Heat Pump Water Heaters - Code Compliance Brief

Overview:

The intent of this brief is to provide code-related information about heat pump water heaters to help ensure that the measure will be accepted as being in compliance with the code. Providing notes for codes officials on how to plan review and conduct field inspections can help builders or remodelers with proposed designs and provide jurisdictional officials with information for acceptance. Providing the same information to all interested parties (e.g., code officials, builders, designers, etc.) is expected to result in increased compliance and fewer innovations being questioned at the time of plan review and/or field inspection.

Heat pump water heaters (HPWHs) are an energy-efficient alternative to electric resistance water heaters. Instead of heating the stored water by running electrical current through resistors (i.e., the electric water heater elements), HPWHs use a vapor-compression refrigerant cycle (the same basic mechanism used by regular heat pumps, air conditioners, and refrigerators) to transfer heat from the surrounding air to the water.

Because electric resistance water heaters convert electrical energy into heat, their maximum theoretical efficiency is 100% (corresponding to an energy factor (EF) of 1, or one unit of energy supplied to the water per unit of energy input to the water heater).[1] HPWHs can achieve EFs of greater than 1 because more than one unit of heat energy can be moved from the surrounding air to the water per unit of electrical energy used by the heat pump's compressor (ENERGY STAR certified HPWHs have rated EFs of 2.21-3.39).[2]

The installation and use of HPWHs requires special considerations that would not be applicable to traditional electric resistance water heaters. Because HPWHs remove heat from the surrounding air, there must be a sufficient volume of air[3] that can circulate around the unit so that a steady supply of warm air from the surroundings can be drawn across the unit's evaporator coil. For this reason, a small closet (especially if the door to the closet is typically shut) is not suitable as a location for a HPWH.

As the surrounding air is drawn across an HPWH's evaporator coil and cooled, moisture in the air will condense on the coil. This condensed water must be routed to a drain. An HPWH's fan and compressor will make noise while operating, so the unit should ideally be located in a place where this noise will not be disruptive to occupants.

HPWHs located within the conditioned space (i.e., located inside the home's thermal envelope) have a small impact on the space conditioning loads. During the summer, an HPWH will provide a minor reduction in the home's cooling load. During the winter, the HPWH will cause a minor increase in the heating load. For a given home, the specific impact on space conditioning energy use depends on the climate, the home's size and configuration, the location of the HPWH, and the space conditioning systems used. Care should be taken to ensure that cooled air from an HPWH does not cause comfort issues for occupants, although this potential issue is generally mitigated by the fact that water heaters are typically installed in locations that are not frequented by occupants (e.g., storage areas, utility closets, laundry/utility rooms, etc.). For HPWHs installed in unconditioned "buffer" spaces (e.g., garages), there is only a very minor, indirect space conditioning impact (because those spaces exchange heat with the conditioned spaces). Garages or basements that are not frequently occupied are good locations for an HPWH in terms of isolating the fan/compressor noise from occupants.

An important consideration for HPWHs located in unconditioned spaces like garages is the temperature of the surrounding air. HPWHs are more efficient when the surrounding air is warmer. For this reason, warm climates with lengthy cooling seasons are a very good fit for HPWHs. The efficiency and capacity of all heat pumps decrease with decreasing air temperature, so an HPWH located in a garage in a cold climate will have more difficulty keeping up with the hot water load when operating in heat-pump-only mode. Most HPWHs come with backup electric resistance heating elements and can operate in full electric-resistance mode or "hybrid" mode (i.e., the unit switches between heat-pump and electric-resistance modes as needed). The hybrid or full electric-resistance modes can be used to keep up with demanding hot water loads (e.g., periods of high hot water draw and/or during the winter for units located in the garage of a cold-climate home).

This code brief discusses the provisions in the International Residential Code (IRC) that are related to HPWHs. Federal appliance standards for residential water heaters are germane to the discussion and are addressed briefly prior to the code provisions.

NEW Energy Conservation Standards for Residential Water Heaters:

A new federal standard for the minimum allowable EFs for residential water heaters became effective on April 16, 2015.[4] All water heaters manufactured on or after the effective date must comply with the standard.

Water heaters manufactured prior to April 16, 2015, had to comply with the previous federal standard, which had been in effect since January 20, 2004. Under the previous standard, electric storage water heaters with a rated storage volume (RSV)[5] of 20-120 gallons were required to have a minimum EF of:

$EF = 0.97 – (0.00132 \times RSV)$.

For a typical 50-gallon electric storage water heater, the minimum EF under the previous standard was $0.97 – (0.00132 \times 50) = 0.904$. For an 80-gallon electric storage water heater, the minimum EF was: $0.97 – (0.00132 \times 80) = 0.864$.

Under the new federal standard, electric storage water heaters with an RSV of 20-55 gallons must have a minimum EF of:

EF = 0.960 – (0.0003 × RSV).

For a typical, 50-gallon water heater, the minimum EF is 0.960 – (0.0003 × 50) = 0.945. Electric storage water heaters with an RSV >55 gallons but ?120 gallons must have a minimum EF of:

EF = 2.057 – (0.00113 × RSV).

For an 80-gallon water heater, the minimum EF is: 2.057 – (0.00113 × 80) = 1.967.

The new federal standard effectively mandates the use of HPWHs for residential applications where electricity is the water-heating fuel and a storage volume >55 gallons is desired.

[1] In practice, there are losses associated with the energy conversion, so the EF of most electric resistance water heaters is approximately 0.9.

[2] ENERGY STAR Certified Water Heaters. Accessed October 2015 at **http://www.energystar.gov/productfinder/product/certified-water-heaters/** [1]

[3] A common manufacturer recommendation is 750 ft^3 of air. Source: "Heat Pump Water Heaters 101." Steven Winter Associates. January 2012. **http://www.carb-swa.com/Collateral/Documents/CARB-SWA/Research/Heat_Pump_Water_Heaters.pdf** [2].

[4] U.S. Department of Energy, Building Technologies Office. Residential Water Heaters. Table 2. Amended Energy Conservation Standards for Residential Water Heaters. **https://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/27** [3]

[5] The RSV is the water storage capacity of a water heater, in gallons, as certified by the manufacturer.

Plan Review:

Per the ***International Energy Conservation Code and International Residential Code (IECC)/(IRC), Section R103.3/R106.3 Examination of Documents***. The code official/building official must examine, or cause to be examined, construction documents for code compliance.

This section lists the applicable code requirements and details helpful for plan review regarding the provisions to meet the requirements for HPWHs.

Construction Documentation. Review the construction documents to identify the equipment, system controls, and design.

- ***2015 IECC/IRC, Section R103.2/N1101.5 Information on Construction Documents.*** Construction documents should include:

- HPWH system design criteria
- Equipment types, sizes and efficiencies
- Equipment and system controls
- Location and installation

- **General Installation Provisions**. The provisions in the 2015 and 2012 IRC have similar language with only minor updates included in the 2015 version. Review the construction documents for equipment installation.

- ***2015 IRC, Section M2005 General*.** Water heaters should be listed and labeled in accordance with UL**[6]** 174 and should be installed:

1. In accordance with manufacturer's instructions M2005.1
2. With plumbing fixtures and appliances intended for bathing, washing, or culinary purposes per Section P2801
3. With a storage tank constructed of noncorrosive metal or lined with noncorrosive material per Section P2801
4. With a drain valve (not less than ¾ inch in size with male hose thread) for emptying the tank installed at the bottom of each hot water storage tank per Section P2801.2
5. With a pressure relief valve and a temperature relief valve per Section P2804
6. To protect the potable water supply in accordance with section P2902
7. In accordance with the applicable provisions of Part VIII – Electrical (Chapters 34 through 43) requirements of the IRC.

Mounting and Location. Verify equipment is correctly supported and installed in the structure.

- ***IRC Section P2801.4 Location.*** Water heaters and storage tanks should be installed in accordance with Section M1305 and should be located and connected to provide access for observation, maintenance, servicing, and replacement.

- ***IRC Section M1305.1.4.1 Ground Clearance.*** Equipment and applications supported from the ground should be level and firmly supported on a concrete slab or other approved material extending not less than 3 inches (76 millimeters) above the adjoining ground. Such support should be in accordance with the manufacturer's installation instructions. Appliances suspended over the floor should have a clearance of not less than 6 inches (152 millimeters) from the ground.

- ***IRC Section P2801.8 Water Heater Seismic Bracing***. In Seismic Design Categories D_0, D_1, and D_2 and townhouses in Seismic Design Category C, water heaters should be anchored or strapped in the upper one-third and in the lower one-third of the appliance to resist a horizontal force equal to one-third of the operating weight of the water heater, acting in any horizontal direction, or in accordance with the appliance manufacturer's recommendations.

- ***IRC Section M2005.2.1 Water Heater Access.*** Access to water heaters that are located in an attic or underfloor crawl space is permitted to be through a closet located in a sleeping room or bathroom where ventilation of those spaces is in accordance with this code.

- ***IRC Section 1305.1.3 Appliances in Attics.*** Water heaters installed in an attic should comply with the requirements of Section M1305.1.3.[7] Domestic electric water heaters should comply with UL[5]174.

- ***IRC Section P2801.7 Water Heaters Installed in Garages***. Water heaters having an ignition source should be elevated such that the source of ignition is not less than
18 inches (457 millimeters) above the garage floor (currently not relevant to HPWHs).

- ***IRC Section P2801.6 Required pan***. Where a storage tank-type water heater or a hot water storage tank is installed in a location where water leakage from the tank will cause damage, the tank should be installed in pan constructed of one of the following:

  - Galvanized steel or aluminum of not less than 0.0236 inch (0.6010 millimeter) in thickness.
  - Plastic not less than 0.036 inch (0.9 millimeter) in thickness.
  - Other approved materials.

- ***IRC Section P2801.6.1 Pan Size and Drain***. The pan should be not less than
1-½ inches (38 millimeters) deep and should be of sufficient size and shape to receive dripping or condensate from the tank or water heater. The pan should be drained by an indirect waste pipe of not less than ¾ inch diameter.

- ***IRC Section P2801.6.2 Pan Drain Termination***. The pan drain should extend full size and terminate over a suitably located indirect waste receptor or should extend to the exterior of the building and terminate not less than 6 inches and not more than 24 inches above the adjacent ground surface.

- **Relief Valves.** Verify that the water heater is protected with appropriate relief valves as directed in Section P2804 of the IRC.

- ***IRC Section P2804.1 Relief Valves Required.*** Appliances and equipment used for heating water or storing water hot water should be protected by:

  1. A separate pressure-relief valve and a separate temperature-relief valve; or
  2. A combination pressure- and temperature-relief valve.

- ***IRC Section P2804.2 Rating***. Relief valves should have a minimum rated capacity for the equipment served and should conform to ANSI Z21.22.

- ***IRC Section P2804.3 Pressure-Relief Valves***. Pressure-relief valves should have a relief rating adequate to meet the pressure conditions for the appliances or equipment protected. In tanks, they should be installed directly into a tank tapping or in a water line close to the tank. They should be set to open at not less than 25 psi (172 kPa) above the system pressure but not over 150 psi (1034 kPa). The relief-valve setting should not exceed the tank's rated working pressure.

- ***IRC Section P2804.4 Temperature-Relief Valves***. Temperature-relief valves should have a relief rating compatible with the temperature conditions of the appliances or equipment protected. The valves should be installed such that the temperature-sensing element monitors the water within the top 6 inches (152 millimeters) of the tank. The valve should be set to open at a temperature of not greater than 210°F (99°C).

- ***IRC Section P2804.5 Combination Pressure-/Temperature-Relief Valves***. Combination pressure-/temperature-relief valves should comply with all the requirements for separate pressure- and temperature-relief valves.

- ***IRC Section P2804.6 Installation of Relief Valves***. A check or shutoff valve should not be installed in the following locations:

1. Between a relief valve and the termination point of the relief valve discharge pipe
2. Between a relief valve and a tank
3. Between a relief valve and heating appliances or equipment.

- ***IRC Section P2804.6.1 Requirements for Discharge Pipe***. The discharge piping serving a pressure-relief valve, temperature-relief valve, or combination valve should:

1. Not be directly connected to the drainage system.
2. Discharge through an air gap located in the same room as the water heater.
3. Not be smaller than the diameter of the outlet of the valve served and should discharge full size to the air gap.
4. Serve a single relief device and should not connect to piping serving any other relief device or equipment.
5. Discharge to the floor, to the pan serving the water heater or storage tank, to a waste receptor or to the outdoors.
6. Discharge in a manner that does not cause personal injury or structural damage.
7. Discharge to a termination point that is readily observable by the building occupants.
8. Not be trapped.
9. Be installed to flow by gravity.
10. Terminate not more than 6 inches (152 millimeter) and not less than two times the discharge pipe diameter above the floor or waste receptor.
11. Not have a threaded connection at the end of the piping.
12. Not have valves or tee fittings.
13. Be constructed of those materials listed in Section P2905.5 or materials tested, rated, and approved for such use in accordance with ASME A112.4.1.
14. Be one nominal size larger than the size of the relief-valve outlet, where the relief-valve discharge piping is constructed of PEX or PE-RT tubing. The outlet end of such tubing should be fastened in place.

- ***IRC Section P2803.7 Vacuum-Relief Valve***. Bottom fed tank-type water heaters and bottom fed tanks connected to water heaters should have a vacuum-relief valve installed that complies with ANSI Z21.22.

- **Potable Water System Protection.** Verify that potable water connections to the equipment are correct.

- ***IRC Section P2902.1 General*.** A potable water supply system should be designed and installed as to prevent contamination from non-potable liquids, solids, or gases being introduced into the potable water supply. Connections should not be made to a potable water supply in a manner that could contaminate the water supply or provide cross-connection between the supply and a source of contamination except where approved methods are installed to protect the potable water supply. Cross-connections between an individual water supply and a potable public water supply should be prohibited.

- **Controls and Supplemental Devices**

- ***IRC Section M2005.4 Supplemental Water-Heating Devices*.** Potable water-heating devices that use refrigerant-to-water heat exchangers should be approved and installed in accordance with the manufacturer's installation instructions.

- ***IECC Section R403*.5.1 Heated Water Circulation and Temperature Maintenance Systems.** Automatic and manual controls, temperature sensors and pumps should be accessible. Energy conservation measures for service hot water systems

should be in accordance with relevant sections of the IECC, based on the type of circulation systems.

- ***IECC Section R403*.5.4 Drain Water Heat Recovery Units.** Drain water heat recovery units should comply with CSA B55.2. Drain water heat recovery units should be tested in accordance with CSA B55.a. Potable water-side pressure loss of drain water heat recovery units should be less than 3 psi for individual units connected to three or more showers.

- **Insulation**

- ***2015 IECC/IRC, Section R403.5.3/N1103.4.2.*** Insulation for hot water pipe with a minimum thermal resistance (R-value) of R-3 should be applied to:

1. Piping ¾ inch and larger in nominal diameter
2. Piping serving more than one dwelling unit
3. Piping located outside the conditioned space
4. Piping from the water heater to a distribution manifold
5. Piping located under a floor slab
6. Buried in piping
7. Supply and return piping in recirculation systems other than demand recirculation systems.

Existing Buildings and Replacement. New water heaters that are part of an addition should comply with new construction Section R403.4 and relevant sections of the IRC. An exception is, where a drain pan was not previously installed, a drain pan should not be required for a replacement water heater installation per IRC Section P2801.6.1.

[6] *UL (Underwriters Laboratory)* is a global independent safety science company that certifies, validates, tests, inspects, audits, and advises and trains.

[7] M1305.1.3 Appliances in attics. Attics containing appliances should be provided with an opening and a clear and unobstructed passageway large enough to allow removal of the largest appliance.

Field Inspection:

Per the ***2015 IECC, Section R104 Inspections***, construction or work for which a permit is required is subject to inspection. Construction or work is to remain accessible and exposed for inspection purposes until approved. Required inspections include footing and foundation, framing and rough-in work, plumbing rough-in, mechanical rough-in, and final inspection.

Per the ***2015 IRC, Section R109 Inspections***, the wording is somewhat different in that for onsite construction, from time to time the building official, upon notification from the permit holder or his agent, can make, or cause to be made, any necessary inspections. Further details are provided for inspections regarding foundation, plumbing, mechanical, gas and electrical, floodplain, frame and masonry, and final inspection. Any additional inspections are at the discretion of the building official.

This section provides details for inspecting to the specific provisions for HPWHs where one or more specific type of inspection per the IECC or IRC may be necessary to confirm compliance. Verifying code compliance for HPWHs would typically be at the mechanical rough-in and final inspection.

Inspections should provide verification in the following areas:

- HPWH is labeled and meets capacity and efficiency rating per approved construction documents.
- HPWH is properly located and mounted, and connections are made per approved construction documents.
- Drain pan is installed per approved construction documents and manufacturer installation instructions.
- A pressure relief valve and a temperature relief valve are installed per approved construction documents and manufacturer's installation specifications.
- Discharge pipe installed per approved construction documents and manufacturer's installation specifications.
- Pipe insulation is installed in accordance with manufacturer's installation instructions, the manufacturer's R-value mark is readily available, and meets the approved R-value per construction documents.

Technical Validation(s):

This section provides additional information and helpful resources.

- Building America Guide for Heat Pump Water Heaters: **https://basc.pnnl.gov/resource-guides/heat-pump-water-heaters** [4]
- Heat Pump Water Heaters: Selection and Quality Installation Guide. Steven Winter Associates. June 2012. **http://www.carb-swa.com/Collateral/Documents/CARB-SWA/Guides/HPWH_QI_Guide.pdf** [5]
- Federal Standard for Residential Water Heaters: **https://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/27** [3]