October 8, 2024

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United States Environmental Protection Agency
Washington, DC 20460

(Submitted via email to HVAC@energystar.gov)

Re: AHRI Comments in Response to ENERGY STAR® Commercial Heat Pump Water Heaters Discussion Guide and Draft 1 Test Method for Central Heat Pump Water Heater Systems – Draft Proposal Issued July 31, 2024

Rheem Manufacturing Company (Rheem) appreciates the opportunity to comment on the Environmental Protection Agency's (EPA) ENERGY STAR Commercial Heat Pump Water Heaters Discussion Guide and Draft 1 Test Method for Central Heat Pump Water Heater Systems published on July 31, 2024.

Rheem is an industry leader in total heating, cooling, refrigeration, and water heating solutions, including pool heating, headquartered in Atlanta, Georgia. Rheem has U.S. based manufacturing facilities in Alabama, Arkansas, California, Connecticut, and North Carolina and distribution facilities throughout the U.S., Canada and around the world.. Rheem is at the forefront of developing and commercializing products that advance the goals of emissions reduction at an affordable price to the customer, working cooperatively with environmental agencies and regulators.

Rheem supports the development of a central heat pump water heater (CHPWH) system test method and the planned product specification. EPA developing this test method as a national standard while utilizing a consensus process should ensure broad stakeholder participation. Further, a national specification and qualified products list (QPL) will help reduce the proliferation of competing specifications and QPLs that industry has been compelled to comply with. Rheem has concerns over the authority to regulate CHPWH systems within the DOE and EPA framework, along with the stated understanding of a heat pump water heater's (HPWH) role within a CHPWH system. Rheem is an active member of Air-Conditioning, Heating and Refrigeration Institute (AHRI) and supports their separately submitted comments.

DISCUSSION GUIDE

Scope and Definitions

Rheem agrees with EPA that the existing DOE test procedure (Appendix E to Subpart G of Part 431) and version 2.0 of the Energy Star Specification for commercial water heaters, which references the DOE test procedure, do not adequately address CHPWH systems. However, Rheem understands this inadequacy to mean that CHPWH systems are not covered by DOE or Energy Star. On November 10, 2016, prior to the publication of version 2.0, DOE published a commercial water heater test procedure final rule. 81 FR 79261. In this rulemaking, DOE clearly establishes a test procedure which covers integrated and split-system commercial HPWHs (see section 4.1.1 of Appendix E to Subpart G of Part 431 where installation requirements for HPWHs with and without an integral storage tank are discussed). Were DOE to add a test procedure and energy conservation standard for CHPWH systems, Rheem would expect a coverage determination rulemaking to occur first.

Rheem understands that EPA can develop a voluntary specification for CHPWH systems under its existing authority, even if it gets ahead of the current DOE regulation. It is unclear whether EPA intends to replace the existing Energy Star specification for commercial HPWHs with a system specification or whether a system test method and specification will be used to augment the information available for commercial HPWHs. Rheem recommends EPA retain the current commercial HPWH specification, with a minor update to the commercial HPWH definition to align with the amended DOE definition. Replacing the current specification before the system test method and specification are fully understood could adversely impact in the nascent commercial HPWH market. For example, assumptions made in a system metric calculation could favor one technology over another[1] and effectively force certain HPWH configurations off the market. Further, in the short term, the commercial HPWH specification could be used for incentives that cover replacement applications and the CHPWH system specification can be referenced by the Energy Star whole home specifications or directly by commercial building codes.

EPA stated that the current specification, version 2.0,[2] "includes only those [HPWHs] with back up resistance elements, most of which are integrated units sold with the heat pump as a heat source and the tank together." Rheem cannot find any language within the specification, cover letter, webinar slides, or Draft 1 comment matrix for version 2.0 that would suggest split-system

[1] This has already occurred to some extent in California where the 2025 building code will not allow multi-pass HPWHs to be used to meet the prescriptive compliance pathway.

[2] Energy Star Commercial Water Heaters Specification Version 2.0 Development: https://www.energystar.gov/products/spec/commercial_water_heaters_specification_version_2_0_pd.

commercial HPWHs are not covered by the specification. In fact, in version 1.0[3] of the specification commercial HPWHs were listed as a "storage-type unit" but in version 2.0 commercial HPWHs were recategorized to be separate from the storage or instantaneous definitions, suggesting that EPA was aware of split-system commercial HPWHs and sought to include them. Further, in section 2.B.d of the specification, where storage water heaters with >140 gallons of capacity are excluded from the scope of the specification, the specification states commercial HPWHs "designed to operate in conjunction with tanks or storage type water heaters are exempt from this exclusion." If a type of commercial HPWH is exempt from exclusion from the specification, then that type of commercial HPWH is included in the specification.

Rheem supports alignment of EPA's commercial HPWH definition with that of DOE in regard to the referencing voltage and amperage instead of input rate. Rheem disagrees with EPA's statement that "DOE updated the definition of commercial HPWH to include heat pump units that do not include an electric resistance element." The electrical requirement revision came from a more accurate reading of the Energy Policy and Conservation Act (EPCA), as amended, and a better understanding of the water heaters available for residential and commercial applications. 88 FR 40406, 40416 (June 21, 2023). Further, in the NOPR that preceded the final rule which changed the commercial HPWH definition DOE stated, "In determining the input rate of a water heater with a heat pump component for the purpose of classifying such a water heater as either a consumer water heater or a commercial water heater, DOE would consider the total input rate, including all heat pump components and the resistive elements. […] Similarly, DOE would consider all heat pump components and resistive elements in determining voltage and amperage." 87 FR 1554, 1562-1563 (Jan. 11, 2022). Rheem also notes that S. 4061[4] of the 117th Congress (2021-2022) proposed, in relevant part, in a definition of "heat pump type units" a list of ancillary equipment including electric resistance heating elements. This bill was reviewed by many industry and Federal stakeholders. Rheem understands this proposal as an attempt to more clearly state DOE's interpretation from the 2022 test procedure NOPR and resistance elements be included when determining the input rate, voltage, and amperage of a HPWH.

EPA stated, "The updated definition clarifies that all ancillary equipment (tanks, pumps, etc.) are part of the commercial HPWH, and provides the opportunity for the ENERGY STAR specification to address the impact of system design on performance." Rheem disagrees as the language "including all necessary ancillary equipment fans, blowers, pumps, storage tanks, piping, and controls" has existed in industry test procedures since first introduced into ASHRAE

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[3] Energy Star Commercial Water Heaters Specification Version 1.0 Development: https://www.energystar.gov/products/spec/commercial_water_heaters_specification_version_1_0_pd.
[4] S. 4061: https://www.congress.gov/bill/117th-congress/senate-bill/4061/text.

118.1-2003 and this method of test clearly addresses commercial HPWHs with and without a supplied storage tank (*i.e.,* Type IV and Type V).

DOE stated in an energy conservation standards final rule for pool heaters, that "manufacturers may not make representations for heat pump pool heaters at test conditions which are not included in appendix P." 88 FR 34624, 34635 (May 30, 2023). While Rheem recognizes that Appendix P applies strictly to heat pump pool heaters, this infers manufacturers cannot make efficiency representations at test conditions other those explicitly stated in the DOE test procedure. Clarification is needed from DOE, perhaps through publication of an enforcement policy statement, allowing for split-system HPWHs to make efficiency representations at non-DOE test conditions if the DOE test condition is present alongside these claims and clearly identified.

Incentive programs

Rheem supports this CHPWH system test method and specification development; however, if done thoughtfully this will take several years to complete. Meanwhile, Rheem recommends EPA update the existing commercial water heater specification to clearly include both integrated and split-system commercial HPWHs, regardless of whether the HP is supplied with a tank. Energy Star compliance is required for Inflation Reduction Act (IRA) High-Efficiency Electric Home Rebate Act (HEEHRA) rebates. As this update would be a clarification of scope and definition alignment with DOE, it could happen in a fraction of the time the system test method and specification will occur. This change would also align with the Consortium for Energy Efficiency's (CEE) recently updated commercial water heater specification,[5] which simply uses to DOE test procedure for "commercial central and split electric heat pump water heaters."

Flexible Demand

Given the limited uptake of residential flexible demand programs, it is far too early to add flexible demand (demand response) to commercial HPWHs or CHPWH systems. Rheem recommends referencing the industry standard for flexible demand in commercial water heaters, AHRI 1530, after it is finalized and only as an optional requirement.

Point-of-Use Instantaneous

Rheem notes that point-of-use (POU) storage and instantaneous water heaters are an underutilized energy, water, and cost saving option for water heating in both residential and commercial applications. POU water heaters can reduce construction costs, and the structure's

[5] CEE Commercial Water Heating Specification: https://cee1.my.site.com/s/resources?id=a0VTR000000PfPl.

embodied carbon, as only one uninsulated cold-water line needs to be run to the fixture. Energy (pipe losses) and water savings (no need to heat the pipes throughout the house) can also be had as there is minimal piping between a POU water heater and fixture. For instantaneous POU water heaters there are also, minimal standby losses. Rheem notes that for loads such as handwashing and showering, a storage POU water heater may be most appropriate.

Given the system-based focus on water heating, EPA could begin to incorporate POU water heaters into the specifications. This may be particularly useful as part of the whole home specifications.

Pumps

EPA requested comment on the limitation of requiring high efficiency pumps in Energy Star certified systems. Within this CHPWH system test method and eventual specification, Rheem does not support EPA making design or efficiency requirements for individual components of the system. Rheem does support recognition of efficient system components within their own specification. CHPWH systems are more expensive that their non-HP counterparts, so manufacturers will be seeking to optimize cost and efficiency. As described elsewhere in these comments, there are several locations within a CHPWH system where a standalone pump could be used. Requiring high efficiency, or multi-speed, pumps may not save any energy while significantly increasing cost.

Draft 1 Test Method for Central Heat Pump Water Heater Systems

OVERVIEW

Request comment on the scope of system components included in this test method. Request comment on whether any other components of central HPWH systems not included in this test procedure would have significant impacts on the energy efficiency of the system.

Rheem understands the intent of this test method development effort is to address heat pump water heating systems in commercial buildings, where the primary HPWH is not an integrated HPWH. "Split-system" HPWHs have the evaporator separated from the storage tank(s) and "monobloc" HPWHs are a subset of split-system HPWHs that have the condenser in the HP unit (*i.e.,* water, as opposed to refrigerant, is circulated between the HP unit and the tank). Several different types of equipment are necessary for the system to function properly.

The primary HPWH is a split-system HPWH that can be either electric (*i.e.,* vapor-compression) or gas (*e.g.,* absorption or adsorption) driven. The split-system HPWH is connected to either an unfired storage tank (*e.g.,* if the primary HPWH circulates water), an indirect water heater (*e.g.,* if the primary HPWH circulates refrigerant), or an external heat exchanger (*e.g.,* if the primary

HPWH circulates a water brine mixture). When an external heat external heat exchanger is used, the next equipment in line would typically be an unfired storage tank. A pump is required to circulate water/brine through the primary HPWH, if this pump is not present within the unit, then an external pump is required. If an external heat exchanger is used, a pump may be needed between the heat exchanger and the unfired storage tanks. The first tank in the line is referred to as the "primary storage tank." In single-pass HPWH systems, a temperature maintenance or "swing" tank is typically used. This is a water heater with its own heating source that can be electric resistance, heat pump (integrated or split), or gas-fired. In multi-pass HPWH system, an in-line booster heater (electric or gas-fired flow activated instantaneous water heater) can be used and can be located after the mixing valve (for higher-than-expected capacity) or between the primary HPWH and primary storage tank (for lower ambient periods). For systems with a recirculation loop, a pump is required. All commercial water heating systems should have a mixing valve installed. Finally, while all logic could reside within the primary HPWH, a third-party controller may also be used for whole system integration.

Request comment on whether combining the performance of each system component into an overall system performance metric could be representative of the overall efficiency of the system using only the information required for and gathered in this test procedure and manufacturer literature.

A well thought out test method, developed through a consensus process, can be adequately representative of in-field energy usage. This combined test method is more complex than a test on a single piece of equipment, so care must be taken to avoid being overly dependent on the test method before industry has had a chance to implement it.

Request comment on how this test procedure should gather other information that may be required to produce a representative system efficiency.

Rheem recommends that the test method use the certified ratings and results of the already established test procedures covering the various types of equipment as much as possible. Specific recommendations are made throughout these comments.

Request comment on an appropriate method to calculate the overall system performance given the system configuration and the efficiency of each component as tested according to the test procedures set out in this test method.

Rheem recommends calculation be for an entire year at national average ambient conditions. Optional representations should be explicitly allowed at each climate zone (*e.g.,* IECC or ASHRAE). Piping insulation should be accounted for and be set at a conservative level as older buildings have lower amounts of insulation than newly constructed buildings. All systems should be installed with a mixing valve that mixes down to 120°F.[6] Most commercial buildings require a recirculation loop, so Rheem recommends a recirculation loop be included in all system representations.

At this time, Rheem does not recommend a bin weighting/operating hours approach as important aspects of system operation will be lost. For example, many of the coldest hours may not have any hot water demand meaning heating is not needed or could be delayed.

Rheem notes that ASHRAE 90.1-2022 includes an energy credit for heat pump water heaters. This credit was developed with limited industry engagement and is being amended for the 2025 release to more accurately capture the energy consumption improvement of heat pump water heaters from the baseline. While Rheem doesn't recommend serious review of this energy credit until the 2025 amendment, Rheem does agree with the trend in energy credits given to each application. Multifamily and hotel/motel receive the most energy credits as they have a large bathing load. Restaurants also receive a good amount of energy credits due to a consistent need for hot water for sanitation. Multifamily/hotel/motel load profiles generally have two peaks while restaurant load profiles generally have one extended period of high usage. Rheem recommends the CHPWH system test method address two-peak bathing applications and extended single-peak sanitation applications.

DEFINITIONS

Please see comments above on the commercial heat pump water heater definition and scope of DOE and EPA's authority.

DOE covers integrated, split-system supplied with a matching tank, and split-system supplied without a matching tank as a commercial heat pump water heater. Including "central heat pump water heater system" as a type of commercial heat pump water heaters is inside out. Commercial water heating systems encompass all components that touch the hot water lines and can be central, distributed, or a combination. These systems can have multiple water heaters with various fuel types and technologies. A central heat pump water heater system is a subset of central water heating systems that uses a heat pump water heater as the primary[7] water heater. Rheem notes that the description for Ecosizer[8] states that it's a "tool for sizing central water heating systems based on commercial heat pump water heaters (CHPWHs) in multifamily and

[6] Rheem notes that some commercial applications require significantly hotter water than 120°F.

[7] Where "primary" means first to be used and does not need to provide a certain amount of hot water. That is, systems where a majority of the water is heated with gas or electric resistance due to application constraints (*e.g.,* commercial kitchen) can get credit for including a heat pump within the system.

[8] Ecosizer: https://ecosizer.ecotope.com/sizer/

commercial buildings." Therefore, industry already understands that the system includes the heat pump water heater and not the other way around. Rheem recommends the following definitions for heat pump water heaters and their system architecture.

1. **Air-source commercial heat-pump water heater**: A heat pump water heater that utilizes indoor or outdoor air as the heat source. Such equipment includes integrated and split-system heat pump water heaters.
2. **Heat pump water heater**: a water heater (including all ancillary equipment such as fans, blowers, pumps, storage tanks, piping, and controls, as applicable) that uses a refrigeration cycle, such as vapor compression, to transfer heat from a low-temperature source to a higher-temperature sink for the purpose of heating potable water. Such equipment includes, but is not limited to, air-source heat pump water heaters, water-source heat pump water heaters, and direct geo-exchange heat pump water heaters.
    a. **Consumer heat pump water heater**: is a heat pump water heater with a maximum current rating of 24 amperes at a voltage no greater than 250 volts.
    b. **Commercial heat pump water heater**: a heat pump water heater that operates with a current rating greater than 24 amperes or a voltage greater than 250 volts.
3. **Integrated heat pump water heater**: A heat pump water heater that has a built-in storage tank contained within the same casing.
4. **Multi-pass heat pump water heater**: A split-system heat pump water heater that cannot meet the requirements of a single-pass heat pump water heater.
5. **Primary water heater(s)**: The water heater(s), within a central water heater system, which the system controller seeks to maximize operation of.
6. **Secondary water heater(s)**: All water heaters, within a central water heater system, used to make up the water heating load when the primary water heater cannot supply the full load.
    a. **Swing tank**: a water heater with a storage tank, typically used in single-pass systems with a recirculation loop.
    b. **Booster heater**: a flow-activated water heater, typically an instantaneous water heater located after the mixing valve or between the primary water heater and storage tank.
7. **Single-pass heat pump water heater**: A split-system heat pump water heater which has equipment that can modulate the flow rate through the heat pump to achieve the outlet water temperature at each of the specified inlet temperatures.
8. **Split-system heat pump water heater**: A heat pump water heater in which
    a. At least the compressor, which may be installed outdoors, is separate from the storage tank.
    b. May circulate either potable water or a heat exchange fluid (*e.g.,* refrigerant or brine) with the next step in the system, normally a storage tank.
    c. May be supplied with or without a matched storage tank.
    d. May operate as a single and/or multi-pass heat pump water heater.

9. **Water heating system**: all components within a building found on the potable hot water supply line.
    a. **Central water heater system**: a water heating system where all water heaters are in one location.
        i. **Central heat pump water heater system**: A water heating system that uses a split-system heat pump water heater as the primary water heater. A central heat pump water heater system can include products that come pre-mounted on a skid or pallet with multiple components and may require infield plumbing between components.
    b. **Distributed water heater system**: a water heating system where water heaters are located throughout a building (*e.g.,* in each apartment).

As discussed throughout these comments, consumer water heaters for each of the water heating roles within a system. Further, unfired hot water storage tanks and indirect water heaters are currently components of a central water heating system. Rheem recommends the relevant components and metrics be added to the definitions.

1. **First-Hour Rating**: An estimate of the maximum volume of "hot" water that a non-flow activated water heater can supply within an hour that begins with the water heater fully heated (*i.e.,* with all thermostats satisfied).
2. **Indirect water heater**: equipment which utilizes externally heated water or brine to heat potable water.
    a. **Indirect Instantaneous Water Heater**: An indirect water heater consisting of a tank which contains hot water from an external source and a heat exchanger used to transfer heat from this stored water to the potable water.
    b. **Indirect Storage Water Heater**: An indirect water heater consisting of a potable hot water storage tank equipped with an internal or external heat exchanger used to transfer heat to the stored potable water from an external source.
3. **Maximum GPM Rating**: The maximum gallons per minute of hot water that can be supplied by a flow-activated water heater when tested in accordance with section 5.3.2 of Appendix E to Subpart B of Part 430.
4. **R-value**: For unfired storage tanks, the thermal resistance of insulating material as determined using ASTM C177-13 or C518-15 and expressed in ($°F \cdot ft^2 \cdot h/Btu$).
5. **Recovery efficiency**: For consumer and residential-duty commercial water heaters, the ratio of energy delivered to the water to the energy content of the fuel consumed by the water heater.
6. **Tank orientation**: Either vertical or horizontal.
7. **Unfired hot water storage tank**: a tank used to store water that is heated externally.
8. **Uniform energy factor**: For consumer and residential-duty commercial water heaters, the measure of water heater overall efficiency.

The operating range of the heat pump water heater will be important when performing annual calculations. Rheem recommends the lower and upper compressor cut-off temperatures be reported. The proposed definitions align with version 5.0 of the Energy Star residential water heater specification with the reference to electric resistance removed.

1. **Lower Compressor Cut-off Temperature**: The temperature below which a heat pump water heater's compressor will no longer operate.
2. **Upper Compressor Cut-off Temperature**: The temperature above which a heat pump water heater's compressor will no longer operate.

DOE certified volumes are quite confusing, where rated, measured, nominal, or effective volume are required depending on whether the product is consumer or commercial, storage or instantaneous, and gas-fired, electric resistance, or heat pump. Rheem recommends reporting of measured and nominal volume be required for all components with a tank.

1. **Measured Volume**: the actual water storage volume of a tank, which can be determined through testing of at least two samples or through computer modelling.
2. **Nominal Volume**: the volume reported by the manufacturer.

TEST METHODS

Heat Pump Unit

Request comment on whether referencing ANSI/ASHRAE 118.1-2022 (as opposed to ANSI/ASHRAE 118.1-2012, or any other existing test method) is appropriate for this test procedure and if any additional modifications to its reference in this test procedure are necessary.

Rheem supports referencing the most recent version of ANSI/ASHRAE 118.1 as much as possible.

In section C, DOE proposed excluding sections 6.3, 6.4, and 6.5 of ANSI/ASHRAE 118.1-2022. Rheem recommends the test method only exclude section 6.3 of ANSI/ASHRAE 118.1-2022. Section 6.3 sets the minimum divisions on the draft gage at 0.005 in. of water (1 Pa), while earlier in section 6 the instrument accuracy for draft is stated as "±0.005 in. of water (1 Pa)." Therefore, inclusion of section 6.3 would require the least accurate method of draft measurement allowed elsewhere in the standard. Section 6.4 states that the higher heating value (HHV) must be measured. Rheem assumes this is being excluded as it would only affect gas-fired water heaters, but there are gas-fired heat pump water heaters on the market that are used commercial applications, and the scope doesn't currently exclude gas-fired heat pump water heaters. Section 6.4 addresses water flow tolerance and mass conversion, which don't appear to be addressed elsewhere in the test procedure.

Section D references most section 7 of ANSI/ASHRAE 118.1-2022. The only omitted sections appear to be sections 7.4 (gas venting), 7.7.7.3 (water solution), and 7.7.8 (turn off resistance elements). Rheem recommends these sections also be referenced as gas-fired heat pump water heaters are in scope (section 7.4), CHPWH systems may use a water solution or brine in conjunction with a heat exchanger to prevent pipe freezing in colder climates (section 7.7.7.3), and there's a separate instruction in the test method to turn off resistance elements. Referencing the entire section 7 of ANSI/ASHRAE 118.1-2022 would clean up Section D and the only clarifications needed would be around ducted vs. non-ducted, test operating tolerance for external static pressure and airflow (nozzle pressure drop) tolerance, and evaporator-side rating conditions. Rheem request clarification why DOE proposed a different external static pressure and airflow (nozzle pressure drop) tolerance than is in ANSI/ASHRAE 118.1-2022.

Section E.3 states that measurements are to be taken "at equal intervals no greater than one minute" and Section E.5 includes 31 readings within the calculation. This equation couldn't be used for a test that records at an equal interval less than one minute (*i.e.,* every second).

Request comment on whether the ducted configuration is representative of typical performance of such units, or if separate tests should be conducted in both configurations.

Rheem notes that split-system HPWH will typically be installed outdoors, therefore, ducting will not be used in most installations. Rheem recommends HPWHs be tested in a manner that is representative of in field operation. That is, split-system HPWHs should be tested without ducting and integrated, which are typically installed indoors, should be tested with ducting.

Request comment on the standardized temperatures shown in Table 4.1 and Table 4.2 for each type of central HPWH.

Rheem generally supports the proposed temperatures in Table 4.1. Test numbers 1-4 align with the current AHRI 1300 standard and test number 5 (5°F dry bulb) is a temperature currently required by NEEA's AWHS version 8.1. Test number 2 (80.6°F) aligns with the current DOE test procedure condition. Rheem notes that AHRI 1300 is being revised and recommends the CHPWH system test method be updated to align with the amended AHRI 1300 when it is finalized.

Rheem notes that NEEA's AWHS requires test data for three different temperatures 34°F, 68°F, and the lowest temperature the split-system HPWH can operate. Rheem doesn't recommend testing at 68°F given the 50°F and 80.6°F conditions already in Table 4.1. Testing at 34°F may be problematic due to defrosting that occurs around this temperature. Rheem does not recommend a test be performed between 17°F and 50°F. Rheem does recommend defrost operation be addressed either as a separate test or calculation. Rheem addresses split-system HPWH operation below test number 5 in a subsequent comment response.

Rheem has no comment on Table 4.2.

Request comment on the readiness of market-available products to meet the temperatures shown in Table 4.1 and Table 4.2.

Split-system HPWHs exist that can meet all the conditions in Table 4.1. Rheem notes that not all split-system HPWHs can meet every condition but that's a good thing as cold climate split-system HPWHs are not necessary in warm climates.

Request comment on the proposed condenser entering water temperature and rise in Table 4.3 and specifically whether the proposed condenser entering water temperatures will be difficult to meet while using the proposed ambient test conditions in Table 4.1 and Table 4.2.

Rheem supports the proposed temperature rise for the single and multi-pass tests. The outlet water temperature of 140°F is broadly representative of CHPWH system temperatures. Rheem notes that some CHPWH systems may not need to heat up to 140°F and other systems may heat higher due to a larger recirculation load (higher stored temperature allows the heat pump to carry more of the recirculation load compared to the swing tank).

Rheem recommends EPA align the condenser entering water temperatures with those that are eventually prescribed in AHRI 1300, which is currently being updated.

Rheem expects some split-system HPWHs, which can operate at the lower ambient temperatures, to not be capable of achieving the single-pass temperature rise at the lower ambient temperatures. The multi-pass temperature rise should be possible for all split-system HPWHs unless the compressor cutoff temperature is very close to the lower ambient temperature. Rheem recommends that the CHPWH system test method measure and give credit for the capacity taken up by the heat pump at lower ambient temperatures. Further, Rheem recommends that provisions be added to either the test method, future specification, or data collection program that don't allow for representations to be made at conditions where the temperature rise was not achieved.

Request comment on whether additional evaporator or entering water temperature conditions should be included as required test conditions.

Rheem doesn't recommend additional entering water temperature conditions be added. The water temperatures entering the CHPWH come from a storage tank with already heated water, so the cold-water supply to the building is mixed and heated slightly. This mixing means that the evaporator entering water temperature remains constant enough that an additional test point would significantly increase burden while only minimally making the results more representative.

Request comment and information on using a seasonal metric for heat pump units, especially feedback on the considerations listed.

1. *Using bins across the range of outdoor air operating temperatures, with weighting to represent climate conditions (e.g., national average and/or cold climate)*

A bin weighting method may help simplify the calculations, but it ignores the fact that many of the coldest hours occur when no or very little hot water is needed (*i.e.,* overnight), so water heating isn't needed or can be delayed. This nuance can be accounted for in a more sophisticated software or computer model. At this time, Rheem recommends computer modelling be used. Regardless of whether a bin weighting method or computer model are used, the results should be validated by test data.

2. *Comparing unit capacity and water heating load within each bin and applying an electric resistance performance factor to make up the difference for bins with load greater than the highest stage unit capacity.*

Rheem does recommend accounting for backup energy use (electric resistance or gas) when the split-system HPWH cannot supply the full water heating load.

Rheem notes that swing tanks, which are used in single-pass systems are typically electric resistance water heaters but could also be gas-fired storage water heaters, use significant energy when paired with a recirculation loop.

3. *Interpolating capacity between compressor stages for bins where the highest stage capacity is greater than the bin load, but the load is less than the lowest stage capacity.*

Rheem recommends evaluating linear interpolation of the split-system HPWH efficiency at a particular temperature and converting to heating capacity based on known input capacity.

Below the lower compressor cutoff temperature, an electric resistance efficiency of 98% should be used. From the lower compressor cutoff temperature to the next test condition, linearly interpolate from 98% to the measured COP. Linearly interpolate between test conditions until the highest ambient test condition. Above the highest ambient test condition and the to the split-system HPWHs upper compressor cutoff temperature, assume a COP at the measured COP of the highest condition. Rheem notes that at high temperatures compressors may experience performance issues, so an extrapolated increase should not be assumed. Assume electric resistance operation above the upper compressor cutoff temperature.

4. *Multiple outdoor air temperatures and part-load testing for units with multiple compressor stages being used to determine capacity, power, and water heating load at each bin temperature.*

Rheem does not recommend further testing to evaluate part-load operation. Rheem notes that the test procedure does not require the split-system HPWH to operate at maximum capacity, rather the split-system HPWH must achieve a temperature rise. Some test conditions will be closer to the split-system HPWHs maximum capacity than others. Rheem recommends further evaluation of part-load operation be reserved for a future round of the revision when in-field part-load applications will be better understood.

5. *Using different provisions depending on the intended operating conditions for heat pumps (e.g., whether models have defrost mode)*

As stated above, Rheem recommends defrost be addressed as it is most prevalent at an ambient condition between 30-40°F, which isn't part of the proposed test conditions. A standard derate could be applied in this range (*e.g.,* 34°F could be defrost test condition, linearly interpolate between the 17°F and 50°F test conditions and subtract a percentage from the interpolated COP) that a manufacturer can choose to take rather than performing a defrost test. This type of provision is used elsewhere in DOE test procedure for jacket loss calculations.

Rheem recommends that the required CHPWH system metric be a national average. However, as recommended above, the calculations should be performed through computer modeling, so ratings for other operating conditions can be made. Rheem recommends optional ratings be allowed for each climate zone, in addition to the national rating.

6. *Varying the water heating load with outdoor air temperature to reflect variation in ground water temp*

Rheem doesn't expect the hot water demand to change based on ambient conditions (*e.g.,* X gallons of water per day at 120°F are needed for Y number of hotel rooms). The energy used to meet the hot water demand will change and is affected by outdoor air temperature and the water temperature entering the system (ground water temperature or cold-water supply). As discussed above, the cold-water supply mixes with the storage tank and the split-system HPWH sees a relatively consistent entering water temperature. Rheem expects the split-system HPWH will need to operate longer at colder cold-water supply temperatures as the temperature in the tank will need to recover further.

Unfired Storage Tanks

Unfired storage tanks are explicitly covered in the US Code as a type of covered equipment. (42 U.S.C. 6311(1)(K)). Therefore, EPA as part of this development should not be proposing test procedure revisions for this equipment outside of their rulemaking process. Rheem notes that enough issues were raised in response to the test procedure NOPR which initially proposed these changes that DOE did not finalize the proposal. 81 FR 28588; 81 FR 79261, 79311.

As the current energy conservation standard for unfired storage tanks is an R-value greater than or equal to 12.5 °F·ft^2·h/Btu. DOE's CCMS Database has certified R-values up to 30 °F·ft^2·h/Btu. Rheem recommends a simple conversion from R-value to standby loss (Btu/h). This would require tank dimensions to be reported along with the actual R-value of the tank.

$$SL = \frac{Tank\ Surface\ Area \times (T_{Tank} - T_{Indoor\ Ambient})}{R - Value}$$

Electric Storage Water Heaters

Rheem is concerned with the proposed standby loss calculation as the ambient temperature is not accounted for. The calculations in Appendix B to Subpart G of Part 431 have a variable ΔT_3, (T_{Tank}-T_{amb}) which is not found in the proposal. Rheem proposes a different method below.

Electric storage water heaters are often used in single-pass CHPWH systems as swing tanks. This configuration allows for the single-pass HPWH to see lower entering water temperatures for a larger period, while also ensuring the hot water recirculation loop stays hot. Rheem notes that the swing tank can also be an integrated HPWH or a gas-fired storage water heater and that the unit can be either a consumer or commercial water heater depending on the water heating load. Standby loss and steady-state efficiency can both be readily obtained from the existing DOE test procedures.

For consumer storage water heaters, rated volume, first-hour rating (FHR), recovery efficiency (*i.e.,* steady-state efficiency), and UEF are already reported. Rheem recommends using the Water Heater Analysis Model (WHAM)[9] and the already reported data to back out a standby loss value.

$$\frac{V\,\rho\,C_p(T_{del} - T_{in})}{UEF} = \frac{V\,\rho\,C_p(T_{del} - T_{in})}{RE}\left(1 - \frac{UA\,(T_{Tank,1} - T_{amb,1})}{P_{on}}\right) + 24\,UA\,(T_{Tank,1} - T_{amb,1})$$

$$UA = \frac{P_{on}\,V\,\rho\,C_p\,(RE - UEF)\,(T_{del} - T_{in})}{24\,UEF\,RE\,P_{on}\,(T_{Tank,1} - T_{amb,1}) - UEF\,V\,\rho\,C_p\,(T_{Tank,1} - T_{amb,1})(T_{del} - T_{in})}$$

[9] Water Heater Analysis Model: https://www.aceee.org/files/proceedings/1998/data/papers/0114.PDF.

Converting from UA (Btu/h °F), the standby heat loss coefficient, to standby loss can be done by multiplying (T_{Tank}-T_{amb}) at the conditions expected in the CHPWH system test method.

$$SL = \frac{P_{on}\, V\, \rho\, C_p\, (RE - UEF)\, (T_{del} - T_{in})\big(T_{Tank,2} - T_{amb,2}\big)}{24\, UEF\, RE\, P_{on}\, \big(T_{Tank,1} - T_{amb,1}\big) - UEF\, V\, \rho\, C_p\, \big(T_{Tank,1} - T_{amb,1}\big)(T_{del} - T_{in})}$$

Where, T_{del}=125°F, T_{in}=58°F, $T_{Tank,1}$=125°F, $T_{amb,1}$=67.5°F, ρ=density of delivered water in the consumer test procedure, C_p=specific heat of delivered water in the consumer test procedure, V=gallons delivered during the consumer test procedure, P_{on}=active mode energy use (Btu/h), $T_{Tank,2}$=140°F, $T_{amb,2}$=75°F.

Alternatively, manufacturers could submit actual UA test data from their certification tests. If submitting actual test data, the value should be the result of the average of the tested samples.

For commercial storage water heaters, standby loss and thermal efficiency are already calculated but conversion and corrections are needed to get to a common value.

Appendix A to Subpart G of Part 431 is the test procedure that covers commercial gas-fired storage water heaters. Section 6.7.1 calculates a standby loss in percent per hour and section 6.7.2 converts this standby loss to Btu/h. Unfortunately, section 6.7.2 uses a temperature difference of 70°F (*i.e.,* T_{Tank}-T_{in}) and not 65°F (*i.e.,* T_{Tank}-T_{amb}). Rheem recommends the CHPWH system test method correct the rated standby loss using the following equation:

$$SL = SL_{Rated}\,\frac{65}{70}$$

Appendix B to Subpart G of Part 431 is the test procedure that covers commercial electric storage water heaters. Section 5.7.1 calculates a standby loss in percentage per hour. Rheem recommends the CHPWH system test method convert the rated standby loss using an equation similar to section 6.7.2 of the commercial gas-fired storage water heater test procedure, where V is the measured storage volume in gallons.

$$SL = SL_{Rated} \times 8.25 \times V \times 65$$

Indirect Water Heaters

Indirect water heaters (IWH) are a type of water heater that uses a storage tank with a heat exchanger to heat potable water from a non-potable water or brine that has been externally heated. IWHs may be used in CHPWH systems especially with split-system HPWHs designed to operate with water brine solution. AHRI currently has an IWH certification program and QPL Rheem notes that the provisions currently found in the IWH operations manual are being transferred to *AHRI 1400 Performance Rating of Indirect Water Heaters.* A public review draft of AHRI 1400 is expected to be published soon. Rheem recommends EPA evaluate the public review draft and include IWHs in the scope of the CHPWH system test method.

Booster Heater

Rheem recommends provisions be added to account for booster heaters present in a CHPWH system. For consumer and residential-duty commercial water heaters, the max GPM, recovery efficiency, and UEF should be reported. For commercial water heaters, the thermal efficiency and maximum flow rate that can deliver 125°F water with an inlet water temperature of 58°F should be reported.

Thank you for the opportunity to provide these comments.

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