



ENERGY STAR® Central Air Conditioners & Heat Pumps

Cold Climate Heat Pump Controls Verification Procedure

April 13th, 2020





Webinar Audio Access

USE YOUR TELEPHONE:

Call-in Number: (877) 423-6338

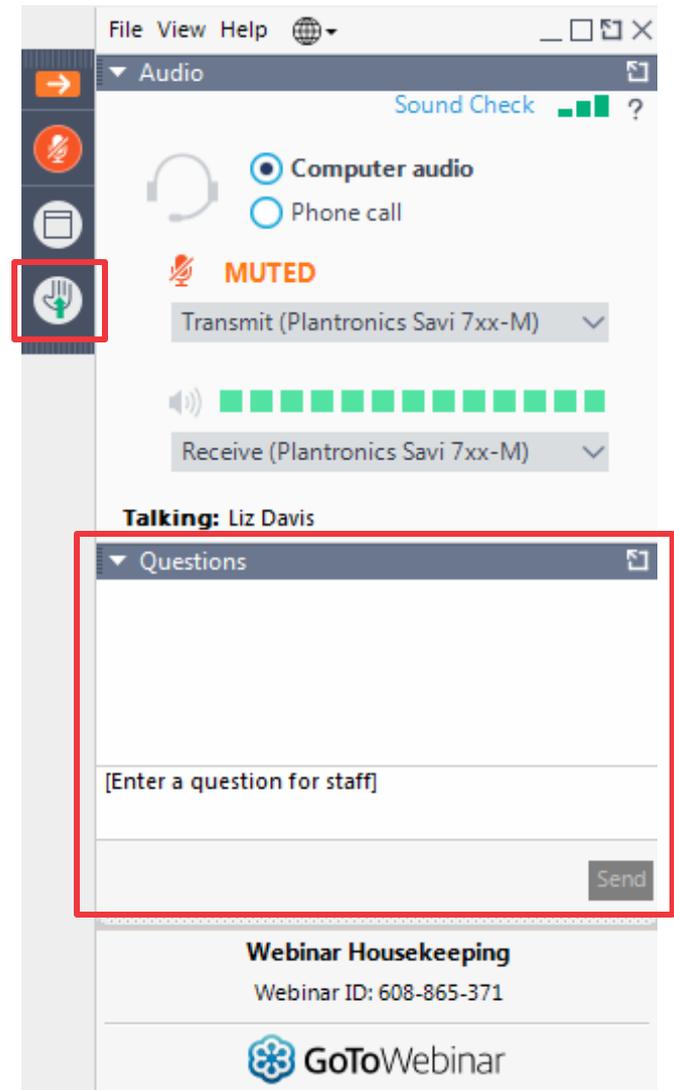
Passcode: 436598#



Webinar Participation

- Please mute yourself when you are not speaking (use local mute or dial *6)
- Feel free to ask questions at any time

Please send written comments to CAC-ASHP@energystar.gov by **May 15, 2020.**





Meeting Agenda

1. Introductions/Background
2. Purpose and Scope
3. Key Definitions
4. Validation Criteria
5. Test Procedure
6. Questions?



Purpose and Scope

- To validate the certified performance of ENERGY STAR air-source central heat pumps using the unit under test's native controls at 5°F conditions specified by the ENERGY STAR test method for Central Heat Pump
- Central Heat Pump capable of operating at two or more distinct capacities or have a capacity which is continuously variable



Key Definitions

- **Native Controls** – configuring the unit under test in settings specified for field use in manufacturer Installation and Operations manual shipped with the unit and operating the unit under test using these settings without overriding its system controls (*Source: CCHP CVP*)
 - **RFC #1:** Where are native control settings typically set? Outdoor unit, Indoor unit, and/or thermostat? Are there differences for ducted / non-ducted indoor units?
 - **RFC #2:** Are central heat pumps capable of multiple configurations specified for field use e.g. “Comfort mode”, “Eco mode”, “Cold-climate mode”, etc.? How should EPA specify which mode to be used for ENERGY STAR verification testing?



Key Definitions

- **Percentage of Heating Capacity @ 5°F** – The capacity of a given unit at 5°F outdoor dry bulb temperature, divided by the heating capacity at 47°F, expressed as a percentage (*Source: ENERGY STAR CAC-ASHP V6.0 Draft Spec*)
 - Calculate Percentage Heating Capacity @ 5°F using heating capacity $Q_{h,x}^{k=2}(5)$ measured during the CVP divided by heating capacity @ 47°F $Q_{h,x}^{k=2}(47)$ certified to ENERGY STAR (i.e., determined from Appendix M H1_N test for units having variable-speed compressors where the compressor speed shall be the maximum speed that the system controls would operate at 47°F, otherwise from Appendix M H1₂ test). If certifying using Appendix M1, reference Appendix M1 H1_N and H1₂ tests.



Validation Criteria

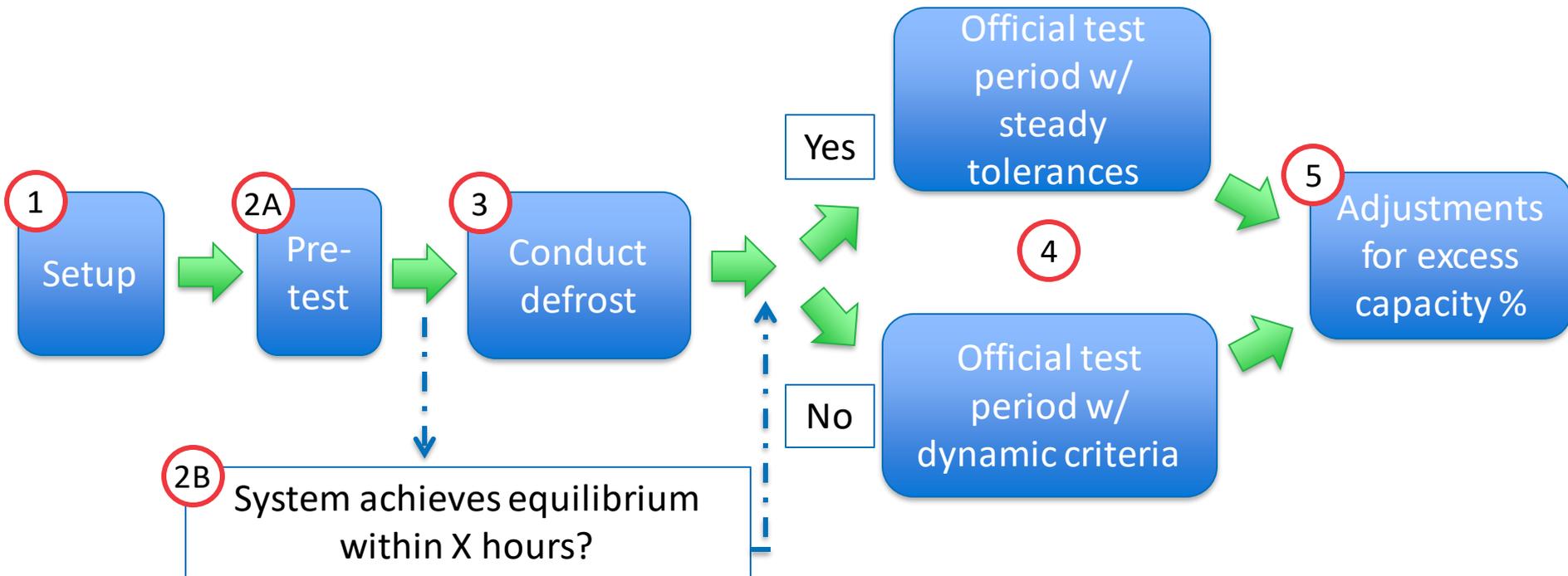
- COP and Percentage Heating Capacity @5°F obtained as described in this procedure must be equal or greater than the criteria below to earn the ENERGY STAR Cold Climate Heat Pump designation: (Table 4A in Certification Criteria)

COP @ 5°F	Percentage of Heating Capacity @ 5°F
1.75	70%

- Pass/Fail criteria, no requirement that manufacturer advertised performance be within a tolerance of performance measured during CVP
- **RFC #3:** What are the relative merits of a CVP designed to validate performance within a tolerance of advertised performance? Such a method would likely include additional elements of a load-based test.



CCHP CVP Diagram





1) Setup

- Operate under native controls i.e. removed from “test mode”
- Set indoor unit thermostats to maximum achievable setpoint
- Set indoor unit airflow-control settings to heating full-load air volume rate (Defined in section 3.1.4.4 of Appendix M)
- For ducted blower-coil systems, test at minimum external specified in Table 4 of appendix M or M1, as appropriate

Rated Cooling ¹ or Heating ² Capacity (Btu/h)	Minimum external resistance ³ (Inches of water)	
	Small-duct, high-velocity systems ⁴⁵	All other systems
Up Thru 28,800	1.10	0.10
29,000 to 42,500	1.15	0.15
43,000 and Above	1.20	0.20

Table 4 – Appendix M

Product variety	Minimum external static pressure (in. wc.)
Conventional (i.e., all central air conditioners and heat pumps not otherwise listed in this table)	0.50
Ceiling-mount and Wall-mount	0.30
Mobile Home	0.30
Low Static	0.10
Mid Static	0.30
Small Duct, High Velocity	1.15
Space-constrained	0.30

Table 4 – Appendix M1



2A) Pre-Test Interval

Table 1. Test Conditions of 5°F Test				
Indoor Unit Dry Bulb (°F)	Indoor Unit Wet Bulb (°F)	Outdoor Unit Dry Bulb (°F)	Outdoor Unit Wet Bulb (°F)	Heating Air Volume Rate
70	60(max)	5	3(max)	Heating Full-Load ¹

If certifying using appendix M1, control indoor and outdoor test chambers to H4 test conditions specified in M1

1. For the pre-test interval, operate the test room reconditioning apparatus and the heat pump until equilibrium conditions* are attained.
2. Use the exhaust fan of the airflow measuring apparatus and, if installed, the indoor blower of the heat pump to obtain and then maintain the indoor air volume rate and/or the external static pressure specified for the particular unit under test
3. Continuously record the dry-bulb temperature of the air entering the indoor coil, and the dry-bulb temperature and water vapor content of the air entering the outdoor coil

* See next slide for description of equilibrium conditions



2B) Operating / Condition Tolerance Check

- The pre-test interval shall not exceed **X** hours
 - RFC #4:** What should be the maximum length of the pre-test interval?
- If steady-state tolerances specified in Table 2 are met for at least 30 minutes during the pre-test interval, then the same criteria shall be applied during the official test period. Proceed to defrost test.
- For variable-speed compressor systems, if steady-state tolerances cannot be met within the **X** hour pre-test interval, then dynamic equilibrium criteria shall be applied during the official test period. Proceed to defrost test.
- Dynamic Equilibrium Criteria** – The system shall be considered in equilibrium when:
 - The dynamic behavior does not exceed the frequency response capability of the capacity measurement instrumentation
 - Both capacity and system power input measured in successive 30-minute intervals are within 2% of each other

Table 2. Test Tolerance for 5°F Heating Test		
	Test operating tolerance	Test condition tolerance
Indoor dry-bulb, °F:		
Entering temperature	4.0	2.0
Leaving temperature	4.0	-
Indoor wet-bulb, °F:		
Entering temperature	2.0	-
Outdoor dry-bulb, °F:		
Entering temperature	4.0	2.0
Leaving temperature	-	-
Outdoor wet-bulb, °F:		
Entering temperature	2.0	1.0
Leaving temperature	-	-
External resistance to airflow, inches of water	0.05	0.02(1)
Electrical voltage, % of rdg	2.0	1.5
Nozzle pressure drop, % of rdg	8.0	



3) Defrost Period

- After satisfying the requirements for the pre-test interval, but before beginning to collect data to determine capacity and power input, conduct a defrost cycle
- Defrost cycle may be manually or automatically initiated, but in all cases the heat pump's own controls must govern when a defrost cycle terminates



4) Official Test Period

- Consistent with ASHRAE 37 requirements, the operating and condition tolerances shall apply when the unit is in heating mode except for the first 10 minutes after terminating a defrost cycle.
- The official test period following chamber recovery shall be 1 hour
- Recording interval: 5 minutes or less, except for input power, which shall be recorded each second unless using an integrated power meter
- Data to be continuously recorded: (Section 3.10 of Appendix M/M1)



5) Adjustments for Variable-Speed Compressor Systems

For units having a variable-speed compressor, if the Percentage Heating Capacity at 5°F exceeds 70% and the COP is less than 1.75:

- Control the total sensible cooling addition to the indoor room such that the heating load approaches and eventually equals the certified 5° Heating Capacity.
- In tandem, incrementally adjust the indoor unit thermostat set point as needed such that the air entering the indoor units approaches the target indoor room dry bulb temperature until the criteria as specified in section Validation Criteria are met or Percentage Heating Capacity drops below 70% with COP that is still lower than 1.75 , which would constitute a failure.
- **RFC #5:** EPA requests feedback on this approach



Questions

For Specification Questions:

Abigail Daken

Daken.Abigail@epa.gov

202-343-9375

Julia Hegarty

Julia.Hegarty@icf.com

202-862-1163

For Test Method Questions:

Antonio M. Bouza

Antonio.Bouza@ee.doe.gov

202-586-4563

Jonathan Caillouet

Jonathan.Caillouet@Guidehouse.com

202-973-3201

Stakeholders are encouraged to provide written comments for EPA consideration to CAC-ASHP@energystar.gov by **May 15, 2020**.