evaluated these standards and is unable to conclude whether they fully comply with the requirements of section 323(b) of the Federal Energy Administration Act (*i.e.,* whether they were developed in a manner that fully provides for public participation, comment, and review).

As required by section 32(c) of the Federal Energy Administration Act of 1974 as amended, DOE will consult with the Attorney General and the Chairman of the FTC before prescribing a final rule about the impact on competition of using the methods contained in these standards.

V. Public Participation

A. Attendance at Public Meeting

The time and date of the public meeting are listed in the **DATES** section at the beginning of this NOPR. The public meeting will be held at the U.S. Department of Energy, Forrestal Building, Room 1E–245. To attend the public meeting, please notify Ms. Brenda Edwards at (202) 586–2945. Foreign nationals visiting DOE Headquarters are subject to advance security screening procedures requiring a 30-day advance notice. Any foreign national wishing to participate in the meeting should advise DOE of this fact as soon as possible by contacting Ms. Brenda Edwards to initiate the necessary procedures.

B. Procedure for Submitting Requests To Speak

Any person who has an interest in today's notice or who is a representative of a group or class of persons that has an interest in these issues may request an opportunity to make an oral presentation. Such persons may hand-deliver requests to speak, along with a computer diskette or CD in WordPerfect, Microsoft Word, PDF, or text (ASCII) file format to the address shown in the **ADDRESSES** section at the beginning of this NOPR between 9 a.m. and 4 p.m. Monday through Friday, except Federal holidays. Requests may also be sent by mail or e-mail to *Brenda.Edwards@ee.doe.gov.*

Persons requesting to speak should briefly describe the nature of their interest in this rulemaking, provide a telephone number for contact, and submit an advance copy of their statements at least one week before the public meeting. At its discretion, DOE may permit any person who cannot supply an advance copy of their statement to participate, if that person has made advance alternative arrangements with the Building Technologies Program. The request to give an oral presentation should ask for such alternative arrangements.

C. Conduct of Public Meeting

DOE will designate a DOE official to preside at the public meeting and may also employ a professional facilitator to aid discussion. The meeting will not be a judicial or evidentiary-type public hearing, but DOE will conduct it in accordance with section 336 of EPCA (42 U.S.C. 6306). A court reporter will record the proceedings and prepare a transcript. DOE reserves the right to schedule the order of presentations and to establish the procedures governing the conduct of the public meeting. After the public meeting, interested parties may submit further comments on the proceedings as well as on any aspect of the rulemaking until the end of the comment period.

The public meeting will be conducted in an informal conference style. DOE will present summaries of comments received before the public meeting, allow time for presentations by participants, and encourage all interested parties to share their views on issues affecting this rulemaking. Each participant will be allowed to make a prepared general statement (within DOE-determined time limits) prior to the discussion of specific topics. DOE will permit other participants to comment briefly on any general statements.

At the end of all prepared statements on a topic, DOE will permit participants to clarify their statements briefly and comment on statements made by others. Participants should be prepared to answer questions from DOE and other participants concerning these issues. DOE representatives may also ask questions of participants concerning other matters relevant to this rulemaking. The official conducting the public meeting will accept additional comments or questions from those attending, as time permits. The presiding official will announce any further procedural rules or modification of the above procedures that may be needed for the proper conduct of the public meeting.

DOE will make the entire record of this proposed rulemaking, including the transcript from the public meeting, available for inspection at the U.S. Department of Energy, 6th Floor, 950 L'Enfant Plaza, SW., Washington, DC 20024, (202) 586–2945, between 9 a.m. and 4 p.m. Monday through Friday, except Federal holidays. Any person may purchase a copy of the transcript from the transcribing reporter.

D. Submission of Comments

DOE will accept comments, data, and other information regarding the proposed rule before or after the public meeting, but no later than the date provided at the beginning of this NOPR. Please submit comments, data, and other information electronically to *RCAC–HP–2009–TP–0004@ee.doe.gov.* Submit electronic comments in WordPerfect, Microsoft Word, PDF, or text (ASCII) file format and avoid the use of special characters or any form of encryption. Comments in electronic format should be identified by the docket number EERE–2009–BT–TP–0004 and/or RIN number 1904–AB94 and wherever possible carry the electronic signature of the author. No telefacsimiles (faxes) will be accepted.

According to 10 CFR 1004.11, any person submitting information that he or she believes to be confidential and exempt by law from public disclosure should submit two copies: one copy of the document including all the information believed to be confidential and one copy of the document with the information believed to be confidential deleted. DOE will make its own determination as to the confidential status of the information and treat it according to its determination.

Factors of interest to DOE when evaluating requests to treat submitted information as confidential include (1) a description of the items; (2) whether and why such items are customarily treated as confidential within the industry; (3) whether the information is generally known by or available from other sources; (4) whether the information has previously been made available to others without obligation concerning its confidentiality; (5) an explanation of the competitive injury to the submitting person which would result from public disclosure; (6) a date upon which such information might lose its confidential nature due to the passage of time; and (7) why disclosure of the information would be contrary to the public interest.

E. Issues on Which DOE Seeks Comment

Although comments are welcome on all aspects of this rulemaking, DOE is particularly interested in receiving comments on following issues:

1. Specific examples, including laboratory data, that address a stakeholder's comment on the failure of the test procedure to capture the performance characteristics of an air conditioner or heat pump that uses "new inverter-driven compressor technology."

2. Do the proposed definitions for off mode air conditioners and off mode heat pumps clarify the meaning of off mode power?

3. What is the impact of proposed lower external static pressure levels and the proposed language for making sure that these levels are limited to testing ducted multi-split systems?

4. What is the impact of the change to the air volume rate setup tolerance? Information on real cases where the indoor unit was adversely affected by the current 5 percent tolerance would be especially helpful.

5. What is the proposed magnitude of the test operating tolerance for the external static pressure relative to its ability to provide an indication of steady, repeatable performance?

6. Do manufacturers foresee obtaining a SEER–HD rating for all of their products? If not, what is an approximate percentage of systems that will likely have a SEER–HD rating?

7. Do manufacturers foresee specifying installation instructions that would result in systems being configured differently for the hot-dry tests than for the normal SEER tests? If so, please provide examples of the likely differences in the setups.

8. Will the proposed hot-dry indoor test condition of 80 °F db/64 °F wb create less stable or less repeatable testing because the indoor coil will likely be only partially wetted? DOE is particularly interested in receiving laboratory data that quantify the relative differences in performance from testing conducted at 80 °F db/64 °F wb versus 80 °F db/67 °F wb.

9. Is it necessary for DOE to develop and incorporate a regional hot-dry SEER rating within the test procedure?

10. Are the proposed changes to cover systems similar to Hallowell cold-climate heat pumps adequate to address testing concerns for these products?

11. Are modifications needed, within the test procedure, for the laboratory set-up of through-the-wall air conditioners and heat pumps?

VI. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of today's NOPR.

List of Subjects in 10 CFR Part 430

Administrative practice and procedure, Energy conservation test procedures, Household appliances, Incorporation by reference.

Issued in Washington, DC on February 12, 2010.

Cathy Zoi,

Assistant Secretary, Energy Efficiency and Renewable Energy.

For the reasons set forth in the preamble, DOE proposes to amend part 430 of chapter II of Title 10, Code of Federal Regulations, to read as follows:

PART 430—ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS

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

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

2. Section 430.2 is amended by revising the definition of "tested combination" to read as follows:

§ 430.2 Definitions.

* * * * *

Tested combination means a multi-split system with multiple indoor coils having the following features:

(1) The basic model of a system used as a tested combination shall consist of one outdoor unit with one or more compressors matched with between two and five indoor units; for the multi-split system, each indoor unit shall be designed for individual operation.

(2) The indoor units shall:

(i) Collectively, have a nominal cooling capacity greater than or equal to 95 percent and less than or equal to 105 percent of the nominal cooling capacity of the outdoor unit;

(ii) Represent the highest sales volume model family [**Note:** another indoor model family may be used if five indoor units from the highest sales volume model family do not provide sufficient capacity to meet the 95 percent threshold level specified in paragraph (2)(i) of this section];

(iii) Individually not have a nominal cooling capacity greater than 50 percent of the nominal cooling capacity of the outdoor unit, unless the nominal cooling capacity of the outdoor unit is 24,000 Btu/h or less;

(iv) Operate at fan speeds consistent with manufacturer's specifications; and

(v) All be subject to the same minimum external static pressure requirement (*i.e.,* 0 in wc for non-ducted; see entries in the column labeled "Short Duct Systems" of Table 2 in Appendix M to subpart B of this part for ducted indoor units) while able to produce the same static pressure at the exit of each outlet plenum when connected in a manifold configuration as per section 2.4.1 of Appendix M.

* * * * *

3. Section 430.3 is amended:

a. By removing, in paragraph (b)(1), "210/240–2006" and adding in its place "210/240–2008."

b. By removing, in paragraph (e)(3), "(Reaffirmed 2001)" and adding in its place "(Reaffirmed 2006)."

c. By revising paragraph (e)(7).

The revisions read as follows:

§ 430.3 Materials incorporated by reference.

* * * * *

(e) * * *

(7) ANSI/AMCA 210–07 (ANSI/ASHRAE 51–07), Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating approved August 17, 2007, IBR approved for Appendix M to Subpart B.

* * * * *

Appendix M [Amended]

4. Appendix M to subpart B of part 430:

(a) In section 1, Definitions by:

1. Removing, in section 1.2, "ARI means Air-Conditioning and Refrigeration Institute" and adding in its place "AHRI means Air-Conditioning, Heating and Refrigeration Institute."

2. Removing, in section 1.3, "ARI" and adding in its place "AHRI" in two locations.

3. Removing, in section 1.7, "RA 01" and adding in its place "RA 06;" and removing "2001" and adding in its place "2006."

4. Removing, in section 1.9, "RA 01" and adding in its place "RA 06;" and by removing "2001" and adding in its place "2006."

5. Adding, in section 1.10, "(RA 06)" after "41.6–00" and adding "and reaffirmed in 2006" after "2000."

6. Removing, in section 1.11, "51–99" and adding in its place "51–07;" and by removing "1999" and adding in its place "2007" in two locations.

7. Redesignating sections 1.32 through 1.33 as 1.33 through 1.34 respectively; 1.34 through 1.43 as 1.36 through 1.45 respectively; and 1.44 through 1.47 as 1.48 through 1.51 respectively.

8. Adding new sections 1.32, 1.35, 1.46, and 1.47.

(b) In section 2, Testing Conditions, by:

1. Removing, in section 2.1, "430.22" and adding in its place "430.3."

2. Revising, in section 2.2 paragraph a., and adding new paragraphs d, e, and f.

3. Revising section 2.2.1.

4. Revising section 2.2.3, and adding new sections 2.2.3.1 and 2.2.3.2.

5. Revising section 2.2.5 and section 2.4.1 paragraph b., first sentence.

6. Removing, in section 2.4.1d, "430.22" and adding in its place "430.3" in two locations.

7. Removing, in section 2.4.2, "430.22" and adding in its place "430.3" in two locations.

8. Removing, in section 2.5, "430.22" and adding in its place "430.3."

9. Removing, in section 2.5.3, "430.22" and adding in its place "430.3" in two locations. and in the second sentence by removing "–99" and adding in its place "–07" in two locations.

10. Removing, in section 2.5.4.2, "430.22" and adding in its place "430.3" in two locations and in the last sentence by removing "RA 01" and adding in its place "RA 06."

11. Revising section 2.5.5a.

12. Removing, in section 2.5.6, third, fourth, and fifth sentences "RA 01" and adding in its place "RA 06," and by removing "430.22" and adding "430.3" in its place in the three locations.

13. Removing, in section 2.6, paragraph a, "–99" and adding in its place "–07" in two locations; and by removing "430.22" and adding in its place "430.3" in three locations.

14. Removing, in section 2.6, paragraph b. "ARI Standard" and adding in its place "AHRI Standard" in one location; and by removing "430.22" and adding in its place "430.3" in three locations.

15. Removing, in section 2.7, "ARI Standard" and adding in its place "AHRI Standard," and by removing "430.22" and adding in its place "430.3."

16. Removing, in section 2.10.2, "430.22" and adding in its place "430.3" in two locations.

17. Removing, in section 2.10.3, "430.22" and adding in its place "430.3" in two locations.

18. Removing, in section 2.11, paragraph a. "430.22" and adding in its place "430.3."

19. Removing, in section 2.11, paragraph b. "RA 01" and adding in its place "RA 06," and by removing "430.22" and adding in its place "430.3."

20. Removing, in section 2.11, paragraph c. "RA 01" and adding in its place "RA 06," and by removing "430.22" and adding in its place "430.3."

21. Removing, in section 2.13, "430.22" and adding in its place "430.3."

(c) In section 3, Testing Procedures, by:

1. Adding three new sentences at the end of section 3.1.

2. Removing, in section 3.1.1, "430.22" and adding in its place "430.3."

3. Removing, in section 3.1.3, "ARI Standard" and adding in its place "AHRI Standard," and by removing "430.22" and adding in its place "430.3."

4. Removing "95" and adding in its place "90" in section 3.1.4.1.1, paragraph a.4b.

5. Revising the first sentence of paragraph a.6 in section 3.1.4.1.1.

6. Revising Table 2 in section 3.1.4.1.1.

7. Adding new paragraphs d. and e. in section 3.1.4.1.1.

8. Adding a new paragraph e. in section 3.1.4.2 .

9. Revising in section 3.1.4.4.2 paragraph c. and adding new paragraphs d. and e.

10. Removing, in section 3.1.4.4.3, paragraph 4b, "95" and adding in its place "90" and revising the first sentence of paragraph a.6.

11. Adding, in section 3.1.4.5, a new paragraph f.

12. Removing, in section 3.1.5, "430.22" and adding in its place "430.3."

13. Removing, in section 3.1.6, "430.22" and adding in its place "430.3."

14. Adding, in section 3.2.1 following Table 3 footnotes, undesignated text, a new Table 3a and additional undesignated text. .

15. Revising sections 3.2.2, 3.2.2.1, and 3.2.2.2.

16. Revising section 3.2.3 introductory sentence and paragraph c., and adding a new paragraph e.

17. Adding a new paragraph d. in section 3.2.4, and adding new sections 3.2.5 and 3.2.6.

18. Revising section 3.3, paragraphs b. and c., and redesignating the second paragraph d. as paragraph e.

19. Removing "0.05" in section 3.3 Table 7 column "Test Operating Tolerance," and adding in its place "0.12."

20. Removing "2.0" in section 3.3 Table 7 row "Nozzle pressure drop, % of rdg", and adding in its place "8.0."

21. Removing "See Definition 1.41" in section 3.3 Table 7 footnote (1), and adding in its place "See Definition 1.43."

22. Removing "See Definition 1.40" in section 3.3 Table 7 footnote (2), and adding in its place "See Definition 1.42."

23. Redesignating paragraph b. as c. in section 3.4, and adding a new paragraph b.

24. Removing "0.05" in section 3.3 Table 8 column "Test Operating Tolerance," and adding in its place "0.12."

25. Removing "2.0" in section 3.3 Table 8 row "Airflow nozzle pressure difference or velocity pressure[3], % of reading", and adding in its place "8.0."

26. Removing "See Definition 1.41" in section 3.3 Table 8 footnote (1), and adding in its place "See Definition 1.43."

27. Removing "See Definition 1.40" in section 3.3 Table 8 footnote (2), and adding in its place "See Definition 1.42."

28. Revising, in section 3.5, the text following equation (3.5–1) in paragraph i.

29. Revising, in section 3.6.2, the first sentence of the first paragraph, Table 10 heading, and adding text following Table 10 footnotes.

30. Adding in section 3.6.3 paragraph a., 2 sentences at the end of the paragraph.

31. Removing, in section 3.6.4, paragraph a last sentence and two unnumbered equations, revising paragraphs b and c, and adding new paragraph d.

32. Adding new sections 3.6.6 and 3.6.7.

33. Revising, in section 3.7, paragraph a., the first sentence of paragraphs b. and d., and adding a new paragraph e.

34. Revising the introductory sentence in section 3.8 and paragraph a.

35. Removing, in section 3.8.1, "430.22" and adding in its place "430.3", and revising Table 14.

36. Adding "$H2_3$" between "$H2$" and "$H2_2$." in section 3.9 introductory sentence, revising the last sentence of paragraph e, and by removing "430.22" and adding in its place "430.3" in paragraph f.

37. Removing, in section 3.9c. "(see Definition 1.42)" from the third sentence and adding in its place "(see Definition 1.44)."

38. Removing "0.05" in section 3.9f Table 15 column "Test Operating Tolerance," and adding in its place "0.12."

39. Removing "2.0" in section 3.9f Table 15 row "External resistance to

airflow, inches of water", and adding in its place "8.0."

40. Removing "See Definition 1.41" in section 3.9f. Table 15 footnote (1), and adding in its place "See Definition 1.43."

41. Removing "See Definition 1.40" in section 3.9f. Table 15 footnote (2), and adding in its place "See Definition 1.42."

42. Removing, in section 3.9.1a., "430.22" and adding in its place "430.3."

43. Revising section 3.9.2 paragraph a., section 3.10, section 3.11.1.1 paragraph a., and 3.11.1.3 paragraph a.

44. Removing, in section 3.11.1.3, paragraph b., "430.22" and adding in its place "430.3" in three locations.

45. Revising, in section 3.11.2, paragraph a.

46. Removing, in section 3.11.2, paragraph b., "430.22" and adding in its place "430.3."

47. Removing, in section 3.11.3, "430.22" and adding in its place "430.3."

48. Adding new sections 3.13, 3.13.1, 3.13.2, 3.13.2.1, 3.13.2.2, 3.13.3, 3.13.3.1, 3.13.3.2, 3.13.3.3, 3.13.3.4, 3.13.3.5, 3.13.4, 3.13.4.1, 3.13.4.2, 3.13.4.3, 3.13.4.4.1, 3.13.4.4.2, 3.13.4.4.3, 3.13.4.4.4, 3.13.4.4.5, 3.13.4.4.6, 3.13.4.4.7, 3.13.4.4.8, 3.13.4.5, 3.13.4.6, 3.13.5, 3.13.5.1, 3.13.5.2, 3.13.5.33.13.5.4, 3.13.5.4.1, 3.13.5.4.2, 3.13.5.43, 3.13.5.4.4, 3.13.5.4.5, 3.13.5.5, 3.13.5.5.1, 3.13.5.5.2, 3.13.5.5.3, 3.13.5.6, and 3.13.5.7.

(d) In section 4, Calculations of Seasonal Performance Descriptors, by:

1. Revising, in section 4.1, the introductory text before equation (4.1–2), and the text following equation (4.1–2).

2. Revising section 4.1.1.

3. Adding, in section 4.1.3, at the end of the first sentence ", including triple-capacity northern heat pumps".

4. Revising, in section 4.1.4.2, the definitions of T_1 and T_2 following equation for calculating *B*.

5. Adding new sections 4.1.5, 4.1.5.1, 4.1.5.2, 4.1.6, 4.1.6.1, 4.1.6.2, 4.1.6.2.1, 4.1.6.2.2, 4.1.6.3, and 4.1.6.4.

6. Adding, in section 4.2, item 4 in the numbered list following the equation for DHR_{max}, and revising the sentence preceding Table 18.

7. Revising, in section 4.2.4.2, the definition of T_4 following the equation for *A*.

8. Adding new sections 4.2.6, 4.2.6.1, 4.2.6.2, 4.2.6.3, 4.2.6.4, 4.2.6.5, 4.2.6.6, 4.2.6.7, 4.2.6.8, 4.2.7, 4.2.7.1, 4.2.7.2, 4.2.8, 4.2.8.1, 4.2.8.1.1, 4.2.8.1.2, 4.2.8.1.3, 4.2.8.2, 4.2.8.2.1, 4.2.8.2.2, 4.2.8.3, 4.2.8.3.1, and 4.2.8.3.2.

9. Revising, in section 4.3.1, the equation which immediately follows the introductory text, and adding new text at the end of the last sentence.

10. Revising sections 4.3.2 and 4.4, and adding a new section 4.5.

The additions and 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

* * * * *

1. Definitions

* * * * *

1.32 Off mode means:

(1) For air conditioners, all times during the non-cooling season of an air conditioner. This mode includes the "shoulder seasons" between the cooling and heating seasons when the unit provides no cooling to the building and the entire heating season, when the unit is idle. The air conditioner is assumed to be connected to its main power source at all times during the off mode; and

(2) For heat pumps, all times during the non-cooling and non-heating seasons of a heat pump. This mode includes the "shoulder seasons" between the cooling and heating seasons when the unit provides neither heating nor cooling to the building. The heat pump is assumed to be connected to its main power source at all times during the off mode.

* * * * *

1.35 Seasonal Energy Efficiency Ratio—Hot Dry (SEER–HD) means the total heat removed from the conditioned space during the annual cooling season for the designated hot-dry climatic region, expressed in Btus, divided by the total electrical energy consumed by the air conditioner or heat pump during the same season, expressed in watt-hours. Calculate SEER–HD as specified in section 4.1.6 of this Appendix.

* * * * *

1.46 Triple-capacity (or triple-stage) compressor means an air conditioner or heat pump with one of the following:

(1) A three-speed compressor,

(2) Two compressors where one is a two-capacity compressor—as defined in section 1.45—and one is a single-speed compressor where the two-capacity compressor operates at both low and high capacity with the single-speed compressor turned off and then operates exclusively at high capacity when the single speed compressor is turned on, or

(3) A compressor capable of cylinder or scroll unloading to provide a total of three levels of compressor capacity.

For such systems, low capacity means:

(1) Operating at the low compressor speed,

(2) Operating the two-capacity compressor at low capacity with the single-speed compressor turned off, and

(3) Operating with the compressor fully unloaded.

For such systems, high capacity means:

(1) Operating at the high compressor speed,

(2) Operating the two-capacity compressor at high capacity with the single-speed compressor turned off, and

(3) Operating with the compressor partially unloaded.

For such systems, booster capacity means:

(1) Operating at the booster compressor speed,

(2) Operating the two-capacity compressor at high capacity with the single-speed compressor turned on, and

(3) Operating the compressor fully loaded.

1.47 Triple-capacity northern heat pump means 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 called the booster capacity stage. Of the three heating mode stages, the booster capacity stage offers the highest heating capacity output for a given set of ambient operating conditions.

* * * * *

2. Testing Conditions

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2.2 Test unit installation requirements.

a. Except as noted in this appendix, install the unit according to section 8.2 of ASHRAE Standard 37–2005 (incorporated by reference, see § 430.3) where references to "manufacturer's installation instructions" shall mean the installation instructions that come packaged with the unit. If the particular model of air conditioner or heat pump is not yet in production, the installation instructions used must be written and saved until they are confirmed as being consistent with the instructions that are thereafter packaged with the full production model. With respect to interconnecting tubing used when testing split systems, follow the requirements in section 6.1.3.5 of AHRI Standard 210/240–2008 (incorporated by reference, see § 430.3). When testing triple-split systems (see Definition 1.48), use the tubing length specified in section 6.1.3.5 of AHRI Standard 210/240–2008 (incorporated by reference, see § 430.3) to connect the outdoor coil, indoor compressor section, and indoor coil while still meeting the requirement of exposing 10 feet of the tubing to outside conditions. When testing split systems having multiple indoor coils, connect each indoor fan-coil to the outdoor unit using 25 feet of tubing or manufacturer-furnished tubing, whichever is longer. If needed to make a secondary measurement of capacity, install refrigerant pressure measuring instruments as described in section 8.2.5 of ASHRAE Standard 37–2005 (incorporated by reference, see § 430.3). Refer to section 2.10 of this Appendix to learn which secondary methods require refrigerant pressure measurements. At a minimum, insulate the low-pressure line(s) of a split system with insulation having an inside diameter that matches the refrigerant tubing and a nominal thickness of 0.5 inch.

* * * * *

d. When testing coil-only air conditioners and heat pumps, install a nominal 24–V transformer to power the low-voltage components of the system. The transformer must have a load rating of either 40 or 50 V-amps and must be designed to operate with a primary input that is 230 V, single phase, 60 Hz. The transformer may be powered from the same source as supplies powered to the outdoor unit or powered by a separate 230–V source. The power consumption of the added low-voltage transformer must be measured as part of the total system power consumption during all tests.

e. If the manufacturer's installation instructions include steps that apply to a hot-dry climate different from the steps that apply for a mixed climate, apply these differing installation steps in advance of conducting the laboratory tests that apply for the respective climates.

f. For third-party testing conducted to meet DOE certification requirements, the working relationship between the test laboratory and the manufacturer shall not be restricted as long as the test unit installation and laboratory testing are conducted in complete compliance with the procedures specified in this appendix.

* * * * *

2.2.1 Defrost control settings. Set heat pump defrost controls at the normal settings which most typify those encountered in generalized climactic region IV. (Refer to Figure 2 and Table 17 of section 4.2 for information on region IV.) For heat pumps that use a time-adaptive defrost control system (see Definition 1.44), the manufacturer must specify the frosting interval to be used during the Frost Accumulation tests and provide the procedure for manually initiating the defrost at the specified time. To ease testing of any unit, the manufacturer should provide information and any necessary hardware to manually initiate a defrost cycle.

* * * * *

2.2.3 Special requirements for systems that would normally operate using two or more indoor thermostats, including multi-split air conditioners and heat pumps, systems composed of multiple mini-split units (outdoor units located side-by-side), and ducted systems using a single indoor section containing multiple blowers. Because these types of systems will have more than one indoor fan and possibly multiple outdoor fans and compressor systems, references in this test procedure to a single indoor fan, outdoor fan, and compressor mean all indoor fans, all outdoor fans, and all compressor systems turned on during the test.

2.2.3.1 Additional requirements for multi-split air conditioners and heat pumps and systems composed of multiple mini-split units. For any test where the system is operated at part load (*i.e.,* one or more compressors "off," operating at the intermediate or minimum compressor speed or at low compressor capacity), the manufacturer shall designate the particular indoor coils that are turned off during the test. For variable-speed systems, the manufacturer must designate at least one indoor unit that is turned off for all tests conducted at minimum compressor speed. For all other part-load tests, the manufacturer shall choose to turn off zero, one, two, or more indoor units. The chosen configuration shall remain unchanged for all tests conducted at the same compressor speed/capacity. For any indoor coil turned off during a test, take steps to cease forced airflow through this indoor coil and block its outlet duct.

2.2.3.2 Additional requirements for ducted systems with a single indoor section containing multiple blowers where the blowers are designed to cycle on and off independently of one another and are not controlled such that all blowers are modulated to always operate at the same air volume rate or speed. This Appendix covers systems with a single-speed compressor or systems offering two fixed stages of compressor capacity (*e.g.,* a two-speed compressor, two single-speed compressors). For any test where the system is operated at its lowest capacity—*i.e.,* the lowest total air volume rate allowed when operating the single-speed compressor or when operating at low compressor capacity—blowers accounting for at least one-third of the full-load air volume rate must be turned off unless prevented by the controls of the unit. In such cases, turn off as many blowers as permitted by the unit's controls. Where more than one option exists for meeting this "off" blower requirement, the manufacturer shall choose which blower(s) are turned off. The chosen configuration shall remain unchanged for all tests conducted at the same lowest capacity configuration. For any indoor coil turned off during a test, take steps to cease forced airflow through any outlet duct connected to an "off" blower.

* * * * *

2.2.5 Additional refrigerant charging requirements. The test unit shall be charged in accordance with both the following instructions and the manufacturer's installation instructions described in section 2.2.

If the manufacturer's installation instructions specify as part of a standard installation and/or commissioning practice to either alter or check the refrigerant charge while the unit is operating, the testing laboratory shall do so in conjunction with establishing the cooling full-load air volume rate (see section 3.1.4.1) and operating entering air conditions specified in the *A* (or A_2) Test. For heating-only heat pumps, this refrigerant charge evaluation and potential adjustment step shall be done in conjunction with establishing the heating full-load air volume rate (see section 3.1.4.4) and operating entering air conditions specified for the *H1* (or $H1_2$) Test. For the entering db and wb air temperature conditions noted above, determine from the manufacturer's installation instructions the target value(s) for the system's measurable operating parameter(s)—*e.g.,* suction superheat temperature, liquid line subcooling temperature, refrigerant suction pressure, etc. If the manufacturer's installation instructions list a range for a particular parameter, use the midpoint value as the target value. The testing laboratory shall add or subtract the correct amount of refrigerant to achieve as closely as possible the target value(s).

If a unit requires charging but the manufacturer's installation instructions do not specify a charging procedure, then evacuate the unit and add the nameplate refrigerant charge. Where the manufacturer's installation instructions contain two or more sets of refrigerant charging criteria, use the set most appropriate for a normal field installation.

Once the test unit has been properly charged with refrigerant, all cooling mode and, if a heat pump, all heating mode-laboratory tests shall be conducted, and the testing laboratory shall not add or subtract any more refrigerant to or from the test unit.

* * * * *

2.4.1 * * *

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b. For systems having multiple indoor coils or multiple indoor blowers within a single indoor section, attach a plenum to each indoor coil or blower outlet. * * *

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2.5.5 * * *

a. Measure dry bulb temperatures as specified in sections 4, 5, 6.1–6.10, 9, 10, and 11 of ASHRAE Standard 41.1–86 (RA 06) (incorporated by reference, see § 430.3). The transient testing requirements cited in section 4.3 of ASHRAE Standard 41.1–86 (RA 06) apply if conducting a cyclic or frost accumulation test. If the temperature sensors used to measure the indoor-side dry bulb temperature difference are different for steady-state tests and cyclic tests; in addition, the two sets of instrumentation must be correlated as described in section 3.4 for cooling mode tests and section 3.8 for heating mode tests.

* * * * *

3. Testing Procedures

3.1 * * * Use the testing procedures in this section to collect the data used for calculating (1) the seasonal performance ratings for air conditioners and heat pumps during the cooling season; (2) the seasonal performance ratings for heat pumps during the heating season; and (3) the seasonal off-mode power consumption rating(s) for air conditioners and heat pumps during the parts of the year not captured by the cooling and heating seasonal performance descriptors. For air conditioners, the non-cooling seasons are the heating season and the shoulder seasons that separate the cooling and heating seasons. For heat pumps, the collective shoulder season is the only time of the year where a seasonal off-mode power consumption rating applies.

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3.1.4.1.1 * * *

a. * * *

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6. If the conditions of step 4b occur first, make an incremental change to the set-up of the indoor fan that increases air volume rate while maintaining the same operating features (*e.g.,* next highest fan motor pin setting that maintains the same fan delay interval, next highest fan motor speed) and repeat the evaluation process beginning with the above step 1. * * *

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TABLE 2—MINIMUM EXTERNAL STATIC PRESSURE FOR DUCTED SYSTEMS TESTED WITH AN INDOOR FAN INSTALLED

Rated Cooling [1] or Heating [2] Capacity *Btu/h*	Minimum external resistance [3] *in wc*		
	SDHV [4,5]	Multi-split systems	All other systems
≤28,800	1.10	0.03	0.10
29,000–42,500	1.15	0.05	0.15
≥43,000	1.20	0.07	0.20

[1] For air conditioners and heat pumps, the value cited by the manufacturer in published literature for the unit's capacity when operated at the *A* or A_2 Test conditions.
[2] For heating-only heat pumps, the value the manufacturer cites in published literature for the unit's capacity when operated at the *H1* or $H1_2$ Test conditions.
[3] For ducted units tested without an air filter installed, increase the applicable tabular value by 0.08 inch of water.
[4] See Definition 1.37 to determine if the equipment qualifies as a small-duct, high-velocity system.
[5] If a closed-loop, air-enthalpy test apparatus is used on the indoor side, limit the resistance to airflow on the inlet side of the indoor blower coil to a maximum value of 0.1 inch of water. Impose the balance of the airflow resistance on the outlet side of the indoor blower.

d. For systems having multiple blower coil indoor units, conduct the above section 3.1.4.1.1 setup steps for each indoor unit separately. If two or more indoor units are connected to a common duct as per section 2.4.1, either turn off the other indoor units connected to the same common duct or temporarily divert their air volume to the test room when confirming or adjusting the setup configuration of individual indoor units. If the indoor units are all the same size or model, the target air volume rate for each indoor unit equals the full-load air volume rate divided by the number of indoor units. If different size indoor units are used, the manufacturer must allocate the system's full-load air volume rate assigned to each indoor unit during this set-up phase.

e. For ducted systems having multiple indoor blowers within a single indoor section, obtain the full-load air volume rate with all blowers operating unless prevented by the controls of the unit. In such cases, turn on the maximum number of blowers permitted by the unit's controls. Where more than one option exists for meeting this "on" blower requirement, the manufacturer shall choose which blower(s) are turned on. Conduct section 3.1.4.1.1 setup steps for each blower separately. If two or more indoor blowers are connected to a common duct as per section 2.4.1, either turn off the other indoor blowers connected to the same common duct or temporarily divert their air volume to the test room when confirming or adjusting the setup configuration of individual blowers. If the indoor blowers are all the same size or model, the target air volume rate for each blower plenum equals the full-load air volume rate divided by the number of "on" blowers. If different size blowers are used within the indoor section, the manufacturer must allocate the system's full-load air volume rate assigned to each "on" blower.

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3.1.4.2 * * *

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e. For ducted systems having multiple indoor blowers within a single indoor section, operate the indoor blowers such that the lowest air volume rate allowed by the unit's controls is obtained when operating the lone single-speed compressor or when operating at low compressor capacity while meeting the requirements of section 2.2.3.2 for the minimum number of blowers that must be turned off. The air volume rate for each "on" blower must then be determined using the first section 3.1.4.2 equation if the blower operates at fixed fan speeds or must be specified by the manufacturer if the blower is designed to provide a constant air volume rate. The sum of the individual "on" blowers' air volume rates is the cooling minimum air volume rate for the system.

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3.1.4.4.2 * * *

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c. When testing ducted, two-capacity northern heat pumps (see Definition 1.50), use the appropriate approach of the above two cases for units that are installed with an indoor fan installed. For coil-only (fanless) northern heat pumps, the Heating Full-Load Air Volume Rate is the lesser of the rate specified by the manufacturer or 133 percent of the Cooling Full-Load Air Volume Rate. For this latter case, obtain the Heating Full-Load Air Volume Rate regardless of the pressure drop across the indoor coil assembly.

d. For systems having multiple indoor blower coil units where individual blowers regulate the speed (as opposed to the cfm) of the indoor fan, use the first section 3.1.4.4.2 equation for each blower coil individually. Sum the individual blower coil air volume rates to obtain the heating full-load air volume rate for the system.

e. For ducted systems having multiple indoor blowers within a single indoor section, obtain the heating full-load air volume rate using the same "on" blowers as used for the cooling full-load air volume rate. For systems where individual blowers regulate the speed (as opposed to the cfm) of the indoor fan, use the first section 3.1.4.4.2 equation for each blower individually. Sum the individual blower air volume rates to obtain the heating full-load air volume rate for the system.

* * * * *

3.1.4.4.3 * * *

a. * * *

6. If the conditions of step 4b occur first, make an incremental change to the set-up of the indoor fan that increases air volume rate while maintaining the same operating features (*e.g.,* next highest fan motor pin setting that maintains the same fan delay interval, next highest fan motor speed) and repeat the evaluation process beginning with the above step 1. * * *

* * * * *

3.1.4.5 * * *

* * * * *

f. For ducted systems with multiple indoor blowers within a single indoor section, obtain the heating minimum air volume rate using the same "on" blowers as used for the cooling minimum air volume rate. For systems where individual blowers regulate the speed (as opposed to the cfm) of the indoor fan, use the first section 3.1.4.5 equation for each blower individually. Sum the individual blower air volume rates to obtain the heating minimum air volume rate for the system.

* * * * *

3.2.1 * * *

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In order to evaluate the cooling season performance of the test unit when applied in a hot-dry climate, conduct one steady-state test, the *AD* Test. Conducting an additional steady-state, dry climate test (the *BD* Test) is optional. Test conditions for the two dry climate tests are specified in Table 3A.

TABLE 3a—DRY CLIMATE COOLING MODE TEST CONDITIONS FOR UNITS HAVING A SINGLE-SPEED COMPRESSOR AND A FIXED-SPEED INDOOR FAN, A CONSTANT AIR VOLUME RATE INDOOR FAN, OR NO INDOOR FAN

Test description	Air entering indoor unit temperature °F		Air entering outdoor unit temperature °F		Dry climate air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb [1]	
AD Test—required (steady)	80	64	95	75	Dry-Climate Full-Load.
BD Test—optional (steady)	80	64	82	65	Dry-Climate Full-Load.

[1] The specified test condition only applies if the unit rejects condensate to the outdoor coil.

As an alternative to conducting the optional *BD* Test, use the following equations to approximate the capacity and electrical power of the test unit at the *BD* test conditions:

$$\dot{Q}_{HD}(82) = \dot{Q}_{HD}(95) + MD_Q \times (82 - 95)$$

$$\dot{E}_{HD}(82) = \dot{E}_{HD}(95) + MD_E \times (82 - 95)$$

Where:

$$MD_Q = 0.95 \times \left[\frac{\dot{Q}_c(95) - \dot{Q}_c(82)}{95 - 82}\right] \times \left[\frac{\dot{Q}_{HD}(95)}{\dot{Q}_c(95)}\right]$$

$$MD_E = 0.95 \times \left[\frac{\dot{E}_c(95) - \dot{E}_c(82)}{95 - 82}\right] \times \left[\frac{\dot{E}_{HD}(95)}{\dot{E}_c(95)}\right]$$

In evaluating the above equations, determine the quantities $\dot{Q}_{HD}$ (95) and $\dot{E}_{HD}$ (95) from the *AD* Test. Determine the quantities $\dot{Q}_c$ (82) and $\dot{E}_c$ (82) from the *B* Test and the quantities $\dot{Q}_c$ (95) and $\dot{E}_c$ (95) from the *A* Test. Evaluate all six quantities according to section 3.3. If the manufacturer conducts the *BD* Test, the option of using the above default equations is not forfeited. Use the paired values of $\dot{Q}_{HD}$ (82) and $\dot{E}_{HD}$ (82) derived from conducting the *BD* Test and evaluated as specified in section 3.3 or use the paired values calculated using the above default equations, whichever contribute to a higher SEER–HD.

Determine and obtain the dry-climate full-load air volume rate used for the *AD* and *BD* Tests as specified in section 3.1.4.1 for the cooling full-load air volume rate, only now replacing references to the *A* Test and cooling full-load with references to the *AD* Test and the dry-climate full load.

3.2.2 Tests for a unit with a single-speed compressor where the indoor section uses a single variable-speed variable-air-volume rate indoor fan or multiple blowers.

3.2.2.1 Indoor fan capacity modulation that correlates with outdoor dry-bulb temperature or systems with a single indoor coil but multiple blowers. Conduct four steady-state wet-coil tests: the A_2, A_1, B_2, and B_1 Tests. Use the two optional dry-coil tests, the steady-state C_1 Test and the cyclic D_1 Test to determine the cooling mode cyclic-degradation coefficient, C_D^c. If the two optional tests are conducted but 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 4 specifies test conditions for these six tests.

TABLE 4—COOLING MODE TEST CONDITIONS FOR AIR CONDITIONERS AND HEAT PUMPS WITH A SINGLE-SPEED COMPRESSOR THAT MEET THE SECTION 3.2.2.1 INDOOR UNIT REQUIREMENTS

Test description	Air entering indoor unit temperature °F		Air entering outdoor unit temperature °F		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-Load.[2]
A_1 Test—required (steady, wet coil)	80	67	95	[1] 75	Cooling Minimum.[3]
B_2 Test—required (steady, wet coil)	80	67	82	[1] 65	Cooling Full-Load.[2]
B_1 Test—required (steady, wet coil)	80	67	82	[1] 65	Cooling Minimum.[3]
C_1 Test[4]—optional (steady, dry coil)	80	([4])	82	—	Cooling Minimum.[3]
D_1 Test[4]—optional (cyclic, dry coil)	80	([4])	82	—	([5])

[1] The specified test condition only applies if the unit rejects condensate to the outdoor coil.
[2] Defined in section 3.1.4.1.
[3] Defined in section 3.1.4.2.
[4] The entering air must have a low enough moisture content so no condensate forms on the indoor coil. (It is recommended that an indoor wet-bulb temperature of 57 °F or less be used.)
[5] Maintain the airflow nozzles static pressure difference or velocity pressure during the ON period at the same pressure difference or velocity pressure as measured during the C_1 Test.

In order to evaluate the cooling season performance of the test unit when applied in a hot-dry climate, conduct two steady-state tests (the AD_2 and the AD_1). Two additional steady-state, hot-dry-climate tests (the BD_2 Test and the BD_1 Test) are optional. Test conditions for the four dry climate tests are specified in Table 4a. As an alternative to conducting the optional BD_2 and BD_1 Tests, use the following equations to approximate the capacity and electrical power of the test unit at the BD_2 (k=2) and BD_1 (k=1) test conditions:

$$\dot{Q}_{HD}^{k}(82) = \dot{Q}_{HD}^{k}(95) + MD_{Q}^{k} \times (82-95)$$

$$\dot{E}_{HD}^{k}(82) = \dot{E}_{HD}^{k}(95) + MD_{E}^{k} \times (82-95)$$

Where:

$$MD_{Q}^{k} = 0.95 \times \left[\frac{\dot{Q}_{c}^{k}(95) - \dot{Q}_{c}^{k}(82)}{95-82}\right] \times \left[\frac{\dot{Q}_{HD}^{k}(95)}{\dot{Q}_{c}^{k}(95)}\right]$$

$$MD_{E}^{k} = 0.95 \times \left[\frac{\dot{E}_{c}^{k}(95) - \dot{E}_{c}^{k}(82)}{95-82}\right] \times \left[\frac{\dot{E}_{HD}^{k}(95)}{\dot{E}_{c}^{k}(95)}\right]$$

In evaluating the above equations for *k*=2 (dry-climate full-load air volume rate) and *k*=1 (dry-climate minimum air volume rate), determine the quantities $\dot{Q}_{HD}^{k=2}$ (95) and $\dot{E}_{HD}^{k=2}$ (95) from the AD_2 Test and the quantities $\dot{Q}_{HD}^{k=1}$ (95) and $\dot{E}_{HD}^{k=1}$ (95) from the AD_1 Test. Determine the quantities $\dot{Q}_{c}^{k=2}$ (95) and $\dot{E}_{C}^{k=2}$ (95) from the A_2 Test, the quantities $\dot{Q}_{c}^{k=1}$ (95) and $\dot{E}_{c}^{k=1}$ (95) from the A_1 Test, the quantities $\dot{Q}_{c}^{k=2}$ (82) and $\dot{E}_{C}^{k=2}$ (82) from the B_2 Test, and the quantities $\dot{Q}_{c}^{k=1}$ (82) and $\dot{E}_{c}^{k=1}$ (82) from the B_1 Test. Evaluate all 12 quantities according to section 3.3. If the manufacturer conducts either or both the BD_2 and BD_1 Tests, the option of using the above default equations is not forfeited. Use the paired values of $\dot{Q}_{HD}^{k=2}$ (82) and $\dot{E}_{HD}^{k=2}$ (82) derived from conducting the BD_2 Test and evaluated as specified in section 3.3 or use the paired values calculated using the above default equations, whichever contribute to a higher SEER–HD. Similarly, use the paired values of $\dot{Q}_{HD}^{k=1}$ (82) and $\dot{E}_{HD}^{k=1}$ (82) derived from conducting the BD_1 Test and evaluated as specified in section 3.3 or use the paired values calculated using the above default equations, whichever contribute to a higher SEER–HD.

Determine and obtain the dry-climate full-load air volume rate used for the AD_2 and BD_2 Tests as specified in section 3.1.4.1 for the cooling full-load air volume rate, only now replacing references to the A_2 Test and cooling full-load with references to the AD_2 Test and the dry-climate full-load. Similarly, determine and obtain the dry-climate minimum air volume rate used for the AD_1 and BD_1 Tests specified in section 3.1.4.2 for the cooling minimum air volume rate, only now replacing references to the A_1 Test, B_1 Test, A_2 Test, B_2 Test, cooling full-load, cooling minimum, and $\Delta P_{st,A_2}$ with references to the AD_1 Test, BD_1 Test, AD_2 Test, BD_2 Test, dry-climate full-load, dry-climate minimum, and $\Delta P_{st,AD_2}$, respectively.

TABLE 4a—DRY CLIMATE COOLING MODE TEST CONDITIONS FOR AIR CONDITIONERS AND HEAT PUMPS WITH A SINGLE-SPEED COMPRESSOR THAT MEETS THE SECTION 3.2.2.1 INDOOR UNIT REQUIREMENTS

Test description	Air entering indoor unit temperature °F		Air entering outdoor unit temperature °F		Dry climate air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb	
AD_2 Test–required (steady)	80	64	95	75	Dry-Climate Full-Load.
AD_1 Test–required (steady)	80	64	95	75	Dry-Climate Minimum.
BD_2 Test–optional (steady)	80	64	82	65	Dry-Climate Full-Load.
BD_1 Test–optional (steady)	80	64	82	65	Dry-Climate Minimum.

[1] The specified test condition only applies if the unit rejects condensate to the outdoor coil.

3.2.2.2 Indoor fan capacity modulation based on adjusting the sensible to total (S/T) cooling capacity ratio. The testing requirements are the same as specified in section 3.2.1 and Table 3. Use a cooling full-load air volume rate that represents a normal residential installation. If performed, conduct the steady-state *C* Test and the cyclic *D* Test with the unit operating in the same S/T capacity control mode as used for the *B* Test.

3.2.3 Tests for a unit having a two-capacity compressor (see Definition 1.49).

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c. Test two-capacity, northern heat pumps (see Definition 1.50) in the same way as a single speed heat pump with the unit operating exclusively at low compressor capacity (see section 3.2.1 and Table 3).

* * * * *

e. In order to evaluate the cooling season performance of the test unit when applied in a hot-dry climate, conduct two steady-state tests, the AD_2 and the BD_1. Conducting two additional steady-state, dry-climate tests (the BD_2 and the FD_1) are optional. Test conditions for the four dry climate tests are specified in Table 5a. As an alternative to conducting the optional BD_2 Test, use the following equations to approximate the capacity and electrical power of the test unit at the BD_2 test conditions:

$$\dot{Q}_{HD}^{k=2}(82) = \dot{Q}_{HD}^{k=2}(95) + MD_{Q}^{k=2} \times (82-95)$$

$$\dot{E}_{HD}^{k=2}(82) = \dot{E}_{HD}^{k=2}(95) + MD_{E}^{k=2} \times (82-95)$$

Where:

$$MD_{Q}^{k=2} = 0.95 \times \left[\frac{\dot{Q}_{c}^{k=2}(95) - \dot{Q}_{c}^{k=2}(82)}{95-82}\right] \times \left[\frac{\dot{Q}_{HD}^{k=2}(95)}{\dot{Q}_{c}^{k=2}(95)}\right]$$

$$MD_{E}^{k=2} = 0.95 \times \left[\frac{\dot{E}_{c}^{k=2}(95) - \dot{E}_{c}^{k=2}(82)}{95-82}\right] \times \left[\frac{\dot{E}_{HD}^{k=2}(95)}{\dot{E}_{c}^{k=2}(95)}\right]$$

In evaluating the above equations, determine the quantities $\dot{Q}_{HD}^{k=2}(95)$ and $\dot{E}_{HD}^{k=2}(95)$ from the AD_2 Test. Determine the quantities $\dot{Q}_c^{k=2}(95)$ and $\dot{E}_C^{k=2}(95)$ from the A_2 Test and the quantities $\dot{Q}_c^{k=2}(82)$ and $\dot{E}_c^{k=2}(82)$ from the B_2 Test. Evaluate all six quantities according to section 3.3. If the manufacturer conducts the BD_2 Test, the option of using the above default equations is not forfeited. Use the paired values of $\dot{Q}_{HD}^{k=2}(82)$ and $\dot{E}_{HD}^{k=2}(82)$ derived from conducting the BD_2 Test and evaluated as specified in section 3.3 or use the paired values calculated using the above default equations, whichever paired values contribute to a higher SEER–HD.

As an alternative to conducting the optional FD_1 Test, use the following equations to approximate the capacity and electrical power of the test unit at the FD_1 Test conditions:

$$\dot{Q}_{HD}^{k=1}(67) = \dot{Q}_{HD}^{k=1}(82) + MD_Q^{k=1} \times (67-82)$$

$$\dot{E}_{HD}^{k=1}(67) = \dot{E}_{HD}^{k=1}(82) + MD_E^{k=1} \times (67-82)$$

Where:

$$MD_Q^{k=1} = 0.95 \times \left[\frac{\dot{Q}_c^{k=1}(82) - \dot{Q}_c^{k=1}(67)}{82-67}\right] \times \left[\frac{\dot{Q}_{HD}^{k=1}(82)}{\dot{Q}_c^{k=1}(82)}\right]$$

$$MD_E^{k=1} = 0.95 \times \left[\frac{\dot{E}_c^{k=1}(82) - \dot{E}_c^{k=1}(67)}{82-67}\right] \times \left[\frac{\dot{E}_{HD}^{k=1}(82)}{\dot{E}_c^{k=1}(82)}\right]$$

In evaluating the above equations, determine the quantities $\dot{Q}_{HD}^{k=1}(82)$ and $\dot{E}_{HD}^{k=1}(82)$ from the BD_1 Test. Determine the quantities $\dot{Q}_c^{k=1}(82)$ and $\dot{E}_C^{k=1}(82)$ from the B_1 Test and the quantities $\dot{Q}_c^{k=1}(67)$ and $\dot{E}_c^{k=1}(67)$ from the F_1 Test. Evaluate all six quantities according to section 3.3. If the manufacturer conducts the FD_1 Test, the option of using the above default equations is not forfeited. Use the paired values of $\dot{Q}_{HD}^{k=1}(67)$ and $\dot{E}_{HD}^{k=1}(67)$ derived from conducting the FD_1 Test and evaluated as specified in section 3.3 or use the paired values calculated using the above default equations, whichever contribute to a higher SEER–HD.

Determine and obtain the dry-climate full-load air volume rate used for the AD_2 and BD_2 Tests as specified in section 3.1.4.1 for the cooling full-load air volume rate, only now replacing references to the A_2 Test and cooling full-load with references to the AD_2 Test and the dry-climate full-load. Similarly, determine and obtain the dry-climate minimum air volume rate used for the BD_1 and FD_1 Tests as specified in section 3.1.4.2 for the cooling minimum air volume rate, only now replacing references to the B_1 Test, F_1 Test, A_2 Test, cooling full load, cooling minimum, and $\Delta P_{st,A_2}$ with references to the BD_1 Test, FD_1 Test, AD_2 Test, dry-climate full-load, dry-climate minimum, and $\Delta P_{st,AD_2}$, respectively.

TABLE 5a—DRY CLIMATE COOLING MODE TEST CONDITIONS FOR AIR CONDITIONERS AND HEAT PUMPS HAVING A TWO-CAPACITY COMPRESSOR

Test description	Air entering indoor unit temperature °F		Air entering outdoor unit temperature °F		Compressor capacity	Dry climate air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb		
AD_2 Test—required (steady).	80	64	95	75	High	Dry-Climate Full-Load.
BD_2 Test—optional (steady).	80	64	82	65	High	Dry-Climate Full-Load.
BD_1 Test—required (steady).	80	64	82	65	Low	Dry-Climate Minimum.
FD_1 Test—optional (steady).	80	64	67	53.5	Low	Dry-Climate Minimum.

[1] The specified test condition only applies if the unit rejects condensate to the outdoor coil.

3.2.4 * * *

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d. In order to evaluate the cooling season performance of the test unit when applied in a hot-dry climate, conduct two steady-state tests, the AD_2 Test and the BD_1 Test. Conducting two additional steady-state, dry climate tests (the BD_2 and the FD_1) are optional. Test conditions for the four dry climate tests are specified in Table 5a, only now substituting "Maximum" and "Minimum" for the Compressor Capacity entries of "High" and "Low," respectively. As an alternative to conducting the optional BD_2 and FD_1 Tests, use the equations given in section 3.2.3 to approximate the capacity and electrical power of the test unit at the BD_2 and FD_1 test conditions.

3.2.5 Tests for a unit having a triple-capacity compressor (Definition 1.46). With the exception of triple-capacity northern heat pumps (Definition 1.47), no other units having a triple-capacity compressor are currently addressed within this test procedure. Test triple-capacity, northern heat pumps for the cooling mode in the same way as specified in section 3.2.3 for units having a two-capacity compressor.

3.2.6 Tests for an air conditioner or heat pump having a single indoor unit having multiple blowers and offering two stages of compressor modulation. Conduct the cooling mode tests specified in section 3.2.3. Covered multiple blower systems have a single indoor coil connected to a single outdoor unit offering two stages of capacity modulation, and ones with a single indoor coil having two refrigerant circuits where each circuit is connected to separate but identical outdoor units, each having a single-speed compressor.

3.3 * * *

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b. After satisfying the pretest equilibrium requirements, make the measurements specified in Table 3 of ASHRAE Standard 37–2005 (incorporated by reference, see § 430.3) for the Indoor Air Enthalpy method and the user-selected secondary method. Make the Table 3 measurements at equal intervals that span 5 minutes or less. Continue data sampling until reaching a 30-minute period (*e.g.,* seven consecutive 5-minute samples) where the test tolerances specified in Table 7 are satisfied. For those continuously recorded parameters, use the entire data set from the 30-minute interval to evaluate Table 7 compliance. Determine the average electrical power consumption of the air conditioner or heat pump over the same 30-minute interval.

c. Calculate indoor-side total cooling and sensible cooling capacity as specified in sections 7.3.3.1 and 7.3.3.3 of ASHRAE Standard 37–2005 (incorporated by reference, see § 430.3). Do not adjust the parameters used in calculating the capacities for the permitted variations in test conditions. Evaluate air enthalpies based on the measured barometric pressure for calculation of the total cooling capacity. Use the values of the specific heat of air given in section 7.3.3.1 for calculation of the sensible cooling capacities. Assign the average total space cooling capacity, average sensible cooling capacity, and average electrical power consumption over the 30-minute data collection interval to the variables $\dot{Q}_c^k(T)$, $\dot{Q}_{sc}^k(T)$, and $\dot{E}_c^k(T)$, respectively. For these three variables, replace T with the nominal outdoor temperature at which the test was conducted. The superscript k is used only when testing multi-capacity units. Use the superscript k=2 to denote a test with the unit operating at high capacity or maximum speed, k=1 to denote low capacity or minimum speed, and k=v to denote the intermediate speed.

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3.4 * * *

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b. If the temperature sensors used to provide the primary measurement of the indoor-side dry bulb temperature difference during the steady-state dry-coil test and the subsequent cyclic dry-coil test are different, include measurements of the latter sensors among the regularly sampled data. Beginning at the start of the 30-minute data collection period, measure and compute the indoor-side air dry-bulb temperature difference using both sets of instrumentation, ΔT (*Set SS*) and ΔT (*Set CYC*), for each equally spaced data sample. If using a consistent data sampling rate that is less than 1 minute, calculate and record minutely averages for the two temperature differences. If using a consistent sampling rate of one minute or more, calculate and record the two temperature differences from each data sample. After having recorded the seventh (i=7) set of temperature differences, calculate the following ratio using the first seven sets of values:

$$F_{CD} = \frac{1}{7}\sum_{i-6}^{i}\frac{\Delta T(Set\ SS)}{\Delta T(Set\ CYC)}$$

Each time a subsequent set of temperature differences is recorded (if sampling more frequently than every 5 minutes), calculate F_{CD} using the most recent seven sets of values. Continue these calculations until the 30-minute period is completed or until a value for F_{CD} is calculated that falls outside the allowable range of 0.94–1.06. If the latter occurs, immediately suspend the test and identify the cause for the disparity in the two temperature difference measurements. Recalibration of one or both sets of instrumentation may be required. If all the values for F_{CD} are within the allowable range, save the final value of the ratio from the 30-minute test as F_{CD}^*.

If the temperature sensors used to provide the primary measurement of the indoor-side dry bulb temperature difference during the steady-state dry-coil test and the subsequent cyclic dry-coil test are the same, set $F_{CD}^* = 1$.

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3.5 * * *

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i. * * *

Where:

$$\Gamma = F_{CD}^*\int_{\tau_1}^{\tau_2}\left[T_{a1}(\tau) - T_{a2}(\tau)\right]\delta\tau,\ \text{hr} \times {}^\circ\text{F},$$

and, $\dot{V}$, $C_{p,a}$, V_n (or v_n), W_n, and F_{CD}^* = the values recorded during the section 3.4 dry coil steady-state tests,

and $T_{a1}(\tau)$ = dry-bulb temperature of the air entering the indoor coil at time τ, °F.

* * * * *

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 fan whose capacity modulation correlates with outdoor dry bulb temperature or (2) multiple blowers. * * *

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Table 10—Heating Mode Test Conditions for Heat Pumps With a Single-Speed Compressor That Meet the Section 3.6.2 Indoor Unit Requirements * * *

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As an alternative to conducting the optional $H2_1$ Frost Accumulation Test, use the following equations to approximate the capacity and electrical power of the heat pump at the $H2_1$ test conditions:

$$\dot{Q}_h^{k=1}(35) = QR_h^{k=2} \times \left\{\dot{Q}_h^{k=1}(17) + 0.6 \times \left\lfloor \dot{Q}_h^{k=1}(47) - \dot{Q}_h^{k=1}(17)\right\rfloor\right\}$$

$$\dot{E}_h^{k=1}(35) = PR_h^{k=2} \times \left\{\dot{E}_h^{k=1}(17) + 0.6 \times \left\lfloor \dot{E}_h^{k=1}(47) - \dot{E}_h^{k=1}(17)\right\rfloor\right\}$$

Where:

$$QR_h^{k=2}(35) = \frac{\dot{Q}_h^{k=2}(35)}{\dot{Q}_h^{k=2}(17) + 0.6 \times \left[\dot{Q}_h^{k=2}(47) - \dot{Q}_h^{k=2}(17)\right]}$$

$$PR_h^{k=2}(35) = \frac{\dot{E}_h^{k=2}(35)}{\dot{E}_h^{k=2}(17) + 0.6 \times \left[\dot{E}_h^{k=2}(47) - \dot{E}_h^{k=2}(17)\right]}$$

In evaluating the above equations, determine the quantities $\dot{Q}_h^{k=2}(47)$ and $\dot{E}_h^{k=2}(47)$ from the *H1*$_2$ Test, determine the quantities $\dot{Q}_h^{k=1}(47)$ and $\dot{E}_h^{k=1}(47)$ from the *H1*$_1$ Test, and evaluate all four quantities according to section 3.7. Determine the quantities $\dot{Q}_h^{k=2}(35)$ and $\dot{E}_h^{k=2}(35)$ from the *H2*$_2$ Test and evaluate them according to section 3.9. Determine the quantities $\dot{Q}_h^{k=2}(17)$ and $\dot{E}_h^{k=2}(17)$ from the *H3*$_2$ Test, determine the quantities $\dot{Q}_h^{k=1}(17)$ and $\dot{E}_h^{k=1}(17)$ from the *H3*$_1$ Test, and evaluate all four quantities according to Section 3.10. If the manufacturer conducts the *H2*$_1$ Test, the option of using the above default equations is not forfeited. Use the paired values of $\dot{Q}_h^{k=1}(35)$ and $\dot{E}_h^{k=1}(35)$ derived from conducting the *H2*$_1$ Frost Accumulation Test and evaluated as specified in section 3.9 or use the paired values calculated using the above default equations, whichever contribute to a higher Region IV HSPF based on the DHR_{min}.

* * * * *

3.6.3 * * *

a. * * * If the manufacturer conducts the *H2*$_1$ Test, the option of using the above default equations is not forfeited. Use the paired values of $\dot{Q}_h^{k=1}(35)$ and $\dot{E}_h^{k=1}(35)$ derived from conducting the *H2*$_1$ Frost Accumulation Test and calculated as specified in section 3.9 or use the paired values calculated using the above default equations, whichever contribute to a higher Region IV HSPF based on the DHR_{min}.

* * * * *

3.6.4 * * *

a. * * *

b. As an alternative to conducting the optional *H2*$_2$ Frost Accumulation Test, use the following equations to approximate the capacity and electrical power of the heat pump at the *H2*$_2$ test conditions:

$$\dot{Q}_h^{k=2}(35) = 0.90 \times \left\{\dot{Q}_h^{k=2}(17) + 0.6 \times \left\lfloor \dot{Q}_h^{k=2}(47) - \dot{Q}_h^{k=2}(17) \right\rfloor\right\}$$

$$\dot{E}_h^{k=2}(35) = 0.985 \times \left\{\dot{E}_h^{k=2}(17) + 0.6 \times \left\lfloor \dot{E}_h^{k=2}(47) - \dot{E}_h^{k=2}(17) \right\rfloor\right\}$$

In evaluating the above equations, determine the quantities $\dot{Q}_h^{k=2}(47)$ and $\dot{E}_h^{k=2}(47)$ from the *H1*$_2$ Test and evaluate them according to section 3.7. Determine the quantities $\dot{Q}_h^{k=2}(17)$ and $\dot{E}_h^{k=2}(17)$ from the *H3*$_2$ Test and evaluate them according to section 3.10. If the manufacturer conducts the *H2*$_2$ Test, the option of using the above default equations is not forfeited. Use the paired values of $\dot{Q}_h^{k=2}(35)$ and $\dot{E}_h^{k=2}(35)$ derived from conducting the *H2*$_2$ Frost Accumulation Test and evaluated as specified in section 3.9 or use the paired values calculated using the above default equations, whichever contribute to a higher Region IV HSPF based on the DHR_{min}.

c. For heat pumps where the heating mode maximum compressor speed exceeds their cooling mode maximum compressor speed, conduct the *H1*$_N$ Test if the manufacturer requests it. If the *H1*$_N$ Test is done, operate the heat pump's compressor at the same speed as used for the cooling mode *A*$_2$ Test. Refer to the last sentence of section 4.2 for how the results of the *H1*$_N$ Test may be used in calculating the HSPF.

d. For multiple-split heat pumps (only), the following procedures supersede the above requirements. * * *

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3.6.6 Tests for a heat pump having a triple-capacity compressor (Definition 1.46). With the exception of triple-capacity northern heat pumps (Definition 1.47), no other heat pumps having a triple-capacity compressor are currently addressed within this test procedure. Test triple-capacity, northern heat pumps for the heating mode as follows:

(a) Conduct one maximum-temperature test (*H0*$_1$), two high-temperature tests (*H1*$_2$ and *H1*$_1$), one Frost Accumulation test (*H2*$_2$), two low-temperature tests (*H3*$_2$, *H3*$_3$), and one minimum-temperature test (*H4*$_3$). Conduct an additional Frost Accumulation test (*H2*$_1$) and low-temperature test (*H3*$_1$) if both of the following conditions exist: (1) Knowledge of the heat pump's capacity and electrical power at low compressor capacity for outdoor temperatures of 37 °F and less is needed to complete the section 4.2.6 seasonal performance calculations; and (2) the heat pump's controls allow low-capacity operation at outdoor temperatures of 37 °F and less.

If the above two conditions are met, an alternative to conducting the *H2*$_1$ Frost Accumulation Test to determine $\dot{Q}_h^{k=1}(35)$ and $\dot{E}_h^{k=1}(35)$ is to use the following equations to approximate this capacity and electrical power:

$$\dot{Q}_h^{k=1}(35) = 0.90 \times \left\{\dot{Q}_h^{k=1}(17) + 0.6 \times \left\lfloor \dot{Q}_h^{k=1}(47) - \dot{Q}_h^{k=1}(17) \right\rfloor\right\}$$

$$\dot{E}_h^{k=1}(35) = 0.985 \times \left\{\dot{E}_h^{k=1}(17) + 0.6 \times \left\lfloor \dot{E}_h^{k=1}(47) - \dot{E}_h^{k=1}(17) \right\rfloor\right\}$$

In evaluating the above equations, determine the quantities $\dot{Q}_h^{k=1}(47)$ and $\dot{E}_h^{k=1}(47)$ from the *H1*$_1$ Test and evaluate them according to section 3.7. Determine the quantities $\dot{Q}_h^{k=1}(17)$ and $\dot{E}_h^{k=1}(17)$ from the *H3*$_1$ Test and evaluate them according to section 3.10. If the manufacturer conducts the *H2*$_1$ Test, the option of using the above default equations is not forfeited. Use the paired values of $\dot{Q}_h^{k=1}(35)$ and $\dot{E}_h^{k=1}(35)$ derived from conducting the *H2₁* Frost Accumulation Test and evaluated as specified in section 3.9.1 or use the paired values calculated using the above default equations, whichever contribute to a higher Region IV HSPF based on the DHR_{min}.

(b) Conducting a Frost Accumulation Test ($H2_3$) with the heat pump operating at its booster capacity is optional. If this optional test is not conducted, determine $\dot{Q}_h^{k=3}(35)$ and $\dot{E}_h^{k=3}(35)$ using the following equations to approximate this capacity and electrical power:

$$\dot{Q}_h^{k=3}(35) = QR_h^{k=2}(35) \times \left\{ \dot{Q}_h^{k=3}(17) + 1.20 \times \left\lfloor \dot{Q}_h^{k=3}(17) - \dot{Q}_h^{k=3}(2) \right\rfloor \right\}$$

$$\dot{E}_h^{k=3}(35) = PR_h^{k=2}(35) \times \left\{ \dot{E}_h^{k=3}(17) + 1.20 \times \left\lfloor \dot{E}_h^{k=3}(17) - \dot{E}_h^{k=3}(2) \right\rfloor \right\}$$

Where:

$$QR_h^{k=2}(35) = \frac{\dot{Q}_h^{k=2}(35)}{\dot{Q}_h^{k=2}(17) + 0.6 \times \left[\dot{Q}_h^{k=2}(47) - \dot{Q}_h^{k=2}(17) \right]}$$

$$PR_h^{k=2}(35) = \frac{\dot{E}_h^{k=2}(35)}{\dot{E}_h^{k=2}(17) + 0.6 \times \left[\dot{E}_h^{k=2}(47) - \dot{E}_h^{k=2}(17) \right]}$$

Determine the quantities $\dot{Q}_h^{k=2}(47)$ and $\dot{E}_h^{k=2}(47)$ from the $H1_2$ Test and evaluate them according to section 3.7. Determine the quantities $\dot{Q}_h^{k=2}(35)$ and $\dot{E}_h^{k=2}(35)$ from the $H2_2$ Test and evaluate them according to section 3.9.1. Determine the quantities $\dot{Q}_h^{k=2}(17)$ and $\dot{E}_h^{k=2}(17)$ from the $H3_2$ Test, determine the quantities $\dot{Q}_h^{k=3}(17)$ and $\dot{E}_h^{k=3}(17)$ from the $H3_3$ Test, and determine the quantities $\dot{Q}_h^{k=3}(2)$ and $\dot{E}_h^{k=3}(2)$ from the $H4_3$ Test. Evaluate all six quantities according to section 3.10. If the manufacturer conducts the $H2_3$ Test, the option of using the above default equations is not forfeited. Use the paired values of $\dot{Q}_h^{k=3}(35)$ and $\dot{E}_h^{k=3}(35)$ derived from conducting the $H2_3$ Frost Accumulation Test and calculated as specified in section 3.9.1 or use the paired values calculated using the above default equations, whichever contribute to a higher Region IV HSPF based on the DHR_{min}.

(c) Conduct the optional high-temperature cyclic test ($H1C_1$) 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. If a triple-capacity heat pump locks out low capacity operation at lower outdoor temperatures, conduct the optional high-temperature cyclic test ($H1C_2$) to determine the high-capacity heating-mode cyclic-degradation coefficient, $C_D^h(k=2)$. If this optional test at high capacity is conducted but yields a tested $C_D^h(k=2)$ that exceeds the default $C_D^h(k=2)$ or if the optional test is not conducted, assign $C_D^h(k=2)$ the default value. The default $C_D^h(k=2)$ is the same value as determined or assigned for the low-capacity cyclic-degradation coefficient, C_D^h [or equivalently, $C_D^h(k=1)$]. Finally, if a triple-capacity heat pump locks out both low and high capacity operation at the lowest outdoor temperatures, conduct the optional low-temperature cyclic test ($H3C_3$) to determine the booster-capacity heating-mode cyclic-degradation coefficient, $C_D^h(k=3)$. If this optional test at the booster capacity is conducted but yields a tested $C_D^h(k=3)$ that exceeds the default $C_D^h(k=3)$ or if the optional test is not conducted, assign $C_D^h(k=3)$the default value. The default $C_D^h(k=3)$ is the same value as determined or assigned for the high-capacity cyclic-degradation coefficient, C_D^h [or equivalently, $C_D^h(k=2)$]. Table A specifies test conditions for all 13 tests.

TABLE A—HEATING MODE TEST CONDITIONS FOR UNITS WITH A TRIPLE-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, cyclic)	70	60(max)	47	43	High	[3]
$H1_1$ Test (required)	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 [5 6] (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 (optional, cyclic)	70	60(max)	17	15	Booster	[7]
$H3_2$ Test (required, steady)	70	60(max)	17	15	High	Heating Full-Load.[2]

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

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		
H3$_1$ Test[5] (required, steady)	70	60$^{(max)}$	17	15	Low	Heating Minimum.[1]
H4$_3$ Test (required, steady)	70	60$^{(max)}$	2	1	Booster	Heating Full-Load.[2]

[1] Defined in section 3.1.4.5.
[2] Defined in section 3.1.4.4.
[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 section 4.2.6 *HSPF* calculations.
[6] If table note [5] applies, the section 3.6.6 equations for $\dot{Q}_h^{k=1}(35)$ and $\dot{E}_h^{k=1}(17)$ 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.

3.6.7 Tests for a heat pump having a single indoor unit having multiple blowers and offering two stages of compressor modulation. Conduct the heating mode tests specified in section 3.6.3. Covered multiple blower systems have a single indoor coil connected to a single outdoor unit offering two stages of capacity modulation and ones having a single indoor coil having two refrigerant circuits where each circuit is connected to separate but identical outdoor units, each having a single-speed compressor.

3.7 * * *

a. For the pretest interval, operate the test room reconditioning apparatus and the heat pump until equilibrium conditions are maintained for at least 30 minutes at the specified section 3.6 test conditions. Use the exhaust fan of the airflow measuring apparatus and, if installed, the indoor fan of the heat pump to obtain and then maintain the indoor air volume rate and/or external static pressure specified for the particular test. Continuously record the dry-bulb temperature of the air entering the outdoor coil. Refer to section 3.11 for additional requirements that depend on the selected secondary test. After satisfying the pretest equilibrium requirements, make the measurements specified in Table 3 of ASHRAE Standard 37–2005 (incorporated by reference, see § 430.3) for the Indoor Air Enthalpy method and the user-selected secondary method. Make the Table 3 measurements at equal intervals that span 5 minutes or less. Continue data sampling until a 30-minute period (*e.g.,* seven consecutive 5-minute samples) is reached where the test tolerances specified in Table 13 are satisfied. For those continuously recorded parameters, use the entire data set for the 30-minute interval when evaluating Table 13 compliance. Determine the average electrical power consumption of the heat pump over the same 30-minute interval.

TABLE 13—TEST OPERATING AND TEST CONDITION TOLERANCES FOR SECTION 3.7 AND SECTION 3.10 STEADY-STATE HEATING MODE TESTS

	Test operating tolerance[1]	Test condition tolerance[2]
Indoor dry-bulb, °F		
Entering temperature	2.0	0.5
Leaving temperature	2.0	
Indoor wet-bulb, °F		
Entering temperature	1.0	
Leaving temperature	1.0	
Outdoor dry-bulb, °F		
Entering temperature	2.0	0.5
Leaving temperature	[2] 2.0	
Outdoor wet-bulb, °F		
Entering temperature	1.0	0.3
Leaving temperature	[3] 1.0	
External resistance to airflow, inches of water	0.12	[4] 0.02
Electrical voltage, % of rdg	2.0	1.5
Nozzle pressure drop, % of rdg	8.0	

[1] See Definition 1.43.
[2] See Definition 1.42.
[3] Only applies when the Outdoor Air Enthalpy Method is used.
[4] Only applies when testing non-ducted units.

b. Calculate indoor-side total heating capacity as specified in sections 7.3.4.1 and 7.3.4.3 of ASHRAE Standard 37–2005 (incorporated by reference, see § 430.3). * * *

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d. If conducting the optional cyclic heating mode test described in section 3.8, record the average indoor-side air volume rate, $\bar{\dot{V}}$, specific heat of the air,

$C_{p,a}$ (expressed on a dry air basis), specific volume of the air at the nozzles, v_n' (or v_n), humidity ratio at the nozzles, W_n, and either pressure difference or velocity pressure for the flow nozzles.

If the temperature sensors used to provide the primary measurement of the indoor-side dry bulb temperature difference during the steady-state dry-coil test and the subsequent cyclic dry-coil test are different, include measurements of the latter sensors among the regularly sampled data during the steady-state test. Beginning at the start of the 30-minute data collection period, measure and compute the indoor-side air dry bulb temperature difference using both sets of instrumentation, $\Delta T(Set\ SS)$ and $\Delta T(Set\ CYC)$, for each equally spaced data sample. If using a consistent data sampling rate that is less than 1 minute, calculate and record minutely averages for the two temperature differences. If using a consistent sampling rate of one minute or more, calculate and record the two temperature differences from each data sample. After having recorded the seventh (i=7) set of temperature differences, calculate the following ratio using the first seven sets of values:

$$F_{CD} = \frac{1}{7}\sum_{i-6}^{i}\frac{\Delta T(Set\ SS)}{\Delta T(Set\ CYC)}$$

Each time a subsequent set of temperature differences is recorded (if sampling more frequently than every 5 minutes), calculate F_{CD} using the most recent seven sets of values. Continue these calculations until the 30-minute period is completed or until a value for F_{CD} is calculated that falls outside the allowable range of 0.94–1.06. If the latter occurs, immediately suspend the test and identify the cause for the disparity in the two temperature difference measurements. Recalibration of one or both sets of instrumentation may be required. If all the values for F_{CD} are within the allowable range, save the final value of the ratio from the 30-minute test as F_{CD}^*.

If the temperature sensors used to provide the primary measurement of the indoor-side dry bulb temperature difference during the steady-state dry-coil test and the subsequent cyclic dry-coil test are the same, set $F_{CD}^* = 1$.

e. If either or both of the below criteria apply, determine the average, steady-state, electrical power consumption of the indoor fan motor ($\dot{E}_{fan,1}$):

1. The section 3.8 cyclic test will be conducted and the heat pump has a variable-speed indoor fan that is expected to be disabled during the cyclic test; or

2. The heat pump has a (variable-speed) constant-air volume-rate indoor fan and during the steady-state test the average external static pressure (ΔP_1) exceeds the applicable section 3.1.4.4 minimum (or targeted) external static pressure (ΔP_{min}) by 0.03 in wc or more.

Determine $\dot{E}_{fan,1}$ by making measurements during the 30-minute data collection interval, or immediately following the test and prior to changing the test conditions. When the above "2" criteria applies, conduct the following four steps after determining $\dot{E}_{fan,1}$ (which corresponds to ΔP_1):

1. While maintaining the same test conditions, adjust the exhaust fan of the airflow measuring apparatus until the external static pressure increases to approximately $\Delta P_1 + (\Delta P_1 - \Delta P_{min})$.

2. After re-establishing steady readings for fan motor power and external static pressure, determine average values for the indoor fan power ($\dot{E}_{fan,2}$) and the external static pressure (ΔP_2) by making measurements over a 5-minute interval.

3. Approximate the average power consumption of the indoor fan motor if the 30-minute test had been conducted at ΔP_{min} using linear extrapolation:

$$\dot{E}_{fan,\min} = \frac{\dot{E}_{fan,2} - \dot{E}_{fan,1}}{\Delta P_2 - \Delta P_1}\left(\Delta P_{\min} - \Delta P_1\right) + \dot{E}_{fan,1}$$

4. Decrease the total space heating capacity, $\dot{Q}_h^k(T)$, by the quantity ($\dot{E}_{fan,1} - \dot{E}_{fan,}$min), when expressed on a Btu/h basis. Decrease the total electrical power, $\dot{E}_h^k(T)$ by the same fan power difference, now expressed in watts.

3.8 Test procedures for the optional cyclic heating mode tests (the $H0C_1$, $H1C$, $H1C_1$, $H1C_2$, and $H3C_3$ Tests). a. Except as noted below, conduct the cyclic heating mode test as specified in section 3.5. As adapted to the heating mode, replace section 3.5 references to "the steady-state dry coil test" with "the heating mode steady-state test conducted at the same test conditions as the cyclic heating mode test." Use the test tolerances in Table 14 rather than Table 8. Record the outdoor coil entering wet-bulb temperature according to the requirements given in section 3.5 for the outdoor coil entering wet-bulb temperature.

Drop the subscript "dry" used in variables cited in section 3.5 when referring to quantities from the cyclic heating mode test. Determine the total space heating delivered during the cyclic heating test, q_{cyc}, as specified in section 3.5 except for making the following changes:

(1) When evaluating Eq. 3.5–1, use the values of $\bar{\dot{V}}$, $C_{p,a}$, v_n' (or v_n), and W_n that were recorded during the section 3.7 steady state test conducted at the same test conditions.

(2) Calculate Γ using

$$\Gamma = F_{CD}^* \int_{\tau_1}^{\tau_2}\left[T_{a2}(\tau) - T_{a1}(\tau)\right]\delta\tau, \mathrm{hr}\cdot{}^{\circ}\mathrm{F},$$

Where:

F_{CD}^* = recorded during the section 3.7 steady state test conducted at the same test conditions.

* * * * *

3.8.1 * * *

TABLE 14—TEST OPERATING AND TEST CONDITION TOLERANCES FOR CYCLIC HEATING MODE TESTS

	Test operating tolerance [1]	Test condition tolerance [2]
Indoor entering dry-bulb temperature, ° F	2.0	0.5
Indoor entering wet-bulb temperature, ° F	1.0	
Outdoor entering dry-bulb temperature, ° F	2.0	0.5
Outdoor entering wet-bulb temperature, ° F	2.0	1.0
External resistance to air-flow,[3] inches of water	0.12	

TABLE 14—TEST OPERATING AND TEST CONDITION TOLERANCES FOR CYCLIC HEATING MODE TESTS—Continued

	Test operating tolerance [1]	Test condition tolerance [2]
Airflow nozzle pressure difference or velocity pressure, [3] % of reading	2.0	[4] 2.0
Electrical voltage,[5] % of rdg	8.0	1.5

[1] See Definition 1.43.
[2] See Definition 1.42.
[3] Applies during the interval that air flows through the indoor (outdoor) coil except for the first 30 seconds after flow initiation. For units having a variable-speed indoor fan that ramps, the tolerances listed for the external resistance to airflow shall apply from 30 seconds after achieving full speed until ramp down begins.
[4] The test condition shall be the average nozzle pressure difference or velocity pressure measured during the steady-state test conducted at the same test conditions.
[5] Applies during the interval that at least one of the following—the compressor, the outdoor fan, or, if applicable, the indoor fan—are operating, except for the first 30 seconds after compressor start-up.

* * * * *

3.9 * * *

e. * * * Sample the remaining parameters listed in Table 15 at equal intervals that span 5 minutes or less.

* * * * *

3.9.2 * * *

a. Assign the demand defrost credit F_{def} used in section 4.2 to the value of 1 in all cases except for heat pumps having a demand-defrost control system (Definition 1.21). For such qualifying heat pumps, evaluate F_{def} using

$$F_{def} = 1 + 0.03 \cdot \left[1 - \frac{\Delta\tau_{def} - 1.5}{\Delta\tau_{max} - 1.5}\right],$$

Where:

ΔT_{def} = the time between defrost terminations (in hours) or 1.5, whichever is greater. A value of 6 must be assigned to ΔT_{def} if this limit is reached during a frost accumulation test and the heat pump has not completed a defrost cycle.

ΔT_{max} = maximum time between defrosts as allowed by the controls (in hours) or 12, whichever is less. The value of ΔT_{max} must be provided by the manufacturer.

* * * * *

3.10 Test procedures for steady-state low and minimum temperature heating mode tests (the *H3, H3$_3$, H3$_2$, H3$_1$,* and *H4$_3$* Tests). Except for modifications noted in this section, conduct the low temperature and minimum temperature heating mode tests using the same approach as specified in section 3.7 for the maximum and high temperature tests. After satisfying the section 3.7 requirements for the pretest interval but before beginning to collect data to determine $\dot{Q}_h^k$ (17) or $\dot{Q}_h^k$ (2) and $\dot{E}_h^k$ (17) or $\dot{E}_h^k$ (2) , conduct a defrost cycle that can be initiated manually or automatically. The defrost sequence must be terminated by the action of the heat pump's defrost controls. Begin the 30-minute data collection interval described in section 3.7 from which $\dot{Q}_h^k$ (17) and $\dot{E}_h^k$ (17) or $\dot{Q}_h^k$ (2) and $\dot{E}_h^k$ (2) are determined, no sooner than 10 minutes after defrost termination. Defrosts should be prevented over the 30-minute data collection interval.

* * * * *

3.11.1.1 * * *

a. The test conditions for the preliminary test are the same as specified for the official test. Connect the indoor air-side apparatus to the indoor coil; disconnect the outdoor air-side test apparatus. Allow the test room reconditioning apparatus and the unit being tested to operate for at least 1 hour. After attaining equilibrium conditions, measure the following quantities at equal intervals that span 5 minutes or less:

1. The section 2.10.1 evaporator and condenser temperatures or pressures;

2. Parameters required according to the indoor air enthalpy method.

Continue these measurements until a 30-minute period (*e.g.,* seven consecutive 5-minute samples) is obtained where the Table 7 or Table 13, whichever applies, test tolerances are satisfied.

* * * * *

3.11.1.3 * * *

a. Continue (preliminary test was conducted) or begin (no preliminary test) the official test by making measurements for both the indoor and outdoor air enthalpy methods at equal intervals that span 5 minutes or less. Discontinue these measurements only after obtaining a 30-minute period where the specified test condition and operating tolerances are satisfied. To constitute a valid official test:

1. Achieve the energy balance specified in section 3.1.1; and,

2. For cases where a preliminary test is conducted, the capacities determined using the Indoor Air Enthalpy Method from the official and preliminary test periods must agree within 2 percent.

* * * * *

3.11.2 * * *

a. Conduct separate calibration tests using a calorimeter to determine the refrigerant flow rate. Or for cases where the superheat of the refrigerant leaving the evaporator is less than 5 °F, use the calorimeter to measure total capacity rather than refrigerant flow rate. Conduct these calibration tests at the same test conditions as specified for the tests in this Appendix. Operate the unit for at least one hour or until obtaining equilibrium conditions before collecting data that will be used in determining the average refrigerant flow rate or total capacity. Sample the data at equal intervals that span 5 minutes or less. Determine average flow rate or average capacity from data sampled over a 30-minute period where the Table 7 (cooling) or the Table 13 (heating) tolerances are satisfied. Otherwise, conduct the calibration tests according to ASHRAE Standard 23–05 (incorporated by reference, see § 430.3), ASHRAE Standard 41.9–2000 (incorporated by reference, see § 430.3), and section 7.4 of ASHRAE Standard 37–2005 (incorporated by reference, see § 430.3).

* * * * *

3.13 Laboratory testing to determine off-mode energy consumption. The below laboratory testing is used to estimate the energy consumption of an air conditioner during the non-cooling seasons, the heating and shoulder seasons that separate the cooling and heating seasons. Testing to estimate the energy consumption of a heat pump during the collective shoulder seasons is also described. The extent of the testing strongly depends on whether the test unit includes a compressor crankcase heater, the heater is thermostatically controlled, and the heater is provided on an air conditioner or heat pump.

3.13.1 Determine if the air conditioner or heat pump has a compressor crankcase heater. If so equipped, turn off the power to the outdoor unit, isolate the leads that supply power to the crankcase heater, measure the resistance of the heater circuit, record the value as

R_{CC}, reconnect the heater's leads, and resupply power to the outdoor unit.

Determine from the manufacturer if the compressor crankcase heater is thermostatically controlled. If the heater is thermostatically controlled, the manufacturer must provide:

a. A value for the outdoor temperature, *T00,* at which the crankcase heater is expected to begin heating if the indoor temperature is above 75 °F and no space conditioning has been needed for a long enough time that the compressor's shell temperature equals the outdoor air temperature; and

b. A value for the outdoor temperature, *T100,* at which the crankcase heater is expected to begin continuous heating if the indoor temperature is above 75 °F and no space conditioning is needed.

3.13.2 For air conditioners not having a compressor crankcase heater, conduct the following off-mode power test.

3.13.2.1 Conduct the test immediately following the final cooling mode test. No requirements are placed on the ambient conditions within the indoor and outdoor test rooms. The room conditions are allowed to change for the duration of this particular test. Configure the controls of the air conditioner to mimic the operating mode if connected to a building thermostat that is set to the OFF mode.

3.13.2.2 Integrate the power consumption of the air conditioner over a 5-minute interval. Calculate the average power consumption rate for the interval. Round this value to the nearest even wattage value and record it as both *P1* and *P2.* Assign R_{CC}=0.

3.13.3 For heat pumps not having a compressor crankcase heater, conduct the following off-mode power test.

3.13.3.1 Conduct the test immediately following the final cooling mode test. No requirements are placed on the ambient conditions within the indoor and outdoor test rooms. The room conditions are allowed to change for the duration of this particular test. Configure the controls of the heat pump to mimic the operating mode if connected to a building thermostat that is set to the COOL mode but whose temperature setpoint is satisfied.

3.13.3.2 Integrate the power consumption of the heat pump over a 5-minute interval. Calculate the average power consumption rate for the interval. Record this value as *P1C.*

3.13.3.3 Re-configure the controls of the heat pump to mimic the operating mode if connected to a building thermostat that is set to the HEAT mode but whose temperature setpoint is satisfied.

3.13.3.4 Integrate the power consumption of the heat pump over a 5-minute interval. Calculate the average power consumption rate for the interval. Record this value as *P1H.*

3.13.3.5 Calculate $P1 = (P1C + P1H)/2$ and round to the nearest even wattage. Assign R_{CC}=0 and *P2*=0.

3.13.4 For air conditioners having a compressor crankcase heater, conduct the following off-mode power test.

3.13.4.1 Conduct the test immediately following the final cooling mode test.

3.13.4.2 If the compressor crankcase heater is not thermostatically controlled, then (1) configure the controls of the air conditioner to mimic the operating mode if connected to a building thermostat set to the OFF mode; (2) assign *T00* = *T100* = 75 °F; and (3) skip to section 3.13.4.5.9.

3.13.4.3 If the compressor crankcase heater is thermostatically controlled and the manufacturer-provided *T100* is greater than or equal to 75 °F, then (1) *T00* and *T100* are deemed verified; (2) configure the controls of the air conditioner to mimic the operating mode if connected to a building thermostat that is set to the OFF mode; and (3) skip to section 3.13.4.5.9.

3.13.4.4.1 Configure the controls of the air conditioner to mimic the operating mode if connected to a building thermostat that is set to the OFF mode. Maintain the dry bulb temperature in the indoor test room between 75 °F and 85 °F.

3.13.4.4.2 Monitor the power consumption of the air conditioner and denote two operating states: (1) Power draw is at a lower level corresponding to no current flowing to the compressor crankcase heater (power-low) and (2) power draw is at the higher level corresponding to the compressor crankcase heater operating (power-high).

3.13.4.4.3 As needed, temporarily depart from the end of test cooling rate (EOTCR) until the outdoor temperature is at least 3 °F higher than *T100* for at least 15 minutes or, if the crankcase heater is observed to cycle on (power-high) at this temperature, keep increasing the outdoor temperature until the compressor crankcase heater remains off (power-low) for at least 15 minutes. The compressor must have cycled off prior to beginning either 15 minute count.

3.13.4.4.4 Re-establish cooling the outdoor test room with the reconditioning system set to provide EOTCR. As the outdoor temperature decreases, monitor the test unit's electrical power and record the outdoor temperature when the first power-high reading is measured. If this measured temperature is equal to or less than *T00* + 2.5 °F, then the manufacturer-provided *T00* is verified. If the measured temperature is greater than *T00* + 2.5 °F, round the measured outdoor temperature to the nearest 2.5 °F increment relative to a 65 °F reference (*e.g.,* 67.5 °F, 70.0 °F, 72.5 °F, * * * or 65.0 °F, 62.5 °F, 60.0 °F, * * *) and designate this rounded value as the new *T00.*

3.13.4.4.5 If the manufacturer-provided *T100* is greater than or equal to *T00* − 10 °F then *T100* is deemed verified. If *T100* > *T00,* then set *T100* = *T00.* Skip to section 3.13.4.5.

3.13.4.4.6 As needed, depart from the EOTCR to obtain and then maintain within ±1.0 °F an outdoor dry bulb temperature that is between 10 °F and 15 °F less than *T00.* During the time that the outdoor temperature is maintained within the ±1.0 °F tolerance, monitor the elapsed time of each power-high interval ($\Delta\tau_{PH}$) and the elapsed time of the power-low interval ($\Delta\tau_{PL}$) that immediately follows. Also monitor the outdoor temperature. Start data collection at the beginning of a power-high interval—elapsed time = 0. If one or more power-high + power-low cycles is completed when the elapsed time equals 20 minutes, discontinue the data collection and proceed to section 3.13.4.4.7. If a power-high interval is completed before the elapsed time equals 30 minutes, monitor until the subsequent power-low interval is finished before discontinuing the data collection and proceeding to section 3.13.4.4.7. If a power-low condition has not started at an elapsed time of 30 minutes or within 45 minutes of first obtaining outdoor conditions that meet the ±1.0 °F tolerance, then assign *T100* = *T00* − 10 °F and skip to section 3.13.4.5.

3.13.4.4.7 Designate the total number of completed power-high + power-low intervals from section 3.13.4.4.6 as N_{CC}. Calculate the average outdoor temperature recorded over the corresponding interval of complete cycles and designate it as T_{CC}. Calculate the average percent on-time of the crankcase heater, F_{CC}, using

$$F_{CC} = \frac{\sum_{1}^{N_{HL}} \Delta\tau_{PH}}{\sum_{1}^{N_{HL}} \left(\Delta\tau_{PH} + \Delta\tau_{PL}\right)} \times 100\%$$

Using the *T00* from section 3.13.4.4.4, F_{CC}, and T_{CC}, estimate the outdoor temperature at which the crankcase heater would first begin to operate continuously:

$$T100(Lab) = \frac{(T_{CC} - T00)°\mathrm{F}}{(F_{CC} - 0)\%} \times (100 - 0)\% + T00$$

$$= T00 - \frac{100}{F_{CC}} \times (T00 - T_{CC})$$

If *T100*(*Lab*) ≤ *T100* + 2.5 °F, then the manufacturer-provided *T100* is verified. If *T100*(*Lab*) > *T100* + 2.5 °F, round *T100*(*Lab*) to the nearest 2.5 °F increment relative to a 65 °F reference (*e.g.,* 67.5 °F, 70.0 °F, 72.5 °F, * * * or 65.0 °F, 62.5 °F, 60.0 °F, * * *) and designate this rounded value as the new *T100.*

3.13.4.4.8 Approximate the percent time on of the crankcase heater at any outdoor temperatures between *T00* and *T100* using

$$F_{CC}(T_j) = \frac{(100 - 0)\%}{(T100 - T00)°\mathrm{F}} \times (T_j - T00) = \frac{T00 - T_j}{T00 - T100} \times 100\%.$$

For outdoor temperatures T_j that are greater than or equal to *T00,* assign $F_{CC}(T_j)$=0. For outdoor temperatures that are less than or equal to *T100,* assign $F_{CC}(T_j)$=100 percent.

3.13.4.5 At this point in the off-mode power test, no requirements are placed on the ambient conditions within the indoor and outdoor test rooms. The room conditions are allowed to change for the duration of this particular test. Temporarily turn off the power to the outdoor unit and safely disable the compressor crankcase heater to prevent it from consuming any electrical power. Re-energize the outdoor unit.

3.13.4.6 Integrate the power consumption of the air conditioner over a 5-minute interval. Calculate the average power consumption rate for the interval. Record the value as *P0.*

3.13.5 For heat pumps having a compressor crankcase heater, conduct the following off-mode power test.

3.13.5.1 The test shall be conducted immediately following the final cooling mode test. Configure the controls of the heat pump to mimic the operating mode if connected to a building thermostat set to the COOL mode but whose temperature setpoint is satisfied.

3.13.5.2 If the compressor crankcase heater is not thermostatically controlled, assign F_{CC}(65 °F) = 100 percent, and skip to section 3.13.5.5.

3.13.5.3 If the compressor crankcase heater is thermostatically controlled and the manufacturer-provided *T100* is greater than or equal to 65 °F, then assign F_{CC}(65 °F) = 100 percent and skip to section 3.13.5.5.

3.13.5.4 If the compressor crankcase heater is thermostatically controlled and the manufacturer-provided *T100* is less than 65 °F, obtain and then maintain the outdoor dry bulb temperature between 64 °F and 66 °F. Maintain the dry bulb temperature in the indoor test room between 75 °F and 85 °F.

3.13.5.4.1 Monitor the power consumption of the heat pump and denote the two operating states: (1) Power draw is at a lower level corresponding to no current flowing to the compressor crankcase heater (power-low); and (2) power draw is at the higher level corresponding to the compressor crankcase heater operating (power-high).

3.13.5.4.2 After the compressor has been off for a minimum of 15 minutes and while the outdoor temperature is between 64 °F and 66 °F, monitor the elapsed time of each power-high interval ($\Delta\tau_{PH}$) and the elapsed time of the power low interval ($\Delta\tau_{PH}$) that immediately follows. Continue monitoring the outdoor temperature.

Start the data collection at the beginning of a power-high interval—elapsed time = 0. If one or more power-high + power-low cycles is completed when the elapsed time equals 20 minutes, discontinue the data collection and proceed to section 3.13.5.4.3. If a power-high interval is completed before the elapsed time equals 30 minutes, monitor until the subsequent power-low interval is finished before discontinuing the data collection and proceeding to section 3.13.5.4.3. If a power-low condition has not started at an elapsed time of 30 minutes or within 45 minutes of first obtaining an outdoor temperature between 64 °F and 66 °F, then assign F_{CC}(65 °F) = 100 percent and skip to section 3.13.5.5.

3.13.5.4.3 Designate the total number of completed power-high + power-low intervals as N_{CC}. Calculate the average outdoor temperature over the corresponding interval of complete cycles and designate it as T_{CC}. Calculate the average percent on-time of the crankcase heater, F_{CC}, using

$$\mathrm{F}_{CC}(Lab) = \frac{\sum_{1}^{N_{HL}} \Delta\tau_{PH}}{\sum_{1}^{N_{HL}} (\Delta\tau_{PH} + \Delta\tau_{PL})} \times 100\%.$$

3.13.5.4.4 Using the manufacturer-provided *T00* and *T100,* along with lab-measured T_{CC}, calculate the expected value of F_{CC}. If T_{CC} ≥ *T00,* then F_{CC} = 0; if T_{CC} ≤ *T100,* then F_{CC} = 100 percent; and if *T100* < T_{CC} < *T00,* then use:

$$F_{CC} = \frac{(T_{CC} - T00)}{(T100 - T00)} \times (100 - 0)\% + 0\% = \frac{(T00 - T_{CC})}{(T00 - T100)} \times 100$$

3.13.5.4.5 If $F_{CC}(Lab) \leq F_{CC} + 5$ percent, then solve the section 3.13.5.4.4 equation for T_{CC} = 65 °F and assign the result as being F_{CC}(65 °F). If $F_{CC}(Lab) > F_{CC} + 5$ percent, round $F_{CC}(Lab)$ to the nearest 5 percent increment (*e.g.,* 5, 10, 15, * * * 95 percent) and designate this rounded value as F_{CC}(65 °F).

3.13.5.5 At this point in the off-mode power test, no requirements are placed on the ambient conditions within the indoor and outdoor test rooms. The room conditions are allowed to change for the duration of this particular test. Temporarily turn off the power to the outdoor unit and safely disable the compressor crankcase heater to prevent it from consuming any electrical power. Re-energize the outdoor unit.

3.13.5.5.1 Integrate the power consumption of the heat pump over a 5-minute interval. Calculate the average power consumption rate for the interval. Record this value as *P0C.*

3.13.5.5.2 Configure the controls of the heat pump to mimic the operating mode if connected to a building thermostat set to the HEAT mode but whose temperature setpoint is satisfied.

3.13.5.5.3 Integrate the power consumption of the heat pump over a 5-minute interval. Calculate the average power consumption rate for the interval. Record this value as *P0H.* Assign $P0 = (P0C + P0H)/2$.

3.13.5.6 Calculate $P1 = P0 + (F_{CC}(65\ °F)/100\%) \times [(230\ V)^2/R_{CC}]$ and round to the nearest even wattage. Assign $P2 = 0$.

3.13.5.7 Re-enable the compressor crankcase heater so that it may operate in its normal manner.

4. Calculations of Seasonal Performance Descriptors

* * * * *

4.1 * * *

When referenced, evaluate BL(T_j) for cooling using * * *

* * * Where:

$\dot{Q}_c^k(95)$ = the space cooling capacity determined from the *A* or A_2 Test, whichever applies, Btu/h.

1.1 = sizing factor, dimensionless.

The temperatures 95 ° and 65 ° in the building load equation represent the selected outdoor design temperature and the zero-load base temperature, respectively.

* * * * *

4.1.1 SEER calculations for an air conditioner or heat pump having a single-speed compressor that was tested with a fixed-speed indoor fan installed, a constant-air-volume-rate indoor fan installed, or with no indoor fan installed. a. Calculate the seasonal energy efficiency ratio, SEER, using Eq. 4.1–1. Evaluate the quantity $q_c(T_j)/N$ in Eq. 4.1–1 using

$$\frac{q_c(T_j)}{N} = X(T_j) \times \dot{Q}_c(T_j) \times \frac{n_j}{N}$$

Where:

$X(T_j)$ = the cooling mode load factor for temperature bin j, dimensionless,

$\dot{Q}_c(T_j)$ = space cooling capacity of the test unit when operating at outdoor temperature T_j, Btu/h, and

$$\frac{n_j}{N} =$$

fractional bin hours for the cooling season; the ratio of the number of hours during the cooling season when the outdoor temperature fell within the range represented by bin temperature T_j to the total number of hours in the cooling season, dimensionless.

Assign

$$\frac{n_j}{N}$$

using the fractional bin hours listed in Table 16. Calculate the space cooling capacity at outdoor temperature T_j using

$$\dot{Q}_c(T_j) = \dot{Q}_c(82) + \frac{\dot{Q}_c(95) - \dot{Q}_c(82)}{95-82} \times (T_j - 82).$$

Determine $\dot{Q}_c(82)$ from the *B* Test, $\dot{Q}_c(95)$, from the *A* Test, and evaluate both in accordance with section 3.3.

Calculate the cooling mode load factor using

$$X(T_j) = \left\{ \begin{matrix} BL(T_j)/\dot{Q}_c(T_j) \\ or \\ 1 \end{matrix} \right\}, \text{ whichever is less.}$$

Use Eq. 4.1–2 to calculate the building load, $BL(T_j)$.

b. Evaluate the quantity $e_c(T_j)/N$ in Eq. 4.1–1 using

$$\frac{e_c(T_j)}{N} = \frac{X(T_j) \cdot \dot{E}_c(T_j)}{PLF_j} \times \frac{n_j}{N}$$

Where:

$\dot{E}_c(T_j)$ = the electrical power consumption of the test unit when operating at outdoor temperature T_j, Btu/h, and

PLF_f = the part load factor for temperature bin *j*, dimensionless.

The quantities $X(T_j)$ and

$$\frac{n_j}{N}$$

are the same quantities as used for calculating

$$\frac{q_c(T_j)}{N}.$$

Calculate the electrical power consumption at outdoor temperature T_j using

$$\dot{E}_c(T_j) = \dot{E}_c(82) + \frac{\dot{E}_c(95) - \dot{E}_c(82)}{95-82} \times (T_j - 82).$$

Determine $\dot{E}_c$ (82) from the *B* Test, $\dot{E}_c$ (95) from the *A* Test, and evaluate both in accordance with section 3.3. Calculate the part load factor using

$$PLF_j = 1 - C_D^c \cdot \left[1 - X\left(T_j\right)\right]$$

c. If the optional tests described in section 3.2.1 are not conducted, set the cooling mode cyclic degradation coefficient, $C_D{}^c$, to the default value specified in section 3.5.3.

* * * * *

4.1.4.2 * * *

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 ($\dot{Q}_c{}^{k=1}(T_1))=BL(T_1)$), °F. Determine T_1 by equating Eqs. 4.1.3–1 and 4.1–2 and solving for outdoor temperature. Alternatively, T_1 may be determined as specified in section 10.2.4 of ASHRAE Standard 116–95 (RA 05) (incorporated by reference, see § 430.3).

T_2 = the outdoor temperature at which the unit, when operating at the intermediate compressor speed used during the section 3.2.4 E_V Test, 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 Eqs. 4.1.4–1 and 4.1–2 and solving for outdoor temperature. Alternatively, T_2 may be determined as specified in section 10.2.4 of ASHRAE Standard 116–95 (RA 05) (incorporated by reference, see § 430.3).

* * * * *

4.1.5 SEER calculations for an air conditioner or heat pump having a single indoor unit with multiple blowers. Calculate SEER using Eq. 4.1–1, where q_c (T_j)/*N* and e_c (T_j)/*N* are evaluated as specified in applicable below subsection.

4.1.5.1 For multiple blower systems that are connected to a lone, single-speed outdoor unit.

a. Calculate the space cooling capacity, $\dot{Q}_c{}^{k=1}$ (T_j), and electrical power consumption, $\dot{E}_c{}^{k=1}$ (T_j), of the test unit when operating at the cooling minimum air volume rate and outdoor temperature T_j using the equations given in section 4.1.2.1. Calculate 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 the cooling full-load air volume rate and outdoor temperature T_j using the equations given in section 4.1.2.1. In evaluating the section 4.1.2.1 equations, determine the quantities $\dot{Q}_c{}^{k=1}$ (82) and $\dot{E}_c{}^{k=1}$ (82) from the B_1 Test, $\dot{Q}_c{}^{k=1}$ (95) and $\dot{E}_c{}^{k=1}$ (95) from the A_1 Test, $\dot{Q}_c{}^{k=2}$ (82) and $\dot{E}_c{}^{k=2}$ (82) from the B_2 Test, and $\dot{Q}_c{}^{k=2}$ (95) and from the A_2 Test. Evaluate all eight quantities as specified in section 3.3. Refer to section 3.2.2.1 and Table 4 for additional information on the four referenced laboratory tests.

b. Determine the cooling mode cyclic degradation coefficient, $C^c{}_D$, as per sections 3.2.2.1 and 3.5 to 3.5.3. Assign this same value to $C^c{}_D(K{=}2)$.

c. Except for using the above values of $\dot{Q}_c{}^{k=1}$ (T_j), $\dot{E}_c{}^{k=1}$ (T_j), $\dot{Q}_c{}^{k=2}$ (T_j), $\dot{E}_c{}^{k=2}$ (T_j), $C^c{}_D$, and $C^c{}_D$ (k = 2), calculate the quantities q_c (T_j)/*N* and e_c (T_j)/*N* as specified in section 4.1.3.1 for cases where $\dot{Q}_c{}^{k=1}$ (T_j) ≥ *BL* (T_j). For all other outdoor bin temperatures, T_j, calculate q_c (T_j)/*N* and e_c (T_j)/*N* as specified in section 4.1.3.3 if $\dot{Q}_c{}^{k=2}$ (T_j) > *BL* (T_j) or as specified in section 4.1.3.4 if $\dot{Q}_c{}^{k=2}$ (T_j) ≤ *BL* (T_j).

4.1.5.2 For multiple blower systems that are connected to either a lone outdoor unit having a two-capacity compressor or to two separate but identical model single-speed outdoor units.

Calculate the quantities q_c (T_j)/*N* and e_c (T_j)/*N* as specified in section 4.1.3.

* * * * *

4.1.6 Region-specific SEER calculations for a hot-dry climatic region, SEER–HD. Calculate SEER–HD, expressed in units of Btu/W×h, using:

$$SEER-HD = \frac{\sum_{j=1}^{10} q_{HD}\left(T_j\right)}{\sum_{j=1}^{10} e_{HD}\left(T_j\right)} = \frac{\sum_{j=1}^{10} \frac{q_{HD}\left(T_j\right)}{N}}{\sum_{j=1}^{10} \frac{e_{HD}\left(T_j\right)}{N}} \qquad \text{Eq. 4.1.6-1}$$

Where:

$\frac{q_{HD}\left(T_j\right)}{N}$ = for the hot-dry climatic region, the ratio of the total space cooling delivered during periods of the space cooling season when the outdoor temperature fell within the range represented by bin temperature T_j to the total number of hours in the cooling season (*N*), Btu/h.

$\frac{e_{HD}\left(T_j\right)}{N}$ = for the hot-dry climatic region, the ratio of the total electrical energy consumed by the test unit during periods of the space cooling season when the outdoor temperature fell within the range represented by bin temperature T_j to the total number of hours in the cooling season (*N*), W.

T_j = the outdoor bin temperature, °F. Outdoor temperatures are grouped or "binned." Use bins of 5 °F with the 10 dry climate bin temperatures being 67, 72, 77, 82, 87, 92, 97, 102, 107, and 112 °F.

j = the bin number. For dry climate seasonal calculations, *j* ranges from 1 to 10.

When referenced, evaluate the dry climate building load $BL_{HD}(T_j)$ using

$$BL_{HD}\left(T_j\right) = \frac{\left(T_j - 65\right)}{90-65} \times \frac{\dot{Q}_{HD}^{*}(95)}{1.1} \qquad \text{Eq. 4.1.6-2}$$

Where:

$\dot{Q}^*_{HD}$ (95) = the space cooling capacity determined from the *AD* or AD_2 Test, whichever applies, Btu/h, and

1.1 = sizing factor, dimensionless.

The temperatures 95 °F and 65 °F in the building load equation represent the outdoor design temperature and the zero-load temperature, respectively, for the hot-dry climatic region.

4.1.6.1 SEER–HD calculations for an air conditioner or heat pump having a single-speed compressor that was tested with a fixed-speed indoor fan installed, a constant-air-volume-rate fan installed, or with no indoor fan installed. Calculate SEER–HD using Eq. 4.1.6–1. Evaluate the quantities $q_{HD}(T_j)/N$ and $e_{HD}(T_j)/N$ in Eq. 4.1.6–1 as specified in section 4.1.1 for $q_c(T_j)/N$ and $e_c(T_j)/N$, respectively, only now replacing the quantities $\dot{Q}_c(T_j)$ and $\dot{E}_c(T_j)$ with $\dot{Q}_{HD}(T_j)$ and $\dot{E}_{HD}(T_j)$. Also, use the fractional bin hours, $n_j)/N$, given in Table 16a rather than the values listed in Table 16.

Calculate $\dot{Q}_{HD}(T_j)$ using the section 4.1.1 equation for $\dot{Q}_c(T_j)$, replacing $\dot{Q}_c(95)$ and $\dot{Q}_c(82)$ with $\dot{Q}_{HD}(95)$ and $\dot{Q}_{HD}(82)$, respectively. Calculate $\dot{E}_{HD}(T_j)$ using the section 4.1.1 equation for $\dot{E}_c(T_j)$, replacing $\dot{E}_c(95)$ and $\dot{E}_c(82)$ with $\dot{E}_{HD}(95)$ and $\dot{E}_{HD}(82)$, respectively. Determine $\dot{Q}_{HD}(95)$ and $\dot{E}_{HD}(95)$ from the *AD* Test described in section 3.2.1 and conducted in accordance with section 3.3. Determine $\dot{Q}_{HD}(82)$ and $\dot{E}_{HD}(82)$ using the section 3.2.1 default equations or from the *BD* Test described in section 3.2.1 and conducted in accordance with section 3.3.

Replace section 4.1.1 references to $BL(T_j)$ with $BL_{HD}(T_j)$, as evaluated using Eq. 4.1.6–2. In evaluating Eq. 4.1.6–2, set $\dot{Q}_{HD}{}^*(90)$ equal to the value obtained from solving the equation for $\dot{Q}_{HD}(T_j)$ at $T_j = 90\,°F$.

If it helps the user, the remaining section 4.1.1 calculation parameters of $X(T_j)$ and PLF_j may also be designated as their dry climate versions by adding a subscript "HD" when calculating SEER–HD. Finally, use the section 4.1.1 value of $C_D{}^c$ that was used to calculate SEER to also calculate SEER–HD.

4.1.6.2 SEER–HD calculations for an air conditioner or heat pump having a single-speed compressor and a variable-speed variable-air-volume rate indoor fan.

4.1.6.2.1 Units covered by section 3.2.2.1 where the indoor fan capacity modulation correlates with the outdoor dry bulb temperature. The manufacturer must provide information on how the indoor air volume rate or the indoor fan speed varies over the outdoor temperature range of 67 °F to 112 °F. Calculate SEER–HD using Eq. 4.1.6–1. Evaluate the quantities $q_{HD}(T_j)/N$ and $e_{HD}(T_j)/N$ in Eq. 4.1.6–1 as specified in section 4.1.2.1 for $q_c(T_j)/N$ and $e_c(T_j)/N$, respectively, only now replacing the quantities $\dot{Q}_c(T_j)$ and $\dot{E}_c(T_j)$ with $\dot{Q}_{HD}(T_j)$ and $\dot{E}_{HD}(T_j)$. Also, use the fractional bin hours, n_j/N, given in Table 16a rather than the values listed in Table 16.

Calculate $\dot{Q}_{HD}(T_j)$ using Eq. 4.1.2–2, where $\dot{Q}_{HD}(T_j)$, $\dot{Q}_{HD}{}^{k=2}(T_j)$, and $\dot{Q}_{HD}{}^{k=1}(T_j)$ replace $\dot{Q}_c(T_j)$, $\dot{Q}_c{}^{k=2}(T_j)$, and $\dot{Q}_c{}^{k=1}(T_j)$, respectively. Use the section 4.1.2.1 equations for $\dot{Q}_c{}^{k=1}(T_j)$ and $\dot{Q}_c{}^{k=2}(T_j)$ to calculate $\dot{Q}_{HD}{}^{k=1}(T_j)$ and $\dot{Q}_{HD}{}^{k=2}(T_j)$, respectively. In evaluating these equations, use $\dot{Q}_{HD}{}^{k=1}(82)$, $\dot{Q}_{HD}{}^{k=1}(95)$, $\dot{Q}_{HD}{}^{k=2}(82)$, and $\dot{Q}_{HD}{}^{k=2}(95)$. Determine $\dot{Q}_{HD}{}^{k=2}(95)$, and $\dot{Q}_{HD}{}^{k=1}(95)$ from the AD_2 and AD_1 Tests described in section 3.2.2.1 and conducted in accordance with section 3.3. Determine $\dot{Q}_{HD}{}^{k=2}(82)$ and $\dot{Q}_{HD}{}^{k=1}(82)$ using the section 3.2.2.1 default equations or from the BD_2 and BD_1 Tests described in section 3.2.2.1 and conducted in accordance with section 3.3.

Calculate $\dot{E}_{HD}(T_j)$ using Eq. 4.1.2–4, where $\dot{E}_{HD}(T_j)$, $\dot{E}_{HD}{}^{k=2}(T_j)$, and $\dot{E}_{HD}{}^{k=1}(T_j)$ replace $\dot{E}_c(T_j)$, $\dot{E}_c{}^{k=2}(T_j)$, and $\dot{E}_c{}^{k=1}(T_j)$, respectively. Use the section 4.1.2.1 equations for $\dot{E}_c{}^{k=1}(T_j)$ and $\dot{E}_c{}^{k=2}(T_j)$ to calculate $\dot{E}_{HD}{}^{k=1}(T_j)$ and $\dot{E}_{HD}{}^{k=2}(T_j)$, respectively. In evaluating these equations, use $\dot{E}_{HD}{}^{k=1}(82)$, $\dot{E}_{HD}{}^{k=1}(95)$, $\dot{E}_{HD}{}^{k=2}(82)$, and $\dot{E}_{HD}{}^{k=2}(95)$. Determine $\dot{E}_{HD}{}^{k=2}(95)$ and $\dot{E}_{HD}{}^{k=1}(95)$ from the AD_2 and AD_1 Tests described in section 3.2.2.1 and conducted in accordance with section 3.3. Determine $\dot{E}_{HD}{}^{k=2}(82)$ and $\dot{E}_{HD}{}^{k=1}(82)$ using the section 3.2.2.1 default equations or from the BD_2 and BD_1 Tests described in section 3.2.2.1 and conducted in accordance with section 3.3.

Replace section 4.1.2.1 references to $BL(T_j)$ with $BL_{HD}(T_j)$, as evaluated using Eq. 4.1.6–2. In evaluating Eq. 4.1.6–2, set $\dot{Q}_{HD}{}^*(90)$ equal to the value obtained from solving the equation for $\dot{Q}_{HD}{}^{k=2}(T_j)$ at $T_j = 90\,°F$. The parameters $FP_c{}^{k=1}$, $FP_c{}^{k=2}$, and $FP_c(T_j)$ denote the fan speeds described in section 4.1.2.1, only now as applied to the dry climate configuration and, in the case of the first two variables, as used for the AD_1 and AD_2 Tests.

If it helps the user, the remaining section 4.1.2.1 calculation parameters of $X(T_j)$ and PLF_j may also be designated as their dry climate versions by adding a subscript "HD" when calculating SEER–HD. Finally, use the section 4.1.2.1 value of $c_D{}^c$ used to calculate SEER to also calculate SEER–HD.

4.1.6.2.2 Units covered by section 3.2.2 where indoor fan capacity modulation is used to adjust the sensible to total cooling capacity ratio. Calculate SEER–HD as specified in section 4.1.6.1.

4.1.6.3 SEER–HD calculations for an air conditioner or heat pump having a two-capacity compressor.

Calculate SEER–HD using Eq. 4.1.6–1. Evaluate the quantities $q_{HD}(T_j)/N$ and $e_{HD}(T_j)/N$ in Eq. 4.1.6–1 as specified for $q_c(T_j)/N$ and $e_c(T_j)/N$, respectively, in sections 4.1.3.1, 4.1.3.2, 4.1.3.3, and 4.1.3.4, as appropriate, only now replacing the quantities $\dot{Q}_c{}^k(T_j)$ and $\dot{E}_c{}^k(T_j)$ with $\dot{Q}_{HD}{}^k(T_j)$ and $\dot{E}_{HD}{}^k(T_j)$. Also, use the fractional bin hours, n_j/N, given in Table 16a rather than the values listed in Table 16.

Calculate $\dot{Q}_{HD}{}^{k=1}(T_j)$ using Eq. 4.1.3–1, where $\dot{Q}_{HD}{}^{k=1}(T_j)$, $\dot{Q}_{HD}{}^{k=1}(82)$, and $\dot{Q}_{HD}{}^{k=1}(67)$, replace $\dot{Q}_c{}^{k=1}(T_j)$, $\dot{Q}_c{}^{k=1}(82)$, and $\dot{Q}_c{}^{k=1}(67)$, respectively. Calculate $\dot{Q}_{HD}{}^{k=2}(T_j)$ using Eq. 4.1.3–3 where $\dot{Q}_{HD}{}^{k=2}(T_j)$, $\dot{Q}_{HD}{}^{k=2}(95)$, and $\dot{Q}_{HD}{}^{k=2}(82)$ replace $\dot{Q}_c{}^{k=2}(T_j)$, $\dot{Q}_c{}^{k=2}(95)$, and $\dot{Q}_c{}^{k=2}(82)$, respectively. Determine $\dot{Q}_{HD}{}^{k=2}(95)$ and $\dot{Q}_{HD}{}^{k=1}(82)$ from the AD_2 and BD_1 Tests described in section 3.2.3 and conducted in accordance with section 3.3. Determine $\dot{Q}_{HD}{}^{k=2}(82)$ and $\dot{Q}_{HD}{}^{k=1}(67)$ using the section 3.2.3 default equations or from the BD_2 and FD_1 Tests described in section 3.2.3 and conducted in accordance with section 3.3.

Calculate $\dot{E}_{HD}{}^{k=1}(T_j)$ using Eq. 4.1.3–2, where $\dot{E}_{HD}{}^{k=1}(T_j)$, $\dot{E}_{HD}{}^{k=1}(82)$, and $\dot{E}_{HD}{}^{k=1}(67)$, replace $\dot{E}_c{}^{k=1}(T_j)$, $\dot{E}_c{}^{k=1}(82)$, and $\dot{E}_c{}^{k=1}(67)$, respectively. Calculate $\dot{E}_{HD}{}^{k=2}(T_j)$ using Eq. 4.1.3–4, where $\dot{E}_{HD}{}^{k=2}(T_j)$, $\dot{E}_{HD}{}^{k=2}(95)$, and $\dot{E}_{HD}{}^{k=2}(82)$, replace $\dot{E}_c{}^{k=2}(T_j)$,$\dot{E}_c{}^{k=2}(95)$, and $\dot{E}_c{}^{k=2}(82)$, respectively. Determine $\dot{E}_{HD}{}^{k=2}(95)$ and $\dot{E}_{HD}{}^{k=1}(82)$ from the AD_2 and BD_1 Tests described in section 3.2.3 and conducted in accordance with section 3.3. Determine $\dot{E}_{HD}{}^{k=2}(82)$ and $\dot{E}_{HD}{}^{k=1}(67)$ using the section 3.2.3 default equations or from the BD_2 and FD_1 Tests described in section 3.2.3 and conducted in accordance with section 3.3.

Replace section 4.1.3 to 4.1.3.4 references to $BL(T_j)$ with $BL_{HD}(T_j)$, as evaluated using Eq. 4.1.6–2. In evaluating Eq. 4.1.6–2, set $\dot{Q}^*{}_{HD}(90)$ equal to the value obtained from solving the equation for $\dot{Q}_{HD}{}^{k=2}(T_j)$ at $T_j = 90\,°F$.

If it helps the user, the remaining section 4.1.3 to 4.1.3.4 calculation parameters of $X^{k=1}(T_j)$, $X^{k=2}(T_j)$, and PLF_j may also be designated as their dry climate versions by adding a subscript "HD" when calculating SEER–HD. Finally, use the section 4.1.3.1 value of $C_D{}^c$ and the section 4.1.3.3 value of $C_D{}^c(k = 2)$ that were used to calculate SEER to also calculate SEER–HD.

4.1.6.4 SEER–HD calculations for an air conditioner or heat pump having a variable-speed compressor.

Calculate SEER–HD using Eq. 4.1.6–1. Evaluate the quantities $q_{HD}\,(T_j)$ / N and $e_{HD}\,(T_j)$ / N in Eq. 4.1.6–1 as specified for $q_c\,(T_j)$ / N, and $e_c\,(T_j)$ / N, respectively, in sections 4.1.4.1, 4.1.4.2, and 4.1.4.3, as appropriate only now replacing the quantities $\dot{Q}^k{}_c\,(T_j)$ and $\dot{E}^k{}_c\,(T_j)$ with $\dot{Q}^k{}_{HD}\,(T_j)$ and $\dot{E}^k{}_{HD}\,(T_j)$. Also, use the fractional bin hours, n_j/N, given in Table 16a rather than the values listed in Table 16.

Calculate $\dot{Q}_{HD}{}^{k=1}\,(T_j)$ using Eq. 4.1.3–1, where $\dot{Q}_{HD}{}^{k=1}\,(T_j)$, $\dot{Q}_{HD}{}^{k=1}\,(82)$, and $\dot{Q}_{HD}{}^{k=1}\,(67)$, replace $\dot{Q}_c{}^{k=1}\,(T_j)$, $\dot{Q}_c k^{=1}$ (82), and $\dot{Q}_c{}^{k=1}$ (67), respectively. Calculate $\dot{Q}_{HD}{}^{k=2}\,(T_j)$ using Eq. 4.1.3–3 where $\dot{Q}_{HD}{}^{k=2}\,(T_j)$, $\dot{Q}_{HD}{}^{k=2}$ (82) replace $\dot{Q}_c{}^{k=2}\,(T_j)$, $\dot{Q}_{ck}{}^{=2}$ (95), and $\dot{Q}_c{}^{k=2}$ (82), respectively. Determine $\dot{Q}_{HD}{}^{k=2}$ (95) and $\dot{Q}_{HD}{}^{k=1}$ (82) from the AD_2 and BD^1 Tests described in section 3.2.4 and conducted in accordance with section 3.3. Determine $\dot{Q}_{HD}{}^{k=2}$ (82) and $\dot{Q}_{HD}{}^{k=1}$ (67) using the section 3.2.3 default equations or from the BD_2 and FD^1 Tests described in section 3.2.4 and conducted in accordance with section 3.3.

Calculate $\dot{E}_{HD}^{k=1}(T_j)$ using Eq. 4.1.3–2, where $\dot{E}_{HD}^{k=1}(T_j)$, $\dot{E}_{HD}^{k=1}(82)$, and $\dot{E}_{HD}^{k=1}(67)$, replace $\dot{E}_c^{k=1}(T_j)$, $\dot{E}_c^{k=1}(82)$, and $\dot{E}_c^{k=1}(67)$, respectively. Calculate $\dot{E}_{HD}^{k=2}(T_j)$, using Eq. 4.1.3–4, where $\dot{E}_{HD}^{k=2}(T_j)$, $\dot{E}_{HD}^{k=2}(95)$, and $\dot{E}_{HD}^{k=2}(82)$ replace $\dot{E}_c^{k=2}(T_j)$, $\dot{E}_c^{k=2}(95)$, and $\dot{E}_c^{k=2}(82)$, respectively. Determine $\dot{E}_{HDk}{=2}(95)$ and $\dot{E}_{HD}^{k=2}(82)$ from the AD_2 and BD^1 Tests described in section 3.2.4 and conducted in accordance with section 3.3. Determine $\dot{E}_{HD}^{k=2}(82)$ and $\dot{E}_{HD}^{k=1}(67)$ using the section 3.2.3 default equations or from the BD_2 and FD_3 Tests described in section 3.2.4 and conducted in accordance with section 3.3.

Approximate the performance of the air conditioner and heat pump had it been tested for its steady-state, dry climate, intermediate speed ($k = v$) performance at an outdoor dry bulb temperature of 87 °F using the following equations.

$$\dot{Q}_{HD}^{k=v}(87) = \dot{Q}_{HD}^{k=1}(87) + \frac{1}{3} \times \left[\dot{Q}_{HD}^{k=2}(87) - \dot{Q}_{HD}^{k=1}(87)\right]$$

$$\dot{E}_{HD}^{k=v}(87) = \dot{E}_{HD}^{k=1}(87) + \frac{1}{3} \times \left[\dot{E}_{HD}^{k=2}(87) - \dot{E}_{HD}^{k=1}(87)\right]$$

Where:

$\dot{Q}_{HD}^{k=1}(87)$ and $\dot{Q}_{HD}^{k=2}(87)$ = obtained by solving the equations for $\dot{Q}_{HD}^{k=1}(T_j)$ and $\dot{Q}_{HD}^{k=2}(T_j)$ for T_j = 87 °F, and $\dot{E}_{HD}^{k=1}(87)$, and

$\dot{E}_{HD}^{k=2}(87)$ = obtained by solving the equations for $\dot{E}_{HD}^{k=1}(T_j)$ and $\dot{E}_{HD}^{k=2}(T_j)$ for T_j = 87 °F.

Calculate $\dot{Q}_{HD}^{k=v}(T_j)$ using Eq. 4.1.4–1, where $\dot{Q}_{HD}^{k=v}(T_j)$ and $\dot{Q}_{HD}^{k=v}(87)$ replace $\dot{Q}_c^{k=v}(T_j)$ and $\dot{Q}_c^{k=v}(87)$, respectively. Calculate $\dot{E}_{HD}^{k=v}(T_j)$ using Eq. 4.1.4–2, where $\dot{E}_{HD}^{k=v}(T_j)$ and $\dot{E}_{HD}^{k=v}(87)$ replace $\dot{E}_c^{k=v}(T_j)$ and $\dot{E}_c^{k=v}(87)$, respectively.

Replace section 4.1.4 to 4.1.4.3 references to $BL(T_j)$ with $BL_{HD}(T_j)$, as evaluated using Eq. 4.1.6–2. In evaluating Eq. 4.1.6–2, set $\dot{Q}_{HD}(90)$ equal to the value obtained from solving the equation for $\dot{Q}_{HD}^{k=2}(T_j)$ at T_j = 90 °F.

If it helps the user, the remaining section 4.1.4 to 4.1.4.3 calculation parameters of M_Q, M_E, N_Q, N_E, $ERR^{k=1}(T_j)$, A, B, C, D, T_1, T_v, T_2, $EER^{k=1}(T_1)$, $EER^{k=v}(T_v)$, $EER^{k=2}(T_2)$, $X^{k=1}(T_j)$, and PLF_j may also be designated as their dry climate versions by adding a subscript "HD" when calculating SEER–HD. Finally, use the section 4.1.4.1 value of $C^c{}_D$ used to calculate SEER to also calculate SEER–HD.

TABLE 16a—DISTRIBUTION OF FRACTIONAL BIN HOURS WITHIN THE HOT-DRY CLIMATIC REGION

Bin No. *j*	Bin temperature range °F	Representative temperature for bin *j* °F	Fraction of total temperature bin hours n_j/N
1	65–69	67	0.477
2	70–74	72	0.208
3	75–79	77	0.119
4	80–84	82	0.086
5	85–89	87	0.047
6	90–94	92	0.027
7	95–99	97	0.021
8	100–104	102	0.011
9	105–109	107	0.004
10	110–114	112	0.000

* * * * *

4.2 * * *

4. For triple-capacity, northern heat pumps (Definition 1.47), $\dot{Q}_h^k(47) = \dot{Q}_h^{k=2}(47)$, the space heating capacity determined from the $H1_2$ Test.

For HSPF calculations for all heat pumps, see either section 4.2.1, 4.2.2, 4.2.3, 4.2.4, or 4.2.6, whichever applies.

* * * * *

4.2.4.2 * * *

T_4 = the outdoor temperature at which the heat pump, when operating at maximum compressor speed, provides a space heating capacity equal to the building load ($\dot{Q}_h^{k=2}(T_4) = BL(T_4)$), °F. Determine T_4 by equating Eqs. 4.2.2–3 (k=2) and 4.2–2 and solving for outdoor temperature. Alternatively T_4 may be determined as specified in section 10.2.4 of ASHRAE Standard 116–95 (RA 05) (incorporated by reference, see § 430.3).

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4.2.6 Additional steps for calculating the HSPF of a heat pump having a triple-capacity compressor. The only triple-capacity heat pumps covered at this time are triple-capacity, northern heat pumps as defined in section 1.45. For such heat pumps, the calculation of the Eq. 4.2–1 quantities

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

differ depending on whether the heat pump would cycle on and off at low capacity (section 4.2.6.1), cycle on and off at high capacity (section 4.2.6.2), cycle on and off at booster capacity (4.2.6.3), cycle between low and high capacity (section 4.2.6.4), cycle between high and booster capacity (section 4.2.6.5), operate continuously at low capacity (4.2.6.6), operate continuously at high capacity (section 4.2.6.7), operate continuously at booster capacity (4.2.6.8), or heat solely using resistive heating (also section 4.2.6.8) in responding to the building load. As applicable, the manufacturer must supply information regarding the outdoor temperature range at which each stage of compressor capacity is active. Information of the type shown in the example table below is required in such cases.

Compressor capacity	Outdoor temperature range of operation
Low (k=1)	40 °F ≤ T ≤ 65 °F
High (k=2)	20 °F ≤ T ≤ 50 °F
Booster (k=3)	−20 °F ≤ T ≤ 30 °F

a. Evaluate the space heating capacity and electrical power consumption of the heat pump when operating at low compressor capacity and outdoor temperature T_j using the equations given in section 4.2.3 for $\dot{Q}_h^{k=1}(T_j)$ and $\dot{E}_h^{k=1}(T_j)$ In evaluating the section 4.2.3 equations, determine the inputs $\dot{Q}_h^{k=1}(62)$ and $\dot{E}_h^{k=1}(62)$ from the HO_1 Test and determine $\dot{Q}_h^{k=1}(47)$ and $\dot{E}_h^{k=1}(47)$ from the $H1_1$ Test. Calculate all four quantities as specified in section 3.7. If, in accordance with section 3.6.6, the $H3_1$ Test is conducted, calculate $\dot{Q}_h^{k=1}(17)$ and $\dot{E}_h^{k=1}(17)$ as specified in section 3.10 and determine $\dot{Q}_h^{k=1}(35)$ and $\dot{E}_h^{k=1}(35)$ as specified in section 3.6.6.

b. Evaluate the space heating capacity and electrical power consumption of the heat pump when operating at high compressor capacity and outdoor temperature T_j [$\dot{Q}_h^{k=2}(T_j)$ and $\dot{E}_h^{k=2}(T_j)$] by solving Eqs. 4.2.2–3 and 4.2.2–4, respectively, for k = 2. Determine the equation inputs $\dot{Q}_h^{k=2}(47)$ and $\dot{E}_h^{k=2}(47)$ from the $H1_2$ Test, evaluated as specified in section 3.7. Determine the equation inputs $\dot{Q}_h^{k=2}(35)$ and $\dot{E}_h^{k=2}(35)$ from the $H2_2$ Test, evaluated as specified in section 3.9.1. Also, determine the equation inputs $\dot{Q}_h^{k=2}(17)$ and $\dot{E}_h^{k=2}(17)$ from the $H3_2$ Test, evaluated as specified in section 3.10.

c. Evaluate the space heating capacity and electrical power consumption of the heat pump when operating at booster compressor capacity and outdoor temperature T_j using

$$\dot{Q}_h^{k=3}(T_j) = \begin{cases} \dot{Q}_h^{k=3}(17) + \dfrac{\left[\dot{Q}_h^{k=3}(35) - \dot{Q}_h^{k=3}(17)\right] \times (T_j - 17)}{35 - 17}, & if\ 17 < T_j \le 45°F \\ \dot{Q}_h^{k=3}(2) + \dfrac{\left[\dot{Q}_h^{k=3}(17) - \dot{Q}_h^{k=3}(2)\right] \times (T_j - 2)}{17 - 2}, & if\ T_j \le 17°F \end{cases}$$

$$\dot{E}_h^{k=3}(T_j) = \begin{cases} \dot{E}_h^{k=3}(17) + \dfrac{\left[\dot{E}_h^{k=3}(35) - \dot{E}_h^{k=3}(17)\right] \times (T_j - 17)}{35 - 17}, & if\ 17 < T_j \le 45°F \\ \dot{E}_h^{k=3}(2) + \dfrac{\left[\dot{E}_h^{k=3}(17) - \dot{E}_h^{k=3}(2)\right] \times (T_j - 2)}{17 - 2}, & if\ T_j \le 17°F \end{cases}$$

Determine the inputs $\dot{Q}_h^{k=3}(17)$ and $\dot{E}_h^{k=3}(17)$ from the $H3_3$ Test and determine $\dot{Q}_h^{k=3}(2)$ and $\dot{E}_h^{k=3}(2)$ from the $H4_3$ Test. Calculate all four quantities as specified in section 3.10. Determine the inputs $\dot{Q}_h^{k=3}(35)$ and $\dot{E}_h^{k=3}(35)$ as specified in section 3.6.6.

4.2.6.1 Steady-state space heating capacity when operating at low compressor capacity is greater than or equal to the building heating load at temperature T_j, $\dot{Q}_h^{k=1}(T_j) \ge BL(T_j)$, and the heat pump permits low compressor capacity operation at T_j. Evaluate the quantities

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

using Eqs. 4.2.3–1 and 4.2.3–2, respectively. Determine the equation inputs $X^{k=1}(T_j)$, PLF_j, and $\delta'(T_j)$ as specified in section 4.2.3.1. In calculating the part load factor, PLF_j, use the low-capacity cyclic-degradation coefficient C_D^h [or equivalently, $C_D^h(k = 1)$] determined in accordance with section 3.6.6.

4.2.6.2 Heat pump only operates at high (k = 2) compressor capacity at temperature T_j and its capacity is greater than or equal to the building heating load, $\dot{Q}_h^{k=1}(T_j) \ge BL(T_j)$. Evaluate the quantities

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

as specified in section 4.2.3.3. Determine the equation inputs $X^{k=2}(T_j)$, PLF_j, and $\delta'(T_j)$ as specified in section 4.2.3.3. In calculating the part load factor, PLF_j, use the high-capacity cyclic-degradation coefficient, $C_D^h(k = 2)$] determined in accordance with section 3.6.6.

4.2.6.3 Heat pump only operates at booster (k = 3) capacity at temperature T_j and its capacity is greater than or equal to the building heating load, $\dot{Q}_h^{k=3}(T_j) \ge BL(T_j)$.

Calculate $\dfrac{RH(T_j)}{N}$ using Eq. 4.2.3-2. Evaluate $\dfrac{e_h(T_j)}{N}$ using

$$\frac{e_h(T_j)}{N} = \frac{X^{k=3}(T_j) \times \dot{E}_h^{k=3}(T_j) \times \delta'(T_j)}{PLF_j} \times \frac{n_j}{N}$$

Where:

$$X^{k=3}(T_j) = BL(T_j) / \dot{Q}_h^{k=3}(T_j), \text{ and } PLF_j = 1 - C_D^h(k=3) \times \left[1 - X^{k=3}(T_j)\right]$$

Determine the low temperature cut-out factor, $\delta'(T_j)$, using Eq. 4.2.3–3. Use the booster-capacity cyclic-degradation coefficient, $C_D{}^h(k = 3)$, determined in accordance with section 3.6.6.

4.2.6.4 Heat pump alternates between low (k = 1) and high (k = 2) compressor capacity to satisfy the building heating load at temperature T_j, $\dot{Q}_h{}^{k=1}(T_j) < BL(T_j) < \dot{Q}_h{}^{k=2}(T_j)$.

Evaluate the quantities

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

as specified in section 4.2.3.2. Determine the equation inputs $X^{k=1}(T_j)$, $X^{k=2}(T_j)$, and $\delta'(T_j)$ as specified in section 4.2.3.2.

4.2.6.5 Heat pump alternates between high (k = 2) and booster (k = 3) compressor capacity to satisfy the building heating load at temperature T_j, $\dot{Q}_h{}^{k=2}(T_j) < BL(T_j) < \dot{Q}_h{}^{k=3}(T_j)$.

$$\text{Calculate } \frac{RH(T_j)}{N} \text{ using Eq. 4.2.3-2. Evaluate } \frac{e_h(T_j)}{N} \text{ using}$$

$$\frac{e_h(T_j)}{N} = \left[X^{k=2}(T_j) \cdot \dot{E}_h^{k=2}(T_j) + X^{k=3}(T_j) \cdot \dot{E}_h^{k=3}(T_j)\right] \cdot \delta'(T_j) \cdot \frac{n_j}{N}$$

Where:

$$X^{k=2}(T_j) = \frac{\dot{Q}_h^{k=3}(T_j) - BL(T_j)}{\dot{Q}_h^{k=3}(T_j) - \dot{Q}_h^{k=2}(T_j)}, \text{ and}$$

$X^{k=3}(T_j) = X^{k=2}(T_j) =$ the heating mode, booster capacity load factor for temperature bin j, dimensionless.

Determine the low temperature cut-out factor, $\delta'(T_j)$, using Eq. 4.2.3–3.

4.2.6.6 Heat pump only operates at low (k = 1) capacity at temperature T_j and its capacity is less than the building heating load, $BL(T_j) > \dot{Q}_h{}^{k=1}(T_j)$.

$$\frac{e_h(T_j)}{N} = \dot{E}_h^{k=1}(T_j) \times \delta'(T_j) \times \frac{n_j}{N} \text{ and } \frac{RH(T_j)}{N} = \frac{BL(T_j) - \left[\dot{Q}_h^{k=1}(T_j) \times \delta'(T_j)\right]}{3.413 \frac{\text{Btu/h}}{\text{W}}} \times \frac{n_j}{N}$$

where the low temperature cut-out factor, $\delta'(T_j)$, is calculated using Eq. 4.2.3–3.

4.2.6.7 Heat pump only operates at high (k = 2) capacity at temperature T_j and its capacity is less than the building heating load, $BL(T_j) > \dot{Q}_h{}^{k=2}(T_j)$. Evaluate the quantities

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

as specified in section 4.2.3.4. Calculate $\delta''(T_j)$ using the equation given in section 4.2.3.4.

4.2.6.8 Heat pump only operates at booster (k = 3) capacity at temperature T_j and its capacity is less than the building heating load, $BL(T_j) > \dot{Q}_h{}^{k=3}(T_j)$, or the system converts to using only resistive heating.

$$\frac{e_h(T_j)}{N} = \dot{E}_h^{k=3}(T_j) \times \delta''(T_j) \times \frac{n_j}{N} \text{ and } \frac{RH(T_j)}{N} = \frac{BL(T_j) - \left[\dot{Q}_h^{k=3}(T_j) \times \delta''(T_j)\right]}{3.413 \frac{\text{Btu/h}}{\text{W}}} \times \frac{n_j}{N}$$

where $\delta''(T_j)$ is calculated as specified in section 4.2.3.4 if the heat pump is operating at its booster compressor capacity. If the heat pump system coverts to using only resistive heating at outdoor temperature T_j, set $\delta''(T_j)$ equal to zero.

* * * * *

4.2.7 Additional steps for calculating the HSPF of a heat pump having a single indoor unit with multiple blowers. The calculation of the

Eq. 4.2–1 quantities $e_h(T_j)$ /N and $RH(T_j)$ /N are evaluated as specified in applicable below subsection.

4.2.7.1 For multiple blower heat pumps that are connected to a lone, single-speed outdoor unit.

a. Calculate 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 the heating minimum air volume rate and outdoor temperature T_j using Eqs. 4.2.2–3 and 4.2.2–4, respectively. Use these same equations to calculate the space heating capacity, $\dot{Q}_h^{k=2}(T_j)$ and electrical power consumption, $\dot{E}_h^{k=2}(T_j)$, of the test unit when operating at the heating full-load air volume rate and outdoor temperature T_j. In evaluating Eqs. 4.2.2–3 and 4.2.2–4, determine the quantities $\dot{Q}_h^{k=1}(47)$ and $\dot{E}_h^{k=1}(47)$ from the *H1₁* Test; determine $\dot{Q}_h^{k=2}(47)$ and $\dot{E}_h^{k=2}(47)$ from the $H1_2$ Test. Evaluate all four quantities according to section 3.7. Determine the quantities $\dot{Q}_h^{k=1}(35)$ and $\dot{E}_h^{k=1}(35)$ as specified in section 3.6.2. Determine $\dot{Q}_h^{k=2}(35)$ and $\dot{E}_h^{k=2}(35)$ from the $H2_2$ Frost Accumulation Test as calculated according to section 3.9.1. Determine the quantities $\dot{Q}_h^{k=1}(17)$ and $\dot{E}_h^{k=1}(17)$ from the $H3_1$ Test, and $\dot{Q}_h^{k=2}(17)$ and $\dot{E}_h^{k=2}(17)$ from the $H3_2$ Test. Evaluate all four quantities according to section 3.10. Refer to section 3.6.2 and Table 10 for additional information on the referenced laboratory tests.

b. Determine the heating mode cyclic degradation coefficient, C_D^h, as per sections 3.6.2 and 3.8 to 3.8.1. Assign this same value to $C_D^h(k = 2)$.

c. Except for using the above values of $\dot{Q}_h^{k=1}(T_j)$, $\dot{E}_h^{k=1}(T_j)$, $\dot{Q}_h^{k=2}(T_j)$, $\dot{E}_h^{k=2}(T_j)$, C_D^h, and $C_D^h(k = 2)$, calculate the quantities $e_h(T_j)/N$ as specified in section 4.2.3.1 for cases where $\dot{Q}_h^{k=1}(T_j) \geq BL(T_j)$. For all other outdoor bin temperatures, T_j, calculate $e_h(T_j)/N$ and $RH_h(T_j)/N$ as specified in section 4.2.3.3 if $\dot{Q}_h^{k=2}(T_j) > BL(T_j)$ or as specified in section 4.2.3.4 if $\dot{Q}_h^{k=2}(T_j) \leq BL(T_j)$.

4.2.7.2 For multiple blower heat pumps connected to either a lone outdoor unit with a two-capacity compressor or to two separate but identical model single-speed outdoor units.

Calculate the quantities $e_h(T_j)/N$ and $RH(T_j)/N$ as specified in section 4.2.3.

* * * * *

4.2.8 Off-mode seasonal power and energy consumption calculations.

Evaluate the off-mode seasonal power consumption for the collective shoulders seasons, *P1,* which applies to air conditioners and heat pumps. For air conditioners, determine the off-mode seasonal power consumption for the heating season, *P2.* Once *P1* and, for air conditioners, *P2,* are evaluated, use the SSH and the HSH to calculate the site specific seasonal energy consumption values.

4.2.8.1 Off-mode seasonal power consumption for the collective shoulder seasons, *P1.* For air conditioners and heat pumps, the off-mode power consumption for the shoulder seasons is a single value that applies for all locations. The calculation of *P1* varies for different types of systems.

4.2.8.1.1 Air conditioners and heat pumps that do not have a compressor crankcase heater. For air conditioners and heat pumps not having a compressor crankcase heater, assign *P1* as specified in sections 3.13.2.2 and 3.13.3.5, respectively.

4.2.8.1.2 Air conditioners that have a compressor crankcase heater. For air conditioners having a compressor crankcase heater, evaluate *P1* using

$$P1 = \frac{P1(57) + P1(62) + P1(67) + P1(72)}{4}$$

Where:

$$P1(T_j) = P0 + \left[\frac{F_{CC}(T_j)}{100} \cdot \frac{(230\ \text{V})^2}{R_{CC}}\right].$$

Obtain R_{CC}, the measured resistance of crankcase heater element, and *P0,* the average off-mode power consumption of all other air conditioner components except the crankcase heater, as specified in sections 3.13.1 and 3.13.4.6, respectively. Calculate the percent time on of the crankcase heater for outdoor bin temperatures T_j = 57, 62, 67, and 72 °F as specified in section 3.13.4.4.8.

4.2.8.1.3 Heat pumps that have a compressor crankcase heater. For heat pumps having a compressor crankcase heater, evaluate *P1* using

$$P1 = P0 + \left[\frac{F_{CC}(65)}{100} \cdot \frac{(230\ \text{V})^2}{R_{CC}}\right],$$

rounded to the nearest even wattage.

Obtain R_{CC}, the measured resistance of crankcase heater element, and *P0,* the average off-mode power consumption of all other heat pump components except the crankcase heater, as specified in sections 3.13.1 and 3.13.5.5.3, respectively. Calculate the percent time on of the crankcase heater at a 65 °F outdoor temperature, $F_{CC}(65)$, as specified in section 3.13.5.4.5.

4.2.8.2 Off-mode seasonal power consumption for air conditioners during the heating season, *P2.* For air conditioners, *P2* is non-zero and evaluated as specified below. For heat pumps, *P2* equals zero.

4.2.8.2.1 For air conditioners that do not have a compressor crankcase heater. The off-mode power consumption for the heating season is a single value that applies for all locations. Assign *P2 = P1,* as determined in section 3.13.2.2.

4.2.8.2.2 For air conditioners that have compressor crankcase heater. The off-mode power consumption for the heating season depends on the fractional bin hour distribution, for which a different distribution is specified for each of the six generalized climatic regions, Figure 2. Calculate *P2* using

$$P2 = P0 + \sum_{j}^{J}\left[\frac{n_j}{N} \cdot \frac{F_{CC}(T_j)}{100} \cdot \frac{(230\ \text{V})^2}{R_{CC}}\right]$$

rounded to the nearest even wattage. Obtain R_{CC}, the measured resistance of crankcase heater element, and *P0,* the average off-mode power consumption of all other air conditioner components except the crankcase heater, as specified in sections 3.13.1 and 3.13.4.6, respectively. Calculate $F_{CC}(T_j)$, the percent time on of the crankcase heater for outdoor bin temperatures T_j as specified in section 3.13.4.4.8. Obtain n_j/N, the heating season fractional bin hours, from Table 17.

4.2.8.3 Off-mode seasonal energy consumption.

4.2.8.3.1 For the shoulder seasons. Calculate the off-mode energy consumption for the collective shoulder seasons, *E1,* using

$E1 = P1 \times SSH$

Where:

P1 = determined as specified in section 4.2.7.1 and the SSH are determined from Table 19.

TABLE 19—REPRESENTATIVE COOLING AND HEATING LOAD HOURS AND THE CORRESPONDING SET OF SEASONAL HOURS FOR EACH GENERALIZED CLIMATIC REGION

Climatic region	Cooling load hours CLR_R	Heating load hours HLH_R	Cooling season hours CSH_R	Heating Season Hours HSH_R	Shoulder Season Hours SSH_R
I	2400	750	6731	1826	203
II	1800	1250	5048	3148	564
III	1200	1750	3365	4453	942
IV	800	2250	2244	5643	873
Rating Values	1000	2080	2805	5216	739
V	400	2750	1122	6956	682
VI	200	2750	561	6258	1941

4.2.8.3.2 For the heating season—air conditioners only. Calculate the off-mode energy consumption of an air conditioner during the heating season, *E2,* using

$E2 = P2 \times HSH$

Where:

$P2$ = determined as specified in section 4.2.7.2 and the HSH are determined from Table 19.

* * * * *

4.3.1 * * *

$$APF_A = \frac{CLH_A \times \dot{Q}_c^k(95) + HLH_A \times DHR \times C}{\dfrac{CLH_A \times \dot{Q}_c^k(95)}{SEER} + \dfrac{HLH_A \times DHR \times C}{HSPF} + P1 \times SSH + P2 \times HSH}$$

* * *

$P1$ = the off-mode seasonal power consumption for the collective shoulders seasons, as determined in section 4.2.7.1, W, and

$P2$ = the off-mode seasonal power consumption for the heating season, as determined in section 4.2.7.2, W.

Evaluate the HSH using

$$HSH = \frac{HLH \times (65 - T_{OD})}{\sum_{j=1}^{J} (65 - T_j) \times \frac{n_j}{N}}$$

Where:

T_{OD} and n_j/N = listed in Table 19 and depend on the location of interest relative to Figure 2. For the six generalized climatic regions, this equation simplifies to the following set of equations:

Region I $HSH = 2.4348 \times HLH$
Region II $HSH = 2.5182 \times HLH$
Region III $HSH = 2.5444 \times HLH$
Region IV $HSH = 2.5078 \times HLH$
Region V $HSH = 2.5295 \times HLH$
Region VI $HSH = 2.2757 \times HLH$

Evaluate the shoulder season hours using

$SSH = 8760 - (CSH + HSH)$

Where:

CSH = the cooling season hours calculated from $CSH = 2.8045 \times CLH$

* * * * *

4.3.2 Calculation of representative regional annual performance factors (APF_R) for each generalized climatic region and for each standardized design heating requirement.

$$APF_R = \frac{CLH_R \times \dot{Q}_c^k(95) + HLH_R \times DHR \times C}{\dfrac{CLH_R \times \dot{Q}_c^k(95)}{SEER} + \dfrac{HLH_R \times DHR \times C}{HSPF} + P1 \times SSH + P2 \times HSH}$$

Where:

CLH_R = the representative cooling hours for each generalized climatic region, *Table 19,* hr,

HLH_R = the representative heating hours for each generalized climatic region, *Table 19,* hr, and

$HSPF$ = the heating seasonal performance factor calculated as specified in section 4.2 for each generalized climatic region and for each standardized design heating requirement within each region, Btu/W × h.

The SEER, $\dot{Q}_c^k$ (95), *DHR, C, P1, P2, SSH,* and *HSH* are the same quantities as defined in section 4.3.1. *Figure 2* shows the generalized climatic regions. *Table 18* lists standardized design heating requirements.

TABLE 19—REPRESENTATIVE COOLING AND HEATING LOAD HOURS FOR EACH GENERALIZED CLIMATIC REGION

Region	CLH_R	HLH_R
I	2400	750
II	1800	1250
III	1200	1750
IV	800	2250
V	400	2750

TABLE 19—REPRESENTATIVE COOLING AND HEATING LOAD HOURS FOR EACH GENERALIZED CLIMATIC REGION—Continued

Region	CLH_R	HLH_R
VI	200	2750

4.4 Rounding of SEER, HSPF, SHR, and APF for reporting purposes. After calculating SEER according to section 4.1, round it off as specified in subpart B 430.23(m)(3)(i) of Title 10 of the CFR. Round section 4.2 HSPF values and section 4.3 APF values as per § 430.23(m)(3)(ii) and (iii) of Title 10 of the CFR. Round section 4.5 SHR values to 2 decimal places.

4.5 Calculations of the SHR, which should be computed for different equipment configurations and test conditions specified in Table 20.

TABLE 20—APPLICABLE TEST CONDITIONS FOR CALCULATION OF THE SENSIBLE HEAT RATIO

Equipment configuration	Reference Table No. of Appendix M	SHR computation with results from	Computed values
Single-Speed Compressor and a Fixed-Speed Indoor Fan, a Constant Air Volume Rate Indoor Fan, or No Indoor Fan.	3	*B* Test	SHR(B)
Single-Speed Compressor and a Variable Air Volume Rate Indoor Fan.	4	*B2* and *B1* Tests	SHR(B1), SHR(B2)
Units Having a Two-Capacity Compressor	5	*B2* and *B1* Tests	SHR(B1), SHR(B2)
Units Having a Variable-Speed Compressor	6	*B2* and *B1* Tests	SHR(B1), SHR(B2)

The SHR is defined and calculated as follows:

$$SHR = \frac{\text{Sensible Cooling Capacity}}{\text{Total Cooling Capacity}}$$

$$= \frac{\dot{Q}_{sc}^{k}(T)}{\dot{Q}_{c}^{k}(T)}$$

Where both the total and sensible cooling capacities are determined from the same cooling mode test and calculated from data collected over the same 30-minute data collection interval.

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