Measuring and Rating the Performance of Residential Air Conditioners and Heat Pumps

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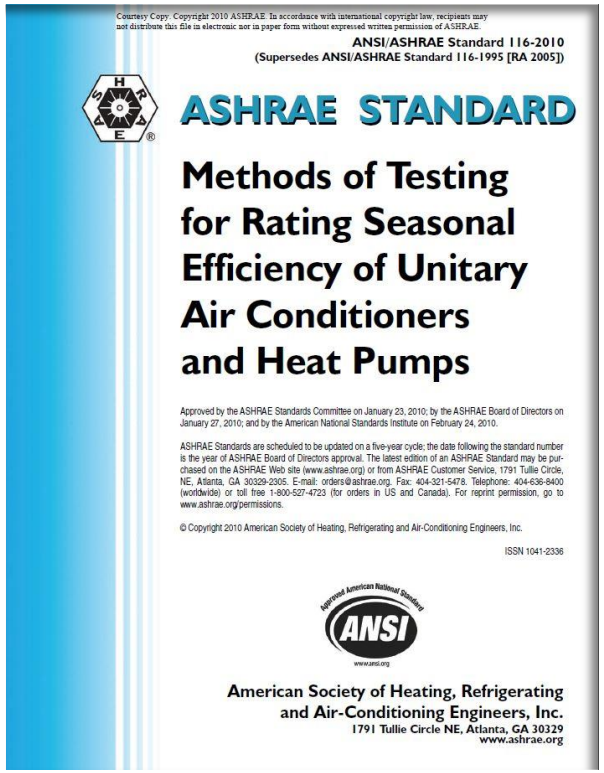
NIST

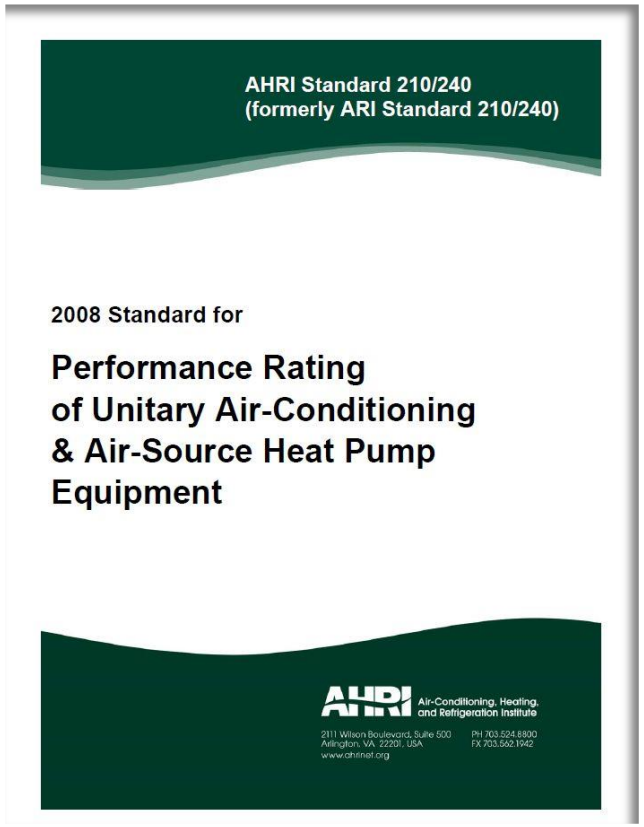
Introduction

- Regulatory Perspective
- Residential Equipment
- Method of Test
- Ratings

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

code of federal regulations





Regulatory Perspective for Residential HVAC Equipment

These laws established minimum efficiency standards for appliances and HVAC equipment and granted the U. S. Department of Energy the authority to review, revise, and issue standards:

- Energy Policy and Conservation Act of 1975 (EPCA)
- National Appliance Energy Conservation Act of 1987 and 1988(NAECA)
- Energy Policy Act of 1992 (EPACT 1992)
- Energy Policy Act of 2005 (EPACT 2005)
- Energy Independence and Security Act of 2007 (EISA)

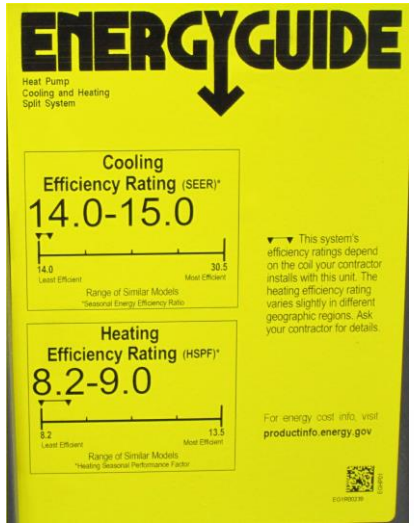
The U.S. Code includes only those standards specifically enacted by Congress. The Department of Energy (DOE) establishes some standards and updates all standards periodically, including those initially established by Congress. The Code of Federal Regulations (CFR) is updated roughly annually and includes regulations currently in effect. For very recent changes which may not yet have been incorporated into the CFR, see rules recently published in the Federal Register by the DOE at http://energy.gov/eere/buildings/current-rulemakings-and-notices.

Regulations for Residential HP & AC's

To determine compliance with DOE standards, manufacturers must follow the test procedures specified at 10 CFR 430.23(m) for residential central air conditioners and heat pumps as of April 21, 2008. The methods to conduct the test procedure are further specified in 10 CFR Part 430 Appendix M to Subpart B. This information is also in the Electronic Code of Federal Regulations.

- Final Rule: Test Procedure, *Federal Register*, 72, FR 59906 (Oct. 22, 2007)
- http://www.gpo.gov/fdsys/pkg/CFR-2012-title10-vol3/pdf/CFR-2012-title10-vol3-part430-subpartB-appM.pdf

DOE supports the testing and verification of ENERGY STAR® products in close collaboration with the Environmental Protection Agency. ENERGY STAR qualified central air conditioners are about 14% more efficient than standard models.



Compliance with DOE Standards

Each basic model of a covered product must be certified using DOE's online certification tool, the Compliance Certification Management System (CCMS), and DOE's preformatted, standardized, product-specific, Excel templates. CCMS allows manufacturers, importers, and third-party representatives to create, submit, and track their certification reports. CCMS also allows DOE to review and assess compliance and certification information effectively and efficiently. (https://www.regulations.doe.gov/ccms/)

The Compliance Certification Database houses certification reports and compliance statements submitted by manufacturers for covered products and equipment subject to Federal conservation standards. The new database offers users an easy-to-use search function for existing records in an easily downloadable format. There is also a consumer-friendly selection tool as well as a search-by-model function. (http://www.regulations.doe.gov/certification-data/)

As funding and scheduling allows, DOE's round-robin testing program assesses the repeatability and reproducibility of DOE test procedures for various appliances. DOE has conducted round-robin testing at the National Institute of Standards (NIST), many third-party laboratories, and select manufacturer-operated facilities.

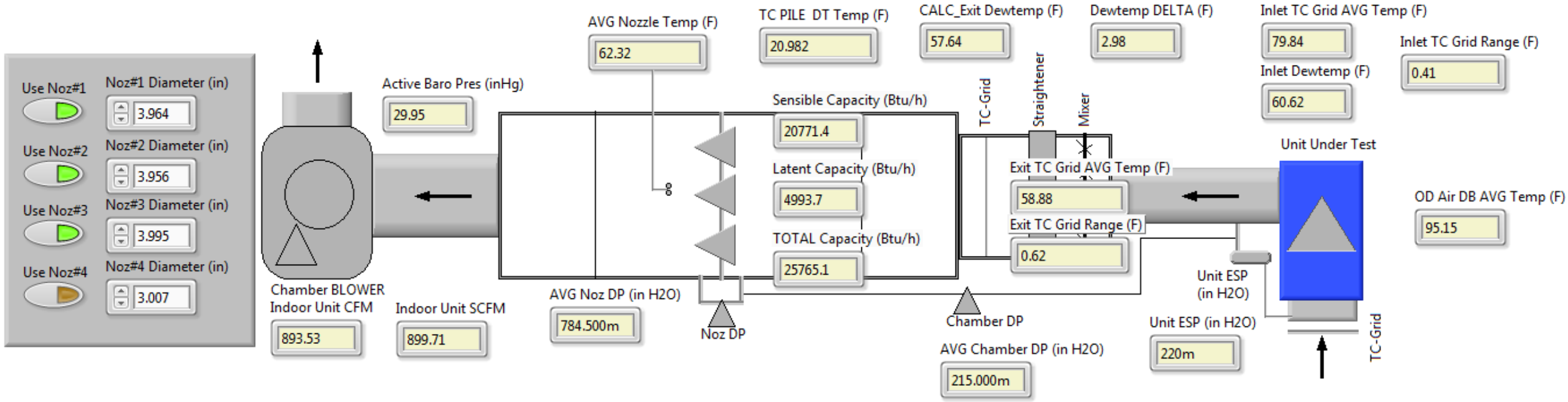
Residential Equipment

What is considered "RESIDENTIAL" for HVAC?

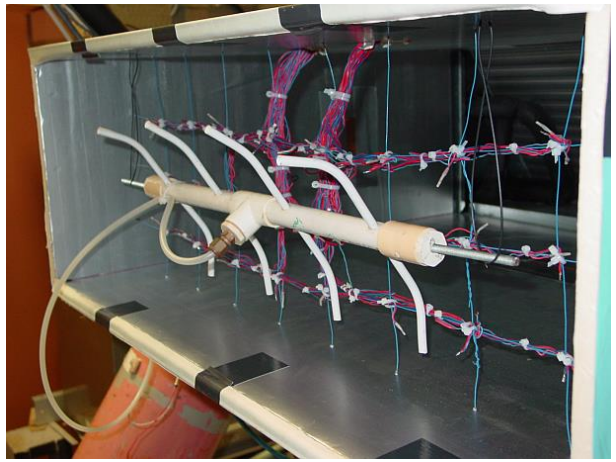
- Cooling capacity less than 65 kBtu/h (19 kW)
- Window or Room AC&HP
- Packaged Terminal AC&HP (hotel style, through the wall)
- Mini-Split and Multi-Split AC&HP
- Unitary, Split AC&HP

NIST has the facilities to perform psychrometric tests on all of the above types of systems using the air-enthalpy method as described in ASHRAE Standard 37.

Method of Test: Air-Enthalpy Method Capacity Measurement

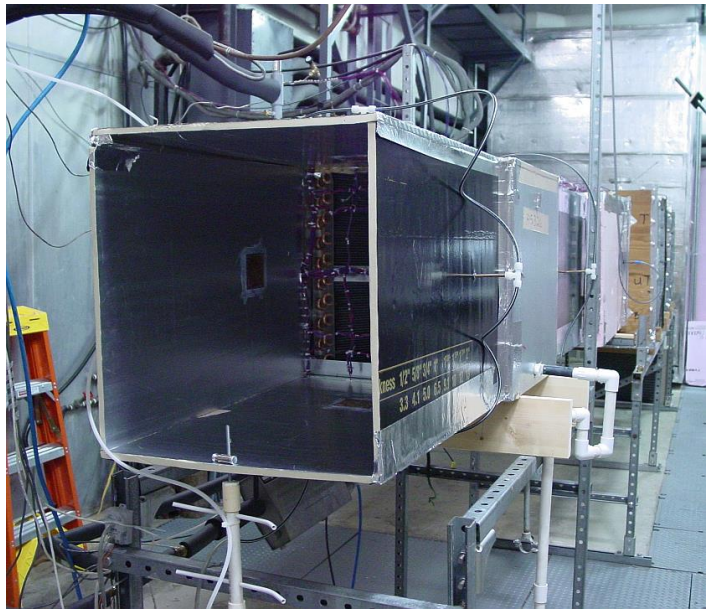


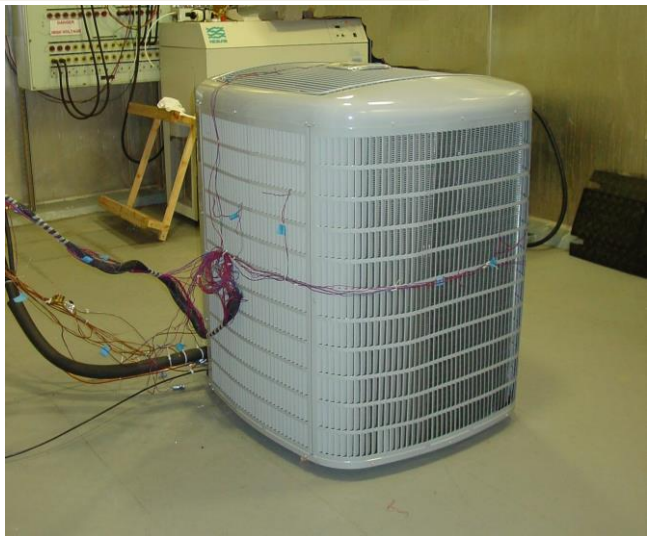
Air-Enthalpy Method (continued)



- Inlet Air Dry-Bulb and Dewpoint Temperature
- Exit Air Dry-Bulb and Dewpoint Temperature
- Air Pressure Drop to Nozzle Inlet and Pressure Drop Across Nozzle(s)
- Indoor and outdoor unit power demand (Watts)

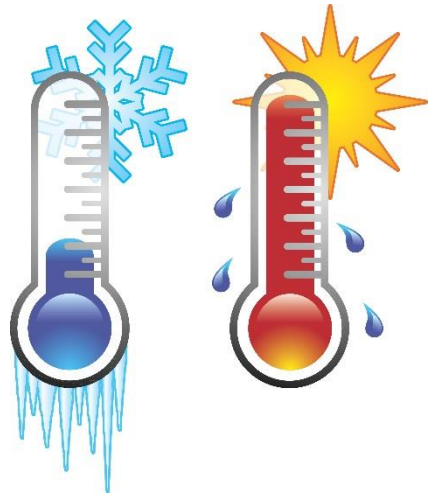
Air Movement and Control Association Intl' Inc. Standard 210-2007 details airflow measurement





Standard Rating Conditions

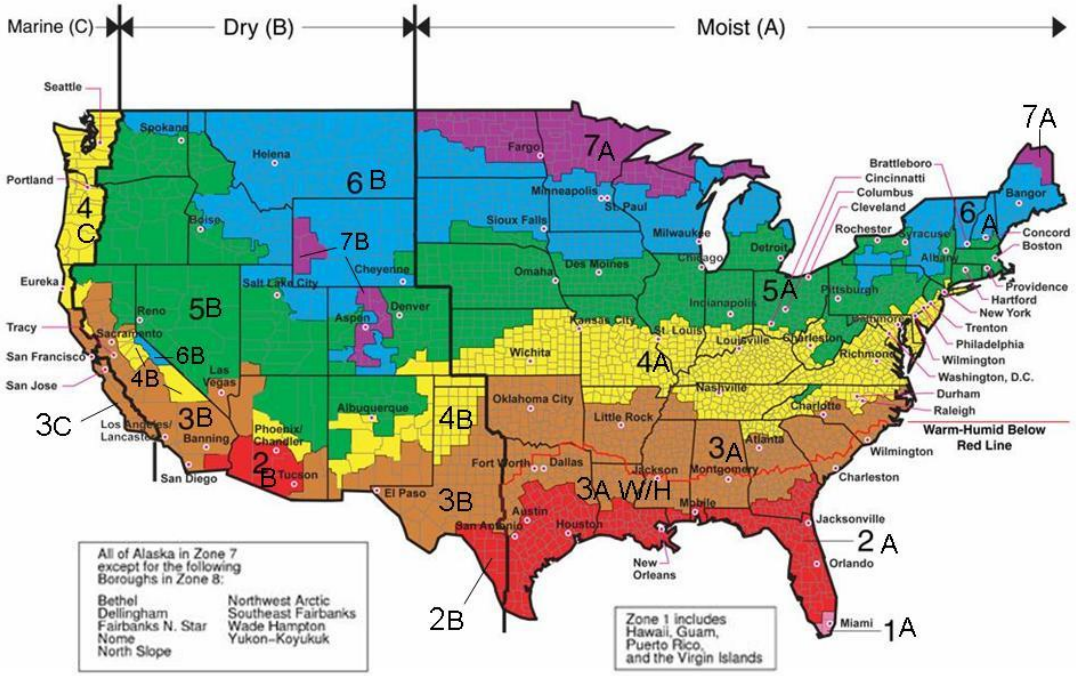
- Cooling Capacity Tests
  - Indoor 80°F (26.7°C), 67°F (19.4°C) wet-bulb
  - Outdoor 95°F (35°C) & 82°F (27.8°C) efficiency
- Heating Capacity Tests
  - Indoor 70°F (21.1°C), 60°F (15.6°C) maximum wet-bulb
  - Outdoor 47°F (8.3°C)
- Additional test conditions are necessary to perform system efficiency calculations for EER, SEER, and HSPF
- Two-speed, multi-speed, or variable speed also require extra tests



AHRI Standard 210/240 provides details on all Standard Ratings Test (FREE Download) (http://ahrinet.org/App_Content/ahri/files/standards%20pdfs/ANSI%20standards%20pdfs/ANSI.AHRI%20Standard%20210.240%20with%20Addenda%201%20and%202.pdf)

Published Ratings

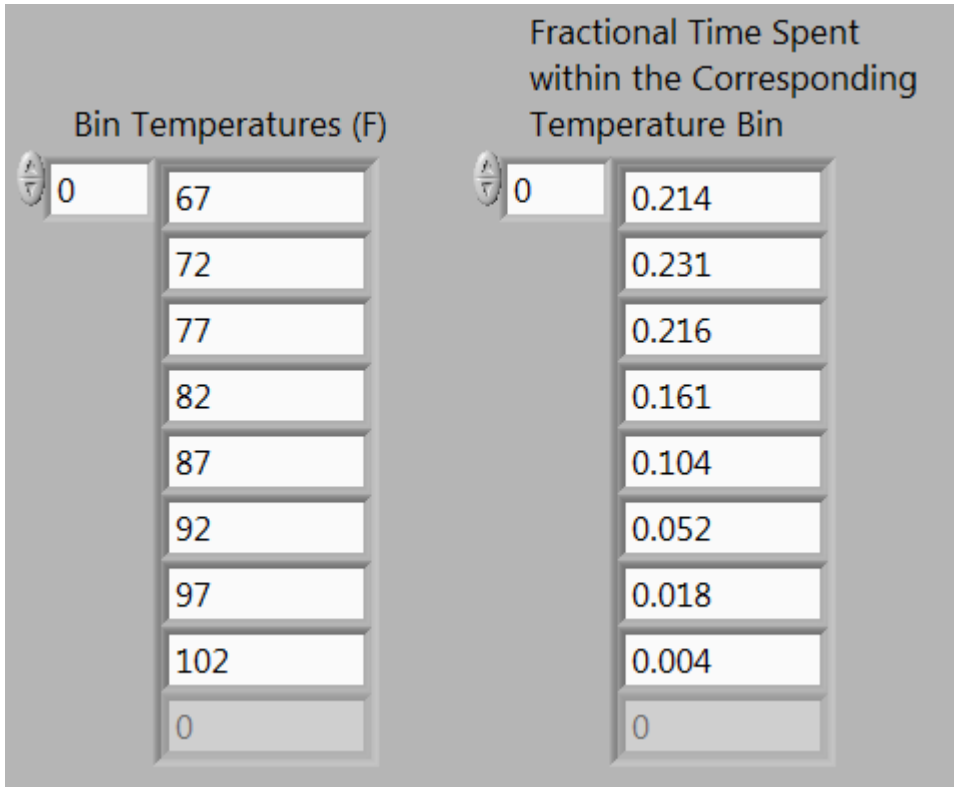
- Cooling Capacity at 95°F (35°C)
- HP Heating Capacity at 47°F (8.3°C)
- Cooling Seasonal Energy Efficiency Ratio (SEER), Region 4
- Heating Seasonal Performance Factor (HSPF), Region 4
- Cooling Energy Efficiency Ratio at 95°F (35°C) (EER)
- Off Mode Electrical Power Consumption



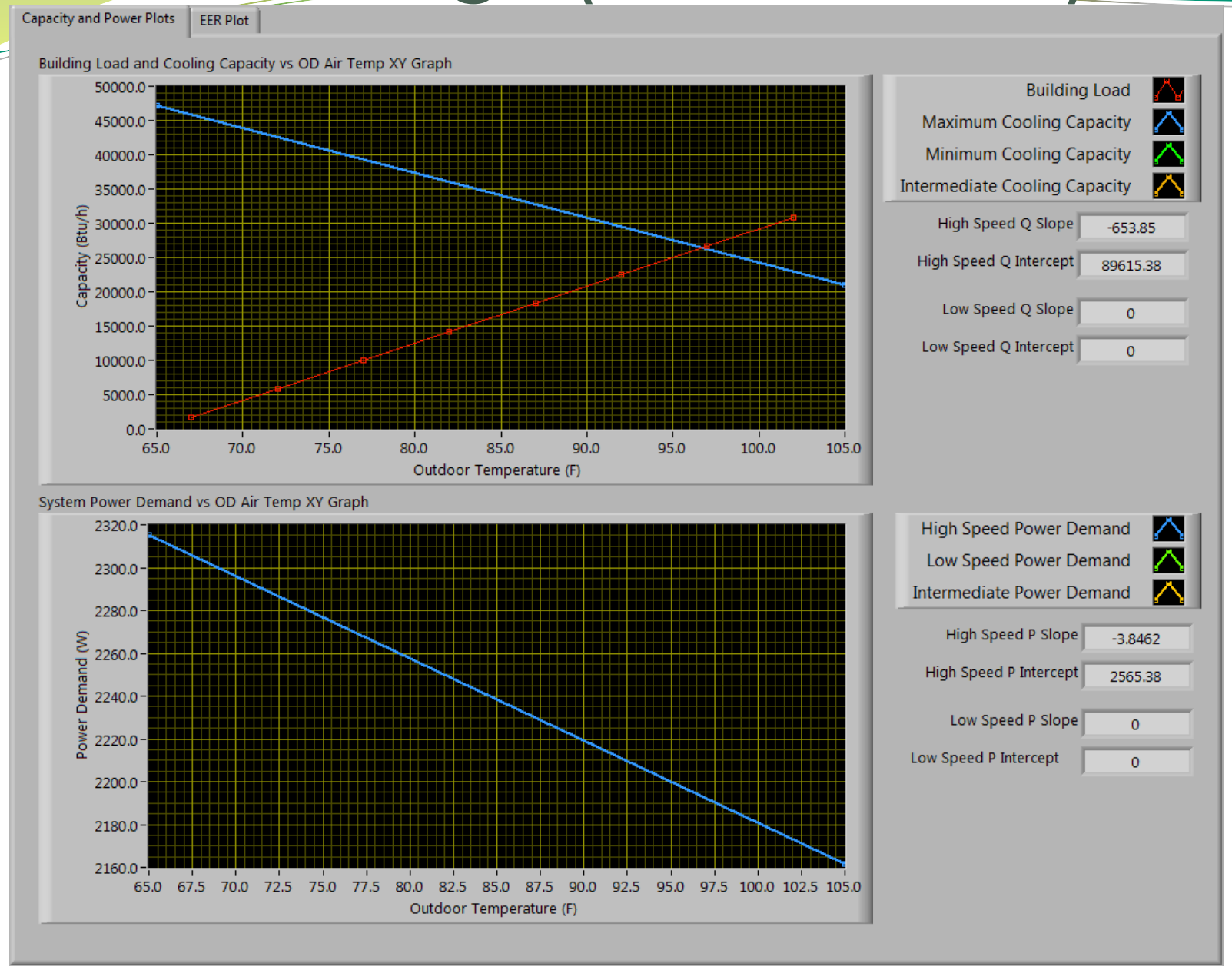
SEER Ratings

- The Seasonal Energy Efficiency Ratio (SEER) measures air conditioning and heat pump COOLING efficiency, which is calculated from the cooling output for a typical cooling season divided by the total electric energy input during the same time frame; a higher SEER rating means greater energy efficiency.
- Shorthand method (single-speed equipment) or optional temperature bin method may be used to calculate SEER.
- Bin method SEER is a weighted average of efficiency at various outdoor temperatures between 67°F (19.4°C) and 102°F (39°C).

DOE Region IV



SEER Ratings (continued)



- Building Load is 10% lower than the 95°F (35°C) capacity and zero at 65°F (18.3°C)
- Power demand is also measured at standard test conditions
- Indoor dry-coil, steady-state and cyclic tests are performed to determine the cooling mode cyclic degradation coefficient

Complaints about SEER

- Tests used to generate SEER values are not realistic
  - Indoor of 80°F DB, 67°F WB (26.7°C, 19.4°C) are not comfortable for most people today (this will vary with climate zone)
  - Outdoor temperature conditions 82°F, 95°F… (27.8°C, 35°C…) are not high enough
  - Indoor air handler external static pressure is too low (< 0.2 in H2O, 49.8 Pa) and does not represent real installations (> 0.5 in H2O, 124.5 Pa)
- No latent capacity performance requirement
- Most of the weighted bin temperatures are below the indoor temperature (Why not open the windows?)
- Assumes 5°F (2.8°C) higher thermostat setting in heating than cooling when it should really be 10°F (5.6°C) difference since heating and cooling test conditions differ by 10°F (5.6°C) (80°F cool - 70°F heat). This would give a 10°F (5.6°C) no-heat and no-cool dead band in the temperature bins.

The Perfect Solution to Cooling Efficiency Ratings (*possibly?, maybe?*)

- Modeling that uses actual weather data and better system performance models (very linear performance) to predict performance (comfort and energy use).
  - Energy Plus, TRNSYS, BEopt, and the like could be adapted to do system ratings
  - Models should accommodate "mixed-systems" (different manufacturer's components)
- This is an important problem for the U.S. because AC&HP systems are being installed everywhere; more than 85% of U.S. homes have central AC.

For example, 2015 year-to-date combined shipments of central air conditioners and air-source heat pumps increased 2.3 percent, to 4,647,076 units, up from 4,541,415 units shipped in July 2014. Year-to-date shipments of central air conditioners increased 2.6 percent to 3,095,315 units, up from 3,016,398 units shipped during the same period in 2014. The year-to-date total for heat pump shipments increased 1.8 percent to 1,551,761 units, up from 1,525,017 units shipped during the same period in 2014.

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Questions?

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