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HPWH Installation Provisions for Health and Safety part 1

I am attaching two documents. One includes revisions to the draft provisions in the Express Terms and the justification for these revisions. The other document is a presentation that has been given to the HPWH manufacturers explaining the health and safety risks associated with improper HPWH installations.

Thank you for considering my comments. Gary Klein

Additional submitted attachment is included below.

My comments begin at Section 500.3.3.7.2. Changes are shown in red.

Energy Code (Title 24, Part 6)

There are proposed changes to Title 24, Part 6, see below.

Title 24, Part 6: Section 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

UNVENTED SURFACE is all door, wall and ceiling surfaces that do not have a vent installed to allow airflow to a communicating space.

Title 24, Part 6: 500.3.3 [Section 110.3(c)] Installation.

500.3.3.7 *[Section 110.3(c)7]* Air-Source Heat Pump Water Heaters (HPWHs).

HPWH shall meet the following requirements:

500.3.3.7.1 *[Section 110.3(c)7A]* Backup heat.

Backup heat is required for systems when inlet air is unconditioned, unless the compressor cut-off temperature is below the Heating Winter Median of Extremes for the closest location listed in Table 2-3 from Reference Joint Appendix JA2. Backup heat may be internal or external to the *HPWH*.

500.3.3.7.2 *[Section 110.3(c)7B]* Ventilation – Residential and Nonresidential with Group R Occupancies.

Consumer integrated *HPWHs* serving single-family or multifamily dwelling units, or nonresidential buildings with Group R Occupancy, shall be installed using a method provided by the manufacturer to meet or exceed the level of performance provided by one of the ventilation requirements below.

Minimum volume and opening size requirements shall be the sum of all *HPWHs* installed within the same space. Compressor capacity shall be determined using *AHRI 540* Table 4 reference conditions for refrigeration with the “High” rating test point.

500.3.3.7.2.1- For *HPWH* installation without ducts, the installation space shall have a volume not less than the greater of 100 cubic feet per kBtu per hour of compressor capacity, or the minimum volume provided by the manufacturer for this method; or

500.3.3.7.2.2- For *HPWH* installation without ducts, the installation space shall be vented to a communicating space via permanent openings, according to the following requirements:

1. Communicating space shall meet the minimum volume of Section 500.3.3.7.2.1 *[Section 110.3(c)7B2]* above, minus the volume of the *HPWH* installation space; and
2. Permanent openings shall consist of a single layer of fixed flat slat louvers or grilles, with a total minimum *Net Free Area (NFA)* the larger of 125 square

inches plus 25 square inches per kBtu per hour of compressor capacity, or the minimum provided by the manufacturer for this method.

3. The permanent openings shall be fully louvered *doors* or two openings of equal area, one in the upper half of the enclosure and one in the bottom half of the enclosure. The top of the upper opening must be 12 inches or less from the enclosure top and the bottom of the lower vent must be 12 inches or less from the enclosure bottom; or

500.3.3.7.2.3- For *HPWH* installations with ducts, the following requirements shall be met:

1. The space joined to the installation space via ducts shall meet the minimum volume of Section 500.3.3.7.2.1 *[Section 110.3(c)7B2]* above, minus the volume of the *HPWH* installation space; and
2. All duct connections and *building* penetrations shall be sealed; and
3. Exhaust air ducts and all ducts which cross pressure boundaries shall be insulated to minimum of R-6; and
4. Where only the *HPWH* inlet or outlet is ducted, installation space shall include permanent openings which consist of a single layer of fixed flat slat louvers or grilles in the bottom half of the room, and/or a *door* undercut. With a ducted inlet, the minimum *NFA* shall be equal to the cross-sectional area of the duct. With a ducted exhaust, the minimum *NFA* shall be the larger of 20 square inches or the minimum *NFA* provided by the manufacturer for this method; and
5. Where the inlet and outlet ducts both terminate within the same *pressure boundary*, airflow from the termination points shall be diverted away from each other.

NOTE: Ducting only the inlet or the exhaust across the *pressure boundary* could interfere with *balanced ventilation systems*. This should be considered when specifying *HPWH* location and ventilation method.

500.3.3.7.3 *[Section 110.3(c)7B]* Ventilation – Nonresidential Excluding Group R Occupancies.

Consumer integrated HPWHs serving *nonresidential buildings* excluding *Group R occupancies* shall meet the provisions of this section. ~~be installed using one of the methods in either Section 500.3.3.7.3.1, 500.3.3.7.3.2, 500.3.3.7.3.3, 500.3.3.7.3.4.~~

500.3.3.7.3.1- Installations Per Manufacturer Provided Method

For *HPWH* installations following a manufacturer provided method, this method shall meet or exceed the level of performance provided by one of the ventilation requirements in ~~either~~ Section 500.3.3.7.3.2 and either 500.3.3.7.3.3 or 500.3.3.7.3.4.

Replace the deleted sections shown below with the following:

500.3.3.7.3.2- Minimum Installation Requirements

All HPWH installations shall meet the following requirements:

1. The center of the HPWH outlet port of all unducted *HPWHs* shall be directed away from all *ventless surfaces* and permanently installed equipment.
    a. Direction shall be 90 to 270 degrees away.
    b. If the manufacturer does not specify a minimum distance, then the minimum distance between the *ventless surfaces* and the center of the HPWH outlet port shall be 36 inches.
2. *HPWH* exhaust and intake air shall be directed at an angle of 90 to 270 degrees away from each other or be separated by a minimum of 36 inches.
3. The minimum HPWH compressor cut-off temperature shall be equal to or lower than 40°F ambient air temperature in heat pump-only mode and equal to or lower than 47°F in hybrid mode in which the unit operates with both heat pump and electric resistance heating methods. Only manufacturer provided compressor cut-off temperature shall be used.
4. If outside air is used to meet the heat source requirements, the heat pump water heater shall be able to operate in heat pump mode under Heating Design Drybulb (0.6%) conditions as described in Table 2.3 from JA2.
5. Air for the inlet and outlet of the *HPWH* shall both terminate on the same side of a *pressure boundary*, either both to outside or both to inside the *building*; and
6. Where the intake or exhaust is ducted, the following provisions apply:
    a. Exhaust air shall be ducted to outside or to a communicating space
    b. All duct joints, connections and *building* penetrations shall be sealed; and
    c. Outlet ducts and all ducts which cross *pressure boundaries* shall be insulated to minimum of R-6; and

d. Intake and exhaust ducts and any vent caps shall be sized so that not less than 95% of the unducted airflow CFM comes out of the end of the exhaust duct
    i. Calculations for pressure loss in the duct shall include the length of the pipe, and the developed length of all fittings and vent caps.

500.3.3.7.3.3- HPWHs Served by Conditioned Air

For HPWH installations utilizing conditioned air the following requirements shall be met:

1. The energy supplied to the intake air serving the HPWHs shall be not less than two times the wattage of all compressors installed in the space.
    i. A calculation shall be done using an energy model that meets the requirements of the ACM to verify that the heat source to the intake air meets or exceeds two times the compressor wattage.
2. The energy supplied to the intake air shall be provided by space conditioning equipment or by permanently installed equipment which generates waste heat sufficient to meet the thermal energy needs of all HPWHs installed in the space.
    i. Permanently installed equipment which generates waste heat may include, but is not limited to, commercial refrigerators, ice makers or ovens.

500.3.3.7.3.4- HPWHs Served by Unconditioned Air

For HPWH installations utilizing unconditioned air the following requirements shall be met:

1. Unconditioned spaces (including garage, basement, attic, podium) *shall* provide not less than 1500 cubic feet per 400 Watts of compressor power installed in the space; or
2. Unconditioned spaces less than 1500 cubic feet shall have a ducted exhaust that complies with Section 500.3.3.7.3.2. This provision applies to portions of larger unconditioned spaces, and to spaces inside the thermal envelope that are not directly *space conditioned*, such as closets, mechanical rooms, laundry rooms.

Delete these sections ~~**500.3.3.7.3.2- Installations Without Ducts**~~

~~For *HPWH* installations without ducts connected to the *HPWH*, the following requirements shall be met:~~

~~1. The installation space shall have a volume larger than 100 cubic feet per kBtu per hour of the combined compressor capacity and larger than the minimum volume provided by the manufacturer. Compressor capacity shall be~~

determined using *AHRI 540* Table 4 reference conditions for refrigeration with the "High" rating test point.

2. Minimum room volume shall be at least the sum of all required volumes for all *HPWHs* installed within the same space.
3. The center of the HPWH outlet port of all unducted *HPWHs* shall be directed at an angle of 90 to 270 degrees away from all ventless surfaces and permanently installed equipment if the outlet is closer than the manufacturer specified minimum distance. If the manufacturer does not specify a minimum distance, then the minimum distance between the *ventless surfaces* and the center of the HPWH outlet port shall be 24 inches.
4. *HPWH* exhaust and intake air shall be directed at a minimum angle of 90 to 270 degrees away from each other or be separated by a minimum of 24 inches.

Exception 1 to 500.3.3.7.3.2- A *HPWH* may be installed in a smaller volume of space without ducts if the installation space contains permanently installed equipment which generates waste heat sufficient to meet the thermal energy needs of all *HPWHs* installed in the space. A calculation shall be done using an energy model that meets the requirements of the *ACM* to verify that the heat source to the *HPWH* installation space meets or exceeds the level of performance provided by the ventilation requirements of Section 500.3.3.7.3.2.

Permanently installed equipment which generates waste heat may include, but is not limited to, commercial refrigerators, ice makers or ovens.

500.3.3.7.3.3- Installations With Ducts

For *HPWH* installations with ducts connected to the *HPWH*, the following requirements shall be met:

1. Air for the inlet and outlet of the *HPWH* shall both terminate on the same side of a *pressure boundary*, either both to outside or both to inside the *building*; and
2. Minimum ventilation opening size shall be at least the sum of all required openings for all *HPWHs* installed within the same space; and
3. The space joined to the installation space via ducts shall meet the minimum volume of Section 500.3.3.7.3.2 [Section 110.3(c)7C1] above, minus the volume of the *HPWH* installation space; and
4. All duct joints, connections and *building* penetrations shall be sealed; and
5. Outlet ducts and all ducts which cross *pressure boundaries* shall be insulated to minimum of R-6; and
6. Outlet ducts shall be installed such that internal condensation will drain back to the *HPWH*'s condensate pan; and

7. All duct vent caps (including exterior facing duct vent caps with a bug screen and rain/snow shield) shall have a minimum *NFA* equal to 110 percent of the cross-sectional area of the unducted *HPWH* outlet port; and
8. Outlet ducts shall terminate at a point within 4 inches of the top of the *HPWH* installation space.

500.3.3.7.3.3.1: Installations with both the inlet and outlet are ducted.

For installations where both the inlet and outlet are ducted, airflow from the termination points shall be diverted away from each other and be separated by a minimum of 24 inches.

500.3.3.7.3.3.2: Installations with only the outlet ducted.

For installations where only the outlet ducted a permanent opening shall be used to provide *makeup air*. In addition, meet the following applicable requirement:

1. Where only the *HPWH* outlet is ducted to a *communicating space*, the *HPWH* installation space shall be within the *conditioned space pressure boundary* and include permanent openings that consist of a single layer of fixed flat slat louvers or grilles in the bottom two feet of the room, and/or a *door* undercut. The minimum *NFA* of the permanent openings shall be equal to the cross-sectional area of the unducted *HPWH* outlet port.
2. Where only the HPWH outlet is ducted to outside, the *HPWH* installation space shall be in the *unconditioned space* outside of the *building pressure boundary* and include permanent openings that consist of a single layer of fixed flat slat louvers or grilles in the bottom two feet of the room, and/or a *door* undercut. The minimum *NFA* of the permanent openings shall be equal to the cross-sectional area of the unducted *HPWH* outlet port.

500.3.4 [New section] Unitary Commercial Heat Pump Water Heaters (HPWH). Unitary commercial HPWH with integrated electric resistance heating elements serving all nonresidential occupancies shall meet the provisions of Section 500.3.3.7.3 and shall meet the sizing requirements of JA14.6.1 and the installation requirements of JA14.6.2. ~~and shall meet the following requirements:~~

~~1. The minimum HPWH compressor cut-off temperature shall be equal to or lower than 40°F ambient air temperature in heat pump-only mode and equal to or lower than 47°F in hybrid mode in which the unit operates with both heat pump and electric resistance heating methods. Only manufacturer provided compressor cut-off temperature shall be used.~~

~~2. For HPWH without direct ducting to the outside, the system shall comply with the manufacturer's minimum air volume requirements. If multiple unitary commercial HPWH installed in a space, then the minimum air volume shall be the sum of the air volume requirements for each unitary commercial HPWH installed in the space.~~

~~3. If outside air is used to meet the heat source requirements, the heat pump water heater shall be able to operate in heat pump mode under Heating Design Drybulb (0.6%) conditions as described in Table 2.3 from JA2.~~

Exception to Section 500.3.4: Unitary commercial HPWH in Group R occupancies.

Reason Statement

I realize that is very late in the current code cycle to be raising these concerns, but what is in the energy code now, and what is proposed for the update, does not properly address the health and safety of the building and its occupants. Nor does it achieve the efficiency needed for the State to meet its energy goals.

It is critical to act now because of the changes to electric water heaters that are scheduled take effect in May 2029. As of that date, electric storage water heaters 35 gallons and larger need to have a UEF of 2.30 or greater. This means that they need to be HPWH. Roughly half of the approximately 10,000,000 water heaters sold in the US each year are electric water heaters. This requirement applies to at least 2.5 million water heaters. Smaller water heaters are often installed in small spaces, such as closets, or under stairs. The risks of moisture damage and mold increase as the installation space gets smaller.

My concerns are outlined below. I have also attached a copy of the presentation I gave to the HPWH manufacturers in October 2026 which explains in detail why we need to pay particular attention to the health and safety risks associated with moisture damage and mold that can be caused by many of the HPWH installation practices allowed in code and by the manufacturers.

Thank you for considering my comments.

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Key issues:

1. Room volume is a red herring. What matters is the energy in the air. The warmer the air, the higher the COP. The colder the air, the lower the COP.
    1. The DOE method of test is done at 67.5F and 50% RH, with a continuous supply of the room temperature air. The cold exhaust air (typically 10-15F lower than the intake air, is not allowed to short-circuit into the intake air stream until it has been warmed up to 67.5
    2. The DOE method of test is essentially an indoor design target for space conditioning buildings. Range is generally 65-75F. This is an indoor target that is most often achieved with space conditioning equipment. It is not the typical condition in a garage, where the vast majority of water heaters are installed in CA SF housing. It is not the typical condition in an attic, or in an outdoor closet, or in commercial buildings in the space between the office and the roof. It is not the condition in a closet (of any size) that does not have it's own source of space conditioning.
    3. The DOE method of test results in the UEF rating, done for different daily hot water volumes. The UEF is a combination of the COP and the standby losses. As an example, if the UEF is 4, the COP needs to be higher in order to account for the standby losses.

4. In short, the UEF is based on an unlimited supply of conditioned intake air, and on preventing the cold exhaust air from being entrained into the intake air stream, thereby lowering the temperature.

2. Fully louvered doors and vents located near the ceiling and the floor of a closet do increase the COP by allowing natural convection to bring new “warm” air into the closet and to allow the colder exhaust air to return to the adjoining space.
    1. What matters most is the height difference between the upper and lower louvers or grilles. Best case is very close to the ceiling and very close to the floor. Say roughly 8-10 feet. The height difference in a fully louvers door is closer to 4-5 feet. More height, more driving force.
    2. The second thing is the temperature difference between the intake air going into the HPWH and exhaust air leaving the HPWH. The typical delta-T is 10-15F and doesn’t seem to vary much among the products currently in the market.
    3. The third thing is that net free area of the fully louvered door or the high-low grilles needs to be large enough so that air flow is not inhibited. The net free area is dependent on the water heater(s) installed in the enclosure, not on the occupancy type of the building.
3. When a HPWH is ducted without restrictions, the air flow with the ducting is very similar to the airflow without ducting.
    1. What matters in this case is the CFM of the fan, the back-pressure capabilities of the fan and any restrictions to airflow.
    2. The currently available units have fan speeds in the range of 125-175 cfm.
        1. For a given CFM and coil size, the only way to increase the output of the heat pump is to increase the delta-T.
        2. For a given delta-T and coil size, the only way to increase the output of the heat pump is to increase the CFM.
    3. If the target airflow rate is 150 cfm, any ducting needs to be constructed such that it doesn’t drop the unducted airflow by no more than say, 5%. This means very few restrictions. Units currently on the market seem to have 8-10 inch exhaust openings. Unless built very carefully, this seems like a good starting place for the duct diameter.
    4. At present, several manufacturers have tables in the installation instructions showing lengths up to 300 equivalent feet and diameters down to 4 inches. These extremes cannot be achieved with centrifugal blowers on HVAC equipment, let alone on those found in HPWH.
        1. Instructions need to be much more clear and specific to the capabilities of the fan in the specific HPWH. If the HPWH is replaced with a unit that has different capabilities, the ducting could very well be incorrect, and would need to be changed when the unit is replaced.
    5. And, as with natural convection into and out of a closet, and with the HPWH installed in a large room, the intake air needs to be warm and the exhaust air cannot be allowed to short circuit. The energy in the air is what matters.
4. Energy summary.
    1. HPWHs need a source of "warm" air to be efficient. (Say COP above 3.0, the warmer the intake air, the higher the COP)
    2. The source of “warm” has to flow into the HPWH. Directly, through natural convection, or through ducting, let me count the ways.
    3. The colder exhaust air cannot be allowed to become entrained into the intake air while it is still cold.

4. The Amazing Shrinking Room tests document the strategies that work to help maintain high COP.

5. Potential for Moisture Damage, Mildew and Mold
    1. The Amazing Shrinking Room tests did not address these public health and safety concerns. They were focused on energy efficiency. However, the same tests that looked at energy efficiency also allow for the assessment of the risk of the exhaust air temperature bring surfaces inside the building below the dew point.
    2. Ben Larson and I are participating in AHRI's Guideline U committee which is intended to provide manufacturers with guidance on what must be included in their installation manuals.
    3. One of my presentations at CABEC took the temperature and time plots from the ASR tests and overlayed dew point and relative humidity to better understand the potential of the exhaust air to bring surfaces inside the building below the dew point, causing moisture to condense and then to assess the risk to the building and the occupants.
        1. All of the <u>enclosed</u> spaces from 1,000 cubic feet down to 84 cubic feet have the potential for condensation to occur at humidity levels typically found inside buildings.
            1. Since the HPWH extracts the moisture from the intake air, moisture damage is not likely to occur on the first surface, which is the side of the gypsum board inside the enclosed space where the HPWH is installed.
            2. Instead the moisture will condense on the second surface, which is the side of the gypsum board that is inside the wall cavity that separates the HPWH from the rest of the building.
        2. The <u>fully louvered door and high-low grilles</u> allow new air into the enclosure. This "warm" air has moisture in it. The HPWH will extract some of that moisture as the air moves through the coil. However, the same air will be touching the first surface. Bringing that surface below the dew point will cause moisture to condense on the first surface.
        3. The tests show only 2 cases where the risk of moisture condensing on any surface inside the building is very, very low.
            1. The integrated air-source HPWH:
                1. Is installed in a conditioned space (65F or warmer), <u>and</u>
                2. The exhaust of the HPWH is well mixed and warmed up above the dew point before it reaches any surface in the room
            2. The integrated air-source HPWH:
                1. Is installed in an enclosure that is not space conditioned, <u>and</u>
                2. The exhaust of the HPWH is ducted out of that enclosure to a location that is space conditioned (65F or warmer), <u>and</u>
                3. The exhaust is well mixed and warmed up above the dew point before it reaches any surface in the conditioned space.
            3. The risk is low independent of
                1. The daily needs for hot water, including cases where the HPWH needs to run 24/7 to meet the daily demand

2. The temperature of the intake air, so long as that temperature is above 60F
3. The actual humidity in the air, so long as that humidity is less than 90%

4. **By the way, the same strategies that minimize the risk for moisture damage, mildew and mold increase the efficiency of the HPWH.** Increased health and safety and increased efficiency at the same time!!!

6. **This is good news!**
    1. Now that we know what can work for every installation using indoor air, we can incorporate this guidance into every installation manual, and where appropriate, can include guardrail language into the appropriate chapters in the T-24 building code.