BUILDING TECHNOLOGIES

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

Energy Conservation Program for Appliance Test Procedures

June 11, 2010

Residential Central Air Conditioners and Heat Pumps

Welcome and Introduction

- Attendee self introductions
- Role of the Facilitator
- Ground rules (norms)
  - Listen as an ally
  - Use short, succinct statements/keep to the point
  - Hold sidebar conversations outside the room
  - Focus on issues, not personalities
  - One person speak at a time (raise hand to be recognized; state your name for the record)
  - Set cell phones to silent/vibrate
- Housekeeping items

Agenda

9:00 – 9:15 am	**Welcome, Introduction & Agenda Review**
9:15 – 9:45 am	**Interested Parties Statements**
9:45 – 10:00 am	**Test Procedure History**
10:00 – 10:10 am	**Scope of Test Procedure Revisions**
10:10 – 11:00 am	**Proposed Revisions Set #1 (e.g., non-EISA)**
11:00 – 11:15 am	**Break**

Agenda (Continued)

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

11:15 – 12:00 pm	**Proposed Revisions Set #2 (e.g., EISA)**
12:00 – 12:15 pm	**Rulemaking Schedule & Impact on Manufacturers**
12:15 – 12:20 pm	**Summary and Next Steps**
12:20 – 12:30 pm	**Questions & Comments / Closing Remarks**
12:30 pm	**Adjourn**

Interested Parties Participation

In all correspondence, include all of the following:

- Energy Conservation Test Procedure for Residential Central Air Conditioners and Heat Pumps
- Docket Number EERE-2009-BT-TP-0004
- Regulatory Identification Number (RIN) 1904-AB94

Federal eRulemaking Portal: http://www.regulations.gov

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Comment period closes August 16, 2010

The Consensus Agreement

DOE is aware of and evaluating the Consensus Agreement. DOE is also aware of the interested parties' desire to address issues related to the Consensus Agreement. DOE will make a determination regarding the agreement at a later time.

Therefore, please limit your comments and questions today to the issues related to the test procedure. You may submit comments related to the Consensus Agreement and other relevant issues in your written comments to DOE.

Interested Parties Statements

At this time DOE welcomes opening remarks on the notice of proposed rulemaking (NOPR) for the residential central air conditioners and heat pumps (CAC) test procedure.

Public Meeting Agenda

1. Test Procedure History
2. Scope of Test Procedure Revisions
3. Proposed Revision Set #1 (Effective w/ TP Rule)
4. Proposed Revision Set #2 (Effective w/ Standard)
5. Rulemaking Schedule and Impact on Manufacturers
6. Summary, Next Steps, and Questions

Test Procedure History

- Most recent revision: Final Rule published October 2007
  - Expand coverage (e.g., small-duct high-velocity, multi-split systems) .
  - Minor updates (e.g., reference standards).
  - Improve complementary sections of Code of Federal Regulations (CFR) on testing requirements and rating options (e.g., update highest sales volume combination definition, Alternative Rating Method submittal guidance).
  - No changes that affect seasonal energy efficiency ratio (SEER) and heating seasonal performance factor (HSPF) of minimally compliant units.

- Expectations following 2007 Final Rule publication
  - Test procedure is adequate for foreseeable future.
  - Use as basis for upcoming Energy Conservation Standards rulemaking.

Test Procedure History

- Energy Independence and Security Act (EISA)
  - Signed into Law December 2007.
  - For CAC, up to two regional standards can be considered in addition to the national standard.
  - Must account for standby and off mode energy consumption.

- DOE concluded that a test procedure rulemaking was merited to assure compliance with EISA and to consider a few non-EISA test procedure updates.

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Scope of Test Procedure Revisions

- Multi-split systems
- Laboratory installation provisions
- Test tolerances and in-situ calibration
  - Indoor air flow
  - Temperature difference during the cyclic D Test
- Address waiver requests
  - Indoor unit having multiple blowers
  - Triple capacity, northern climate heat pumps
- Miscellaneous items

Set #1

- Standby /off mode energy consumption
- Regional standards affect on test procedures
- Related extras /omissions

Set #2

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Multi-Split Systems

- Further revisions to the “Tested Combination” definition
  - Clarifying capacity references mean the nominal value.
  - Slightly broaden indoor combinations that qualify.
  - Not addressing requested change that would only affect commercial size multi-split systems.

- New minimum external statics for ducted multi-split systems
  - Alternative to industry proposal to use manufacturer’s rated value.
  - Consider applying these alternative external statics to ducted mini-split systems and furred down units.

Multi-Split Systems

Rated Capacity Btu/h	Minimum External Resistance (in wc*)		
	SDHV**	Ducted Multi-Splits	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

*wc = water column **Small Duct, High Velocity

Multi-Split Systems

NOPR Issue #3:
Is a separate set of minimum external static pressures an acceptable way to address the testing of ducted multi-splits?

Public Meeting Question #1:
Should the alternative set of minimum external static pressures be applied to (1) ducted mini-splits and/or (2) ducted furred down/ceiling-mounted units*?

***Indoor unit no more than 11 inches high and 24 inches deep with single slab coil that is perpendicular to the flow stream and the system rated capacity does not exceed 39,000 Btu/h.**

Laboratory Installation Provisions

Propose adjustments to indoor blower setup procedure:

- On fixed speed or constant torque blowers, allow reducing air volume as much as 10% below the rated value to meet DOE minimum static before switching to next fan speed, pin or dip switch setting.
- Add caveat that any incremental changes in the indoor blower configuration have to yield the same cyclic/fan delay characteristic.

Laboratory Installation Provisions

Observations on blower coil setup procedure:

- Goal of procedure: repeatable setups; consistent ratings.
- TP currently allows reducing air volume as much as 5%.
- From modeling, a 10% reduction in air volume is projected to decrease capacity by up to 2%.
  - Implication: more chance of failure on capacity if a unit is subject to a third-party certification program.
- SEER is projected to decrease by up to 0.4%.
- SEER is expected to decrease more if procedure leads to one fan setting one time and the next highest setting another time.

Laboratory Installation Provisions

NOPR Issue #4:
Will the proposed adjustments to the indoor blower coil setup procedure yield more repeatable laboratory installations and more consistent SEER/HSPF values?

Laboratory Installation Provisions

Propose amendments to the refrigerant charging procedure:

- Cover the case where a range is given for sub-cooling, superheat, etc. ➔ use the midpoint value.
- No adjusting charge after initial setup.
- Delete language that allowed deviating from the published charging instructions when testing so long as the manufacturer thereafter revised those same instructions.

Laboratory Installation Provisions

Expected outcome:

- Remove potential loop-hole for adjusting the refrigerant charge after the testing process begins.
- Published installation/charging instructions cannot be overridden for DOE testing.
- Better alignment with procedures used for Air-Conditioning, Heating and Refrigeration Institute (AHRI) certification testing.

Laboratory Installation Provisions

Propose clarifications to the system setup procedure:

- For DOE certification tests, a manufacturer may fully interact with a private testing laboratory hired by the manufacturer to conduct the tests.
- Specifically address the case where DOE certification tests are conducted on a pre-production unit and the installation instructions are not yet published.

Expected outcome:

- Better differentiation between initial DOE certification testing and any testing conducted thereafter (e. g,. AHRI certification testing, DOE enforcement testing).

Test Tolerances & In-Situ Calibration

Issue: Airflow test operating tolerances usually exceeded if using an electronic pressure transducer.

- 0.05 in wc tolerance for external resistance to airflow.
- 2.0 % of reading (rdg) tolerance for nozzle pressure drop.
- Tolerances predate DOE TP: appeared in ASHRAE Std 37-78
- Relatively easy to meet tolerance if using liquid manometers because of their inherent damping.
- Different story if using a higher resolution electronic differential pressure transducer; more noticeable for higher sampling rates and variable-speed blowers.
- Test operating tolerance used to confirm steady operation.

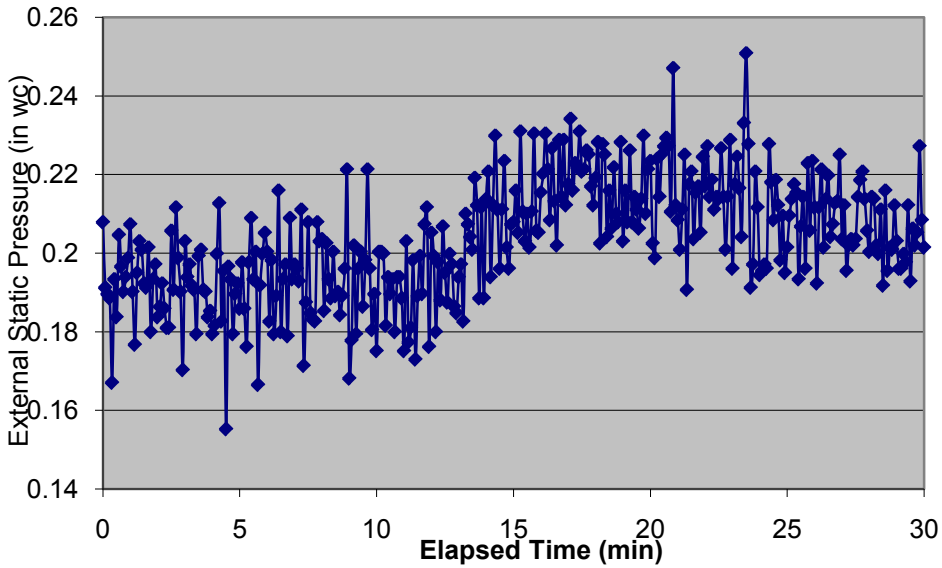
Potential corrective actions considered by DOE:

- Eliminate these two airflow test operating tolerances.
- Integrate the signals and calculate an average for equal subintervals (e.g., 5 sec. readings averaged for each minute).
- Try to mechanically dampen the pressures to mimic a liquid manometer (e.g., pressure snubber).
- Increase the magnitudes of the tolerances.

NOPR: Last Option

0.05 in. wc → 0.12 in. wc

2.0 % rdg → 8.0 % rdg



Test Tolerances & In-Situ Calibration

NOPR Issue #5:
Are greater tolerances the solution for assuring steady performance when using electronic pressure transducers? If not, DOE is seeking comment on other corrective actions.

Test Tolerances & In-Situ Calibration

***Issue*: need to reduce the measurement bias created when using different air-side temperature sensors for the cyclic degradation coefficient (C_D) tests:**

- Two companion tests used to calculate C_D, one steady-state (SS) and one cyclic (CYC).
- C_D used in estimating ratio of CYC to SS efficiencies.
- To comply with ASHRAE Standard 41.1–1986 (RA 2001), may use two sets of temperature sensors.
  - Highly accurate sensors during steady-state tests.
  - Comparatively less accurate but necessarily faster-responding sensors for cyclic tests.

Problem: two sets of temperature sensors lead to different ΔT's.

DOE proposes to minimize the bias when determining the cyclic degradation coefficient, C_D, by:

Correcting the ΔT measured during the cyclic test based on the ratio of the temperature differences measured using the two sets of temperature sensors during the companion SS test.

Proposed ΔT correction process.

- During the steady-state test, measure ΔT using both sets of instrumentation at equal intervals that span 5 minutes or less.
- Calculate an average ΔT for the SS sensors and an average ΔT for the CYC sensors; ratio the two ΔT's.
- Use the final ΔT ratio from the steady-state test to correct the measured ΔT during the cyclic test.

Proposed ΔT correction process (continued)

- Propose placing limits on the ΔT ratio – between 0.94 and 1.06. A ratio outside this range will trigger a recalibration or replacement of one or both ΔT sensors.

- In an effort to avoid having to run a complete SS test before evaluating whether the ΔT ratio is within the allowed range, can calculate the ΔT ratio based on minimum of 7 data samples that are acquired over a interval of 6 minutes or more.

Address Waiver Requests

Proposed amendments to eliminate waiver for systems having a multi-blower indoor unit.

Background:

On 28 August 2008, DOE granted a waiver 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.

DOE Proposal:

Because the commercialization of these products is unknown, keep test procedure add-ons to a minimum and basic.

Address Waiver Requests

Proposed test procedure additions: multi-blower indoor unit.

- Scope:
  - Cover products that use 2 to 8 indoor blowers with a single- or dual-circuit indoor coil.

- Simplifications:
  - Evaluate each system with all and with half of the indoor blowers operating.
  - For two stage systems, high-stage compressor operation evaluated with all blowers on; low-stage evaluated with half the blowers on.

Address Waiver Requests

Proposed amendments to eliminate waiver for a line of triple-capacity, northern climate heat pumps.

Background:

- On 5 February 2010, DOE granted a waiver for a line of heat pumps that offer 3 stages of compressor capacity when heating and 2 stages when cooling.
  - Changes needed for HSPF but not SEER determinations.
  - NOPR slightly different from waiver decision and order.

Proposed TP additions: triple-capacity northern climate HP

- Additional laboratory testing at the 3rd heating stage.
- One new outdoor test condition – different in NOPR versus waiver because of more achievable wet bulb (wb) depression.
  - 2 °F dry bulb (db) and 1 °F wb (proposed in NOPR)
  - 0 °F db and -2 °F wb (listed in waiver)
- Heating building load assigned based on the 2nd stage of heating at 47 ºF outdoor temperature.
- HSPF bin calculations are an extension of the approach used for two-stage heat pumps.
- Calculation algorithm accounts for systems that lock out one or two heating stages at any given outdoor temperature.

Address Waiver Requests

NOPR Issue #10:
Is the coverage for triple-capacity, northern climate heat pumps and multiple blower indoor units sufficiently generic while capturing the unique equipment features?

Clarify inputs for the demand defrost credit equation

- The demand defrost credit (F_{def}) is a direct multiplier within the HSPF calculation.
- Historically, F_{def} has had a value between 1.00 and 1.03.
- In the October 2007 final rule, the maximum test duration was changed from 12 hours to 6 hours.
- The impact on the equation for F_{def} was not fully considered.
- Two possible corrective actions were considered.

Clarify inputs for the demand defrost credit equation

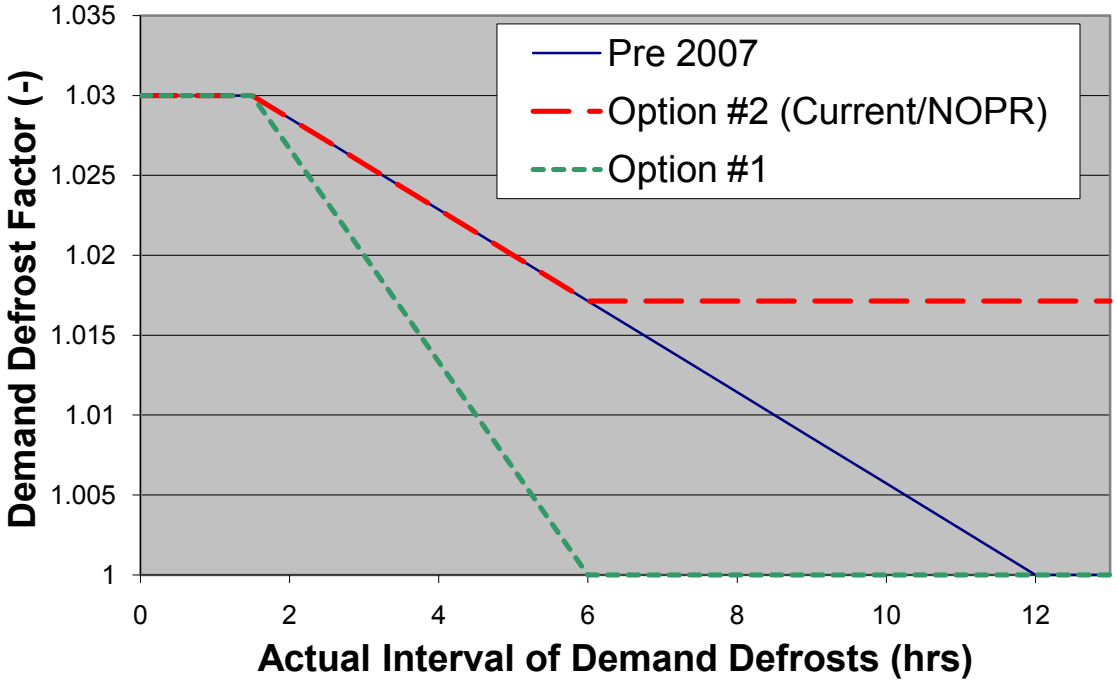
$$F_{def} = 1 + 0.03\left[1 - \frac{\Delta\tau_{def} - 1.5}{\Delta\tau_{\max} - 1.5}\right], \text{ where}$$

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

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

Potential corrective actions:

- Update the equation for F_{def} to use 6 hours as the maximum for $\Delta\tau_{max}$ rather than 12 hours.
- Keep current F_{def} equation but clarify equation inputs if a test is terminated based on the max time of 6 hours. ➡ **NOPR proposal**



Miscellaneous Items

Implications:

- No change for heat pumps that defrost within 6 hours during the (main) Frost Accumulation Test (99% of units?).
- For demand defrost type heat pumps that don't initiate a defrost cycle during the maximum, 6-hour long frosting period, F_{def} will be up to 0.017 higher.

Public Meeting Question #2:
DOE seeks comments on the NOPR proposal to leave the equation for the demand defrost credit unchanged.

Miscellaneous Items

Propose to add calculations for sensible heat ratio (SHR).

- Add to test procedure to endorse its continued use. Specific proposal to calculate SHR for the B Tests.
- No extra test burden as measurements are already made.
- DOE is not using SHR within the calculation of SEER.
- When humidity control is a concern, consumers and their contractors may wish to know the SHRs of different units.
- Adding the SHR to the yellow EnergyGuide Label could only be considered via Federal Trade Commission (FTC) rulemaking on the issue.

Miscellaneous Items

Clarify that optional frost accumulation tests may be conducted without forfeiting use of the default value(s).

- DOE test procedure allows using 0.25 C_D defaults even if optional C_D tests are conducted.
- Propose same practice for optional frost accumulation tests.
- Use default or measured values for capacity and power at 35 °F, whichever contributes to a higher HSPF (Region IV, DHR_{min}).

Miscellaneous Items

Propose to:

- Add references to ASHRAE 116 for equations that calculate SEER and HSPF for variable-speed systems.

- Update test procedure references to the current standards of AHRI and ASHRAE:
  - AHRI Std 210/240-2008
  - ASHRAE Std. 41.1-86 (RA 06)
  - ASHRAE Std. 41.6-94 (RA 06)
  - ASHRAE Std 41.9-00 (RA 06)
  - ASHRAE Std. 51-07 (AMCA Std. 210-07)

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Standby and Off-Mode Energy Consumption Rationale

- SEER accounts for all (modes of) energy consumption that occur during the cooling season, including times when the air conditioner or heat pump is cycled off.

- HSPF accounts for all (modes of) energy consumption that occur during the heating season.

Standby and Off-Mode Energy Consumption Rationale

However, when considered on an annual basis, some of the energy consumption is missed.

- Energy consumed by an air conditioner during the heating season.
- Energy consumed by an air conditioner & a heat pump during the shoulder seasons.
  - Combination of location-specific cooling and heating load hours translates to less than 8,760 hours (see Appendix A of ASHRAE Std 137).

Propose to account for out-of-season energy consumption

Define Off-Mode:

- Air Conditioner (AC): time when the unit is powered but idle during the heating season and the shoulder seasons.
- Heat Pump (HP): same definition as AC except only applies to shoulder seasons .
- Add laboratory testing.
- Add calculations.
  - P1 = representative off-mode power consumption for the shoulder seasons (AC & HP).
  - P2 = representative off-mode power consumption of an air conditioner during the heating season.

Off-mode laboratory testing

- Simple / short duration for models:
  - Not having a compressor crankcase heater.
  - Having a crankcase heater that operates continuously.
- Mid duration for heat pumps having a crankcase heater that is thermostatically controlled.
- Longer duration for air conditioners having a crankcase heater that is thermostatically controlled.
  - Easier if heater is controlled based only on an outdoor temperature sensor.
  - More challenging as the control algorithm and feedback temperature sensor(s) create a heating profile that is not readily correlated to outdoor temperature.

Off-Mode Energy Calculations

Shoulder Seasons: P1 x Shoulder Season Hours

AC During Heating Season: P2 x Heating Season Hours

Climatic Region	Cooling Load Hours	Heating Load Hours	Cooling Season Hours	Heating Season Hours	Shoulder Season Hours
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

Off-Mode Energy Consumption

Key Points:

- Off-Mode energy consumption will not be used to adjust SEER or HSPF. Doing so would have the following impacts:
  - Change the cooling season descriptor SEER into an annual descriptor for ACs and a part-year descriptor for HPs.
  - Change SEER from being regionally independent to dependent on the particular combination of Cooling Season Hours (CSH), Heating Season Hours (HSH), and Shoulder Season Hours (SSH).
- Require measurement of P1 and P2 when new energy conservation standards become effective.

Off-Mode Energy Consumption

NOPR Issue #2:
DOE seeks comments on the definition of off-mode.

Public Meeting Question #3:
DOE seeks comment on the steps in proposed Section 3.13 of Appendix M of the NOPR for off-mode laboratory testing procedure for ACs and HPs having a thermostatically controlled compressor crankcase heater.

Regional Standards Affect on Test Procedures

Task: Make necessary changes to the test procedure to allow consideration of regional standards.

Influencing Factors / Constraints:

- Two additional regions of interest: hot-humid & hot-dry.
  - Focus on cooling.
- EISA requirement: region must be contiguous states.
- Dependent on regions established in standards rulemakings: CAC and Furnaces & Boilers.
- Current structure of test procedure:
  - Generate performance map of system from laboratory testing.
  - Estimate seasonal performance (SEER).

Regional Standards Affect on Test Procedures

Test Procedure Options:

1. Make no changes to the existing test procedure with respect to lab testing and/or calculations. Use SEER as the regulating metric for assigning a regional standard.
2. Add only calculation steps to the procedure; could possibly use a SEER as the regulating metric.
3. Add both lab testing and calculations to determine a region-specific metric; could possibly use SEER Hot-Dry, SEER Hot-Humid, etc. as the metric.

NOPR: Includes Option #3 for SEER Hot-Dry

Regional Standards Affect on Test Procedures

What do we want from a regional regulating metric?

- Information that promotes best use of energy resources.
- Information that helps the consumer:
  - Seasonal energy consumption.
  - Performance at conditions that impact demand charges (as installation of smart meters expands).
- Information that helps the electric utility:
  - Performance at full load conditions.
- Information that helps manufacturer differentiate their products.

NOPR Issue #9:
DOE seeks comment on usage and effectiveness of SEER Hot-Dry and its advantages and disadvantages.

Related Extras / Omissions

Extras:

- Propose requirements for the low-voltage transformer used when testing coil-only units; clarify that transformer's power consumption must be included in metered input to system.

- Propose to change the minimum sampling interval during steady-state tests from 10 minutes to 5 minutes.

- Eliminate the short-cut method for calculating the national SEER for single-speed systems; use bin method instead.
  - Can account for improvements in the A Test relative to the B Test.
  - Avoid confusion as to the basis of the short-cut method.
  - Promotes consistency across all SEER calculations.

Related Extras / Omissions

Omissions from the NOPR:

- Test procedure updates to better address through-the-wall air conditioners and heat pumps.
  - Explicitly waive requirement for 10 feet of refrigerant tubing outdoors.
  - Use same or different refrigerant tubing length?
  - How/where to best measure the outdoor air temperature?

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Rulemaking Schedule

- Written comments due to DOE no later than August 16, 2010.
- Test procedure final rule expected to be completed in 2011.
- Test procedure revisions to become effective in two steps:
  - Set #1 revisions (e.g. non-EISA): 30 days after final rule.
  - Set #2 revisions (e.g., EISA+): same effective date as new standards (6/30/2016).

Impact on Manufacturers

When the test procedure final rule is published:

- Test procedure revisions will not trigger immediate retesting or re-rating of any products.
- SEER and HSPF are not altered as a result of the test procedure revisions introduced 30 days after the final rule.

When any amended energy conservation standards become effective:

- A regional standard, if promulgated, will require the testing and rating of equipment sold/installed in that region.
- Will require testing some existing and new units and adding coverage within Alternative Rating Methods.

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Summary, Next Steps, and Questions

Submit written comments by August 16, 2010.

In all correspondence, include all of the following:

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- Docket Number EERE-2009-BT-TP-0004.
- Regulatory Identification Number (RIN) 1904-AB94.

Written transcript from today's public meeting will be posted on the DOE web site:
http://www1.eere.energy.gov/buildings/appliance_standards/residential/central_ac_hp.html

The Consensus Agreement is being considered by DOE.

Summary, Next Steps, and Questions

Next milestone event: Notice of Proposed Rulemaking on the Energy Conservation Standards.

Energy Conservation Standards rulemaking and the Test Procedure rulemaking will continue to progress concurrently.

Summary, Next Steps, and Questions