Evaporative Cooling Systems

Last Updated: 08/08/2017

Scope

Determine if evaporative cooling is an appropriate option for your climate zone.

Choose the highest performing cooling equipment that project funding will allow to meet the cooling load of the project.

If the design cooling load is low (below around 30,000 Btu capacity) due to high insulation and air sealing levels, consider alternative lower-load cooling sources such as ducted or ductless variable refrigerant flow heat pumps. In dry climates, consider ventilation cooling. Also consider passive cooling techniques such as shading with architectural and landscape features.

Properly size the cooling equipment and ducts for the design cooling load of the home, following the manufacturer’s sizing guidelines.

Design an efficient air distribution system with a compact layout in accord with ACCA Manual D. Install ducts properly for maximum airflow and efficiency.

If you are participating in an energy-efficiency program, select cooling equipment that complies with the requirements for your climate zone. The RESNET Technical Committee has determined that direct evaporative coolers should be modeled with a seasonal energy-efficiency ratio (SEER) of 15 (AEC 2011).

See the Compliance Tab for related codes and standards requirements, and criteria to meet national programs such as DOE’s Zero Energy Ready Home program, ENERGY STAR Certified Homes, and Indoor airPLUS.
Evaporative coolers can be an effective and less expensive alternative to compressor-based air conditioners for cooling your home if you live in a dry climate. Evaporative coolers (known in the past as swamp coolers) use evaporation and blowing air to cool. They can use about one-fourth as much energy as central air conditioners and cost less than half the price to install and operate. Evaporative coolers work best in dry climates where the outdoor relative humidity during the cooling season is less than 50%.

The evaporative cooler is a fairly simple device consisting of a box-like housing that contains a large blower fan and an 8- to 12-inch-thick sponge-like filter made of treated cellulose, fiberglass, plastic foam, or shredded aspen fibers, that is constantly soaked with water from a sprayer and recirculating pump located in the unit. The blower fan pulls in outside air and blows it through the sponge-like medium and into the building.

The flowing air evaporates some of the water, giving up heat in the process, which can reduce the temperature of the air entering the home by 15°F to 40°F.

The incoming air is not recirculated inside the house but is blown through the house and must have a way to exit. When operating, evaporative coolers bring in enough fresh air to completely replace house air every 2 to 3 minutes. For the system to work correctly, doors or windows must be opened to provide a path for the air to exit. Alternatively, ceiling exhaust vents can be installed. These typically exhaust directly into the attic, which must be a vented attic. The exhaust vents usually come with a barometric damper that automatically opens when the cooler is on. They may also have a mechanically-controlled damper so they can be closed during the heating season or if the home is also equipped with refrigerant air conditioning. For every 1,000 CFM of air delivery, 2 ft² of unrestricted air relief is required (PG&E 2004). Because the air will tend to flow to open outlets, some zoning of cooling can be achieved by opening windows or vents in those rooms where cooling is desired.

An evaporative cooler should have at least two speeds and a vent-only option. The vent-only operation allows the unit to be used as a house fan during mild weather. Unlike refrigerant-cycle-based air conditioning, evaporative coolers increase rather than decrease the humidity in the air.

The cooler can be installed to blow air directly into a central location in the home or the cooler can be connected to ductwork to distribute the air to different rooms. Central-location installations work well for compact homes with open floor plans. Ducted systems are required for larger houses with hallways and multiple bedrooms. Down-flow systems, which are mounted on the roof and connected to a duct system in the attic, are the most common installation. However, ground- or wall-mounted units are preferred because they eliminate the risk of roof leaks and they are much easier to access for maintenance.

Evaporative coolers require regular maintenance to keep the water reservoir clean and odor-free. Maintenance should be done at least twice a year, when the unit is first started up in the spring and when it is shut down in the winter. In the spring, the filter media should be replaced or cleaned, the belt inspected for proper tension, and the cabinet cleaned and inspected for damage. In the winter, the water line should be shut off, the pan should be drained and cleaned, and a winter cover should be installed to prevent dirt and dust from getting inside the unit. During the cooling season, the drain pan should be emptied whenever the cooler will be idle for more than a few days as standing water left in the pan can become a breeding ground for mosquitos and bacteria, including Legionnaire’s Disease.

If the local water has a high mineral content, a bleed-off valve can be installed in the recirculating line to drain off water and reduce mineral concentrations; however, this can increase water usage by 10% to 50%. A more efficient alternative is to install an autoflush system (also called a dump pump) that empties the cooler pan and brings in clean water at regular intervals (e.g., every 8 to 12 hours of operation) to reduce mineral buildup. Although evaporative coolers are typically less expensive to purchase, install, and operate; their water usage and water costs must be taken into account. Annual water use varies based on the number of hours run and the dryness of the air. For example for a 1,500 ft² home, annual water use for an evaporative cooler without a bleed-off valve could range from 2,980 gallons in Santa Fe, to 7,261 gallons in Albuquerque, to 12,457 gallons in Las Cruces, New Mexico. Increase these numbers 50% if the cooler has a bleed-off valve (SWEEP 2007).
The single-inlet direct evaporative coolers of today are more efficient than their "swamp cooler" counterparts of years ago. Their cooling effect is dependent on the temperature difference between the dry-bulb and wet-bulb temperature (wet-bulb depression) of the entering air, the velocity of the air moving through the medium, and the quality and condition of the medium itself.

Newer evaporative coolers have thick media with efficiencies (cooling effectiveness) of 75% to 93%. For example, a 12-inch-thick medium can have an efficiency of 90% or better. The cooling effectiveness or efficiency of the evaporative coolers is a measure of how closely the supply air temperature leaving the evaporative cooler approaches the outdoor wet-bulb temperature.
When we think of outdoor temperature, we are usually thinking of dry-bulb temperature, which is the temperature of the air measured using a common, ordinary thermometer. Wet-bulb temperature is measured with a thermometer that has a wet sock or cloth wick wrapped around the bulb (Figure 4). As the water in the sock evaporates, the sock loses heat and cools the sensing bulb, bringing the thermometer reading down to the wet-bulb temperature. The wet-bulb temperature is the lowest temperature that can be reached through evaporation; the more humid the air, the higher the wet-bulb temperature. The local wet-bulb temperature can also be determined from local weather information (the dry-bulb temperature and relative humidity) with the help of a psychrometric chart, which can be found at various education sites online. (See for example ASHRAE 2013.) The temperature difference between the dry-bulb thermometer and wet-bulb thermometer is dependent on the amount of water vapor in the ambient air.

When the wet-bulb temperature is equal to the dry-bulb temperature, the relative humidity will be 100%. If the relative humidity is lower than 100%, the wet-bulb temperature will be lower than the dry-bulb temperature. The difference between the wet-bulb temperature and the dry-bulb temperature is known as the wet-bulb depression. The greater the wet-bulb depression, the better an evaporative cooler works.

For this reason, evaporative coolers work well in dry areas of the country such as the Southwest. For example, according to ACCA Manual J Table 1, Phoenix, Arizona, has an outdoor dry-bulb (1% cooling design) temperature of 108°F and a coincidental wet-bulb temperature of 70°F. The wet-bulb depression would be 38°F (108 − 70 = 38). In these outdoor conditions, evaporative coolers would work very well. However, in Sarasota, Florida, where the outdoor temperature is 92°F and the coincidental wet-bulb temperature is 79°F, the wet-bulb depression is only 13°F (92 − 79 = 13); here an evaporative cooler would not work very well.

If you know the dry-bulb and wet-bulb temperature and the medium manufacturer’s efficiency rating for the medium, you can calculate what the incoming air temperature is likely to be. For example, if the outside air’s dry-bulb and wet-bulb temperatures are 105°F and 60°F, the wet-bulb depression would be 45°F (105 - 60 = 45). If the single-inlet evaporative cooler is using a medium that is 90% efficient, the discharge air temperature should be 105 - (45 x 0.9) = 64.5°F.
Evaporative Coolers - Cooling Effectiveness

Evaporative coolers are not measured in SEER (seasonal energy efficiency ratio, which is the efficiency measurement used for compression cooling systems) and there is no national or international testing organization for rating evaporative coolers, although some guidance for testing can be found in ANSI/ASHRAE Standard 133-2008. Instead, manufacturers refer to the cooling effectiveness of evaporative coolers, which is a measure of how close the supply (leaving) air temperature is to the outdoor (entering) wet-bulb temperature. If the supply air temperature were the same as the outdoor wet-bulb temperature, the cooling effectiveness would be 100%.

The formula used to calculate cooler effectiveness is:

\[ e = \frac{T_{DB} - SAT}{T_{DB} - T_{WB}} \]

Where:
- \( e \) = the cooling effectiveness of the cooler
- \( T_{DB} \) = the outdoor dry-bulb temperature
- \( T_{WB} \) = the outdoor wet-bulb temperature
- SAT = the supply air temperature leaving the evaporative cooler

Note. \( T_{DB} - T_{WB} \) = the wet-bulb depression

Example:
An evaporative cooler that is delivering conditioned air into the home at 74°F when the outdoor conditions are 108°F dry-bulb and 70°F wet-bulb would have the following cooling efficiency:

\[ e = \frac{T_{DB} - SAT}{T_{DB} - T_{WB}} \]

\[ e = \frac{108 - 74}{108 - 70} \]

\[ e = \frac{34}{38} = .89 \text{ or } 89\% \]

In the example, the cooler’s efficiency is 89%, which would be considered an efficient evaporative cooler.

![Figure 5. Average wet-bulb temperatures across the United States.](image)

The chart in Figure 6 shows the cooling temperatures that an evaporative cooler can provide at outdoor temperatures ranging from 75°F to 125°F at 2% to 80% relative humidity. The numbers in blue represent the ideal cooling temperatures achievable across these conditions.
Here is an example of how wet-bulb (WB) temperature impacts an evaporative cooler’s cooling ability. On a day when the outdoor temperature is 100°F dry bulb (DB) at 10% relative humidity (RH) (63°F WB according to a psychrometric chart), the supply air entering the home will be 73°F DB, which is a 27°F DB temperature drop. However, if the outdoor temperature is at 95°F DB at 50% RH (79°F WB), the supply air temperature will be 84°F DB (only an 11°F DB temperature drop).

**System Sizing**

Sizing an evaporative cooler is not an exact science. Evaporative coolers are sized by airflow not by "tons of cooling." Common evaporative cooler sizes range from 3,000 to 6,500 cfm (cubic feet per minute).

Most manufacturers call for something like 20 to 40 air changes per hour (ACH) through the conditioned space, depending on location and outdoor conditions. The map in Figure 7 is a simplified version of the map in Figure 5 and shows the air changes per hour that an evaporative cooler would have to produce to provide comfort at that region’s average wet-bulb temperature at 1% summer design conditions (i.e., the outdoor temperature that will be exceeded only 1% of the time in a given year).

To determine your evaporative cooler system size:

1. Consult the ACH Zone Map shown in Figure 7.
2. Determine the cubic feet (CU FT) of the space to be conditioned.
3. Multiply house volume by regional ACH and divide by 60 to get evaporative cooler size in cfm. Cooler size in cfm = (CU FT x ACH) ÷ 60.
For example, if we have a 2,000-ft² home with 8-ft ceilings located near Salt Lake City, Utah, according to the zone map, we should size the evaporative cooler so that it will provide 20 ACH. The volume of the conditioned space of the home is 16,000 ft³ (2000 x 8). So the formula would look like this: \((16,000 \times 20) \div 60 = 5,333\) cfm.

Newer Technologies

**Indirect coolers** use an air-to-air heat exchanger so they don’t add humidity to the cool air (Figure 8). The main blower fan supplies outside air that is cooled by passing through the heat exchanger as it is drawn into the home. A secondary fan draws exhaust air from the home and/or outside air through wet pads, providing cool air, which takes heat from the incoming supply air as the two air flows cross paths in the heat exchanger.

![Figure 8](image1.png)

**Figure 8.** Indirect evaporative coolers pass outdoor air through a heat exchanger that is cooled by evaporative cooling. The moist air is exhausted out while cooled dry air is blown into the space.

**Indirect/direct coolers cool in two stages.** In the first stage, the air passes through an indirect heat exchanger, which lowers the temperature without adding humidity. The air then enters the second, direct cooling stage where it flows through wet pads just like a direct evaporative cooler to be further cooled and humidified before flowing into the home. Because the air has been pre-cooled in the first stage, when it leaves the second stage it is cooler and has less moisture than the air leaving the single-stage unit. This technology achieves evaporative cooling efficiency of 95% or greater (PG&E 2004). One model, developed by Building America partner Davis Energy, reportedly provides up to 5 tons of cooling while using less than 1600 watts. The model is eligible for utility rebates in several southwestern states.

![Figure 9](image2.png)

**Figure 9.** The indirect/direct cooler's blower passes outside air through the dry side of a heat exchanger with a 14 inch-thick media.
The heat exchanger indirectly cools the air without adding moisture then passes the air through a direct cooling module before directing it into the home.

Another innovative evaporative technology is the **water-cooled evaporative condenser**, which is a scaled-down residential version of the 250-ton chillers used on commercial buildings. Inside the housing, a mist of water is continually sprayed on the condenser coils to remove heat from the refrigerant and at the same time reduce the work of the compressor. Unlike traditional air conditioners, which use 10% more power for each 10°F increase in temperature above 95°F, an evaporative-cooled condenser draws the same power over a wide range of outdoor temperatures. It uses about half the energy of conventional “air-cooled” condensing units. One model has an EER of 17 at 95°F (German et al. 2012).

Evaporative coolers have been developed that use **photovoltaic (PV)** panels to create the electricity used to run the blower and the water pump. For hot desert areas, the combination of evaporative cooling and solar power is a perfect match: the afternoon, when the most solar energy is available, is also the hottest part of the day, when cooling is most needed. And, because evaporative coolers use a fraction of the energy of air conditioners, PV cells can provide enough electricity to run the system effectively (SWEEP 2007).

**How to install an Evaporative Cooler**

1. Select the most efficient model the project can afford. Consider newer types of evaporative coolers including indirect/direct evaporative coolers.

2. Select a model with a cover to minimize maintenance during the off-season.

3. Install on the ground or wall rather than roof to make maintenance easier for the homeowner.

4. Install in a central location for best air distribution. If there is ductwork, size as per ACCA Manual D.

5. Install ceiling vents with barometric and mechanical dampers.

![Figure 10. This wall-mounted evaporative cooler is easy to access for maintenance.](image-url)
Ensuring Success

Select a single-inlet evaporative cooler with a media efficiency of 90%.

If connected to a ducted system, all duct installation best practices apply. This includes duct design, duct sealing, and air tightness testing. See ENERGY STAR HVAC duct installation guidance in the ENERGY STAR checklist (HVAC/R2).
Evaporative coolers work best and supply the most comfort in dry climates where the coincidental wet-bulb temperatures are below 70°F. Evaporative coolers can give relief cooling in climates where coincidental wet-bulb temperatures are as high as 74°F but high humidity becomes a problem.
Training

Right and Wrong Images
None Available
CAD
None Available
**Compliance**

The Compliance tab contains both program and code information. Code language is excerpted and summarized below. For exact code language, refer to the applicable code, which may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

**Environmental Protection Agency (EPA) WaterSense® New Home Specification**

The EPA WaterSense New Home Specification states that:

Individual evaporative cooling systems shall use a maximum of 3.5 gallons (13.3 liters) of water per ton-hour of cooling when adjusted to maximum water use. Blowdown shall be based on time of operation, not to exceed three times in a 24-hour period of operating (every eight hours). Blowdown shall be mediated by conductivity or basin water temperature-based controllers. Once-through or single-pass cooling systems, systems with continuous blowdown/bleedoff, and systems with timer-only mediated blowdown management shall not be used to meet these criteria.

**DOE Zero Energy Ready Home (Revision 07)**

Exhibit 1 Mandatory Requirements.
Exhibit 2 DOE Zero Energy Ready Home Target Home.

The U.S. Department of Energy’s Zero Energy Ready Home program allows builders to choose a prescriptive or performance path. The DOE Zero Energy Ready Home prescriptive path requires builders to meet or exceed the minimum HVAC efficiencies listed in Exhibit 2 of the National Program Requirements (Rev 07), as shown below. The DOE Zero Energy Ready Home performance path allows builders to select a custom combination of measures for each home that is equivalent in performance to the minimum HERS index of a modeled target home that meets the requirements of Exhibit 2 as well as the mandatory requirements of Zero Energy Ready Home Exhibit 1.

Footnote 21) DOE recommends, but does not require, that cooling systems in hot/humid climates utilize controls for immediate blower shutoff after condenser shutoff, to prevent re-evaporation of moisture off the wet coil.

Footnote 22) Air source heat pumps with electric resistance backup cannot be used in homes qualified in Climate Zones 7 & 8 using the Prescriptive Path.

**Exhibit 2: DOE Zero Energy Ready Home Target Home**

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DOE ZERH Target Home HVAC Equipment Requirements ?(Source: [DOE Zero Energy Ready Home (Revision 07)]).

**2009 IECC**

403.1 Each heating and cooling system should have its own thermostat. If the primary heating system is a forced-air furnace at least one thermostat must be programmable and capable of controlling the heating and cooling system on a schedule to maintain different temperatures at different times of the day.

403.2 Ducts - Insulate supply ducts in attics to at least R-8 and all other ducts to at least R-6. Duct tightness shall be verified as described in 403.2.2 Sealing.

403.6 Heating and cooling equipment sizing shall be in accordance with Section M1401.3 of the 2009 International Residential Code.

**2012 IECC**

403.1 Each heating and cooling system should have its own thermostat. If the primary heating system is a forced-air furnace, at least one thermostat must be programmable and capable of controlling the heating and cooling system on a schedule to maintain different temperatures at different times of the day.

403.2 Ducts - Insulate supply ducts in attics to at least R-8 and all other ducts to at least R-6. Duct tightness shall be verified as described in 403.2.2 Sealing.

The air handler shall have a manufacturer's designation showing air leakage is no more than 2% of the design air flow rate when
403.6 Heating and cooling equipment shall be sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J or other approved heating and cooling calculation methods.

**2015 and 2018 IECC**

R403.1 Each heating and cooling system should have its own thermostat. The thermostat controlling the primary heating and cooling system of the dwelling unit shall be capable of controlling the heating and cooling system on a daily schedule to maintain different temperature set points at different times of the day.

403.3.1 Insulation (Prescriptive). Supply and return ducts in attics insulated to at least R-8 if 3 inches in diameter or more or R-6 if less than 3 inches. Duct tightness verified as described in R403.3.2 Sealing.

403.7 Heating and cooling equipment shall be sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J or other approved heating and cooling calculation methods.


Section R101.4.3 (Section R501.1.1 in 2015 and 2018 IECC). Additions, alterations, renovations, or repairs shall conform to the provisions of this code, without requiring the unaltered portions of the existing building to comply with this code. (See code for additional requirements and exceptions.)


Comply with all relevant sections of the applicable International Residential Code.

**Evaporative Cooling - Code Compliance Brief**

**Overview:**

The intent of this brief is to provide code-related information about evaporative cooling 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.

Evaporative cooling (a.k.a., "swamp coolers") is a technology that takes advantage of water evaporation to cool incoming air. Energy is required to change water from a liquid to a vapor (i.e., the heat of vaporization), and in doing so, the sensible air temperature of the air is reduced. The amount of cooling provided is driven by the "dryness" (i.e., the wet bulb temperature) of the incoming air; hence, evaporative cooling is best suited for hot, dry climates.

In general, there are three types of evaporative cooling systems: 1) direct, 2) indirect and 3) direct/indirect. For residential applications, direct systems are by far the most commonly used technology. In direct systems, outside air is drawn across media that is continually saturated with water. The net effect to the conditioned space is lower supply air temperature but also higher humidity. It should be noted that direct evaporative systems are "one-pass" or 100% outside air systems; therefore, it is important that careful attention be paid to the location of any exhaust vents or anything else that could introduce odors or pollutants into the home. Even though evaporative cooling systems use 100% outside air, codes still require ductwork to be insulated and air sealed. This brief discusses the provisions in the 2015 International Energy Conservation Code (IECC) and International Residential Code (IRC) related to evaporative cooling.

**Plan Review:**

Per the **2015 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 followed by details helpful for plan review regarding the provisions to meet the requirement for evaporative cooling.

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

- **2015 IECC/IRC, Section R103.2/N1101.5 Information on construction documents.** Construction documents should include:
● **General Installation Provisions.** Review the construction documents for equipment installation and mounting.

— *2015 IRC, Section M1413.1 General.* Evaporative cooling equipment and appliances should comply with UL\textsuperscript{1} 1995 or UL/CSA/ANCE 60335-2-40 and should be installed:

1. In accordance with the manufacturer's instructions
2. On level platforms in accordance with Section M1305.1.4.1
3. So openings in exterior walls are flashed in accordance with Section R703.4
4. To protect the potable water supply in accordance with section P2902
5. So air intake openings are located are in accordance with section R303.5.1.

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

— *2015 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 mm) above the adjoining ground. Such support should be in accordance with the manufacturer's installation instructions. Appliances suspended from the floor should have a clearance of not less than 6 inches (152 mm) from the ground.

● **Flashing/Moisture Control.** Verify that the design and specification of the weather-resistive covering, water-resistant barrier, flashing, and drainage are specified on the construction documents and meet applicable codes.

— *2015 IRC, Section R303.6 Outside Opening Protection.* Air exhaust and intake openings that terminate outdoors should be protected with corrosion-resistant screens, louvers, or grills having a minimum opening size of ¼ inch (6 mm) and a maximum opening size of ½ inch (13 mm), in any direction. Openings should be protected against local weather conditions. Outdoor air exhaust and intake openings should meet the provisions for exterior wall opening protective in accordance with this code.

— *2015 IRC, Section R703.4 Flashing.* Approved corrosion-resistant flashing should be applied shingle-fashion to prevent water from entering into wall cavities or from penetrating into building structural framing components. Self-adhered flashing must comply with AAMA 711. Fluid-applied membranes used as flashing in exterior walls should comply with AAMA 714. The flashing should extend to the surface of the exterior wall finish or to the water-resistant barrier. For this code, approved corrosion-resistant flashings should be installed at all wall and roof intersections.

● **Potable Water System Protection.** Verify that potable water connections to the equipment are correct. In general, most evaporative coolers have built-in backflow protection devices.

— *2015 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.
Intake Openings. Verify that the location and orientation of intake openings for the evaporative cooler itself meet the applicable code for distances and clearances.

— 2015 IRC, Section R303.5.1. Mechanical and gravity outdoor air intake openings should be located a minimum of 10 feet (3048 mm) from any hazardous or noxious contaminant, such as vents, chimneys, plumbing vents, streets, alleys, parking lots, and loading docks.

Exceptions:

1. The 10-foot separation is not required where the intake opening is located 3 feet or greater below the contaminant source.
2. Vents and chimneys serving fuel-burning appliances should be terminated in accordance with the applicable provisions of Chapters 18 and 24.
3. Clothes dryer exhaust ducts should be terminated in accordance with Section M1502.3.

For the purpose of this section, the exhaust from dwelling unit toilet rooms, bathrooms, and kitchens should not be considered as hazardous or noxious.

• Insulation. Review the construction documents and confirm the specified R-value of insulation for air ducts.

— 2015 IECC/IRC, Section R403.3.1/N1103.3.1 Insulation.

○ Supply and return ducts installed in attics should be insulated to R-8 if ducts are ≥3 inches in diameter or to R-6 if ducts are <3 inches in diameter.

○ Supply and return ducts installed in other portions of the building should be insulated to R-6 if ducts are ≥3 inches in diameter R-4.2 if ducts are <3 inches in diameter.

Exception: Ducts or portions thereof located completely inside the building thermal envelope

• Duct Leakage/Air Sealing. Review the construction documents and confirm that the appropriate level of duct sealing is used based on the code to be applied. Be aware that current codes require that duct tightness beyond just mechanical sealing of joints and seams be verified with field testing, and supporting documentation be provided to the code official. The code official should consider transmitting the jurisdictional requirements during the plan review phase.

— 2015 IECC/IRC, Section R403.3.2/N1103.2.2 Sealing. Ducts, air handlers and filter boxes should be sealed. Joints and seams should comply with the International Mechanical Code or IRC, Section M1601.4.1, as applicable.

Exceptions:

○ Air-impermeable spray foam products should be permitted to be applied without additional joint seals.

○ For ducts having a static pressure classification of less than 2 inches of water column (500 Pa), additional closure systems should not be required for continuously welded joints and seams, and locking-type joints and seams of other than the snap-lock and button-lock types.

1UL (Underwriters Laboratory) is a global independent safety science company that certifies, validates, tests, inspects, audits, and advises and trains.

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, plumbing rough-in, mechanical rough-in, and final inspection.

Per the 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 evaporative cooling systems where one or more specific type of inspection per the IECC or IRC may be necessary to confirm compliance. Inspections should provide verification in the following areas:

• Evaporative cooler is properly located and mounted, and connections are made per approved plans. Proper clearances are maintained for hazardous or noxious fumes.

• All intake and exhaust openings are properly flashed to prevent moisture incursion.
• Duct 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.

• Joints and seams in ductwork are properly sealed, and the duct tightness report is complete and has been submitted per jurisdictional requirements.

Technical Validation(s):

This section provides additional information and helpful resources.


Case Studies

1. **New Whole-House Solutions Case Study: Home Front Inc.: Hot, Humid Climate Region 40+% Energy Savings**
   - **Author(s):** Steven Winter Associates
   - **Organization(s):** CARB, Steven Winter Associates
   - **Publication Date:** August, 2009
   - Case study describing a building project in the hot-humid climate zone.

References and Resources*

1. **2009 IECC - International Energy Conservation Code**
   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** January, 2009
   - Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.

2. **2009 International Mechanical Code**
   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** January, 2009
   - Code containing 2009 ICC language for mechanical draft systems.

3. **2009 IRC - International Residential Code for One and Two Family Dwellings**
   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** January, 2009
   - Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** January, 2012
   - Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.

5. **2012 IRC - International Residential Code for One and Two Family Dwellings**
   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** January, 2012
   - Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

   - **Author(s):** International Code Council
   - **Organization(s):** ICC
   - **Publication Date:** May, 2014
   - Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems and service water heating systems in homes and commercial businesses.

7.
2015 IRC - International Residential Code for One and Two Family Dwellings
Author(s): International Code Council
Organization(s): ICC
Publication Date: May, 2014
Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

Author(s): International Code Council
Organization(s): ICC
Publication Date: November, 2017
Code establishing a baseline for energy efficiency by setting performance standards for the building envelope (defined as the boundary that separates heated/cooled air from unconditioned, outside air), mechanical systems, lighting systems, and service water heating systems in homes and commercial businesses.

9. 2018 IRC - International Residential Code for One and Two Family Dwellings
Author(s): International Code Council
Organization(s): ICC
Publication Date: August, 2017
Code for residential buildings that creates minimum regulations for one- and two-family dwellings of three stories or less. It brings together all building, plumbing, mechanical, fuel gas, energy and electrical provisions for one- and two-family residences.

10. ACCA Manual D - Residential Duct Systems
Author(s): Air Conditioning Contractors of America
Organization(s): Air Conditioning Contractors of America
Publication Date: December, 2013
Standard outlining industry procedure for sizing residential duct systems.

11. ACCA Manual S - Residential Equipment Selection
Author(s): Air Conditioning Contractors of America
Organization(s): Air Conditioning Contractors of America
Publication Date: April, 2013
Standard covering sizing strategies for all types of cooling and heating equipment, as well as how to use comprehensive manufacturer’s performance data on sensible, latent, or heating capacity for various operating conditions.

Author(s): Gilbride, Baechler, Hefty, Hand, Love
Organization(s): Pacific Northwest National Laboratory, Oak Ridge National Laboratory
Publication Date: August, 2011
Report providing information about energy-efficient heating, ventilation, and cooling (HVAC) equipment options to help homeowners cut their energy use, reduce their carbon footprint, and increase their homes comfort, health, and safety.

13. EIA Residential Energy Consumption Survey 2009
Author(s): EIA
Organization(s): EIA
Publication Date: January, 2009
Federal statistics about national energy consumption in residential homes.

14. Evaporative Coolers
Author(s): Architectural Energy Corporation
Organization(s): Architectural Energy Corporation
Publication Date: November, 2011
Article describing RESNET guidance on evaporative coolers.

15. Measure Guideline: Evaporative Condensers
Author(s): German, Dakin, Hoeschele
Organization(s): ARBI, National Renewable Energy Laboratory, Davis Energy Group
Publication Date: March, 2012
Report about evaporative condensers, to provide information on a cost-effective solution for energy and demand savings in homes with cooling loads.

16.
RESNET standards aimed to ensure that accurate and consistent home energy ratings are performed by accredited home energy rating providers through their raters nationwide.

17. **New Evaporative Cooling Systems: An Emerging Solution for Homes in Hot Dry Climates with Modest Cooling Loads**
   - **Author(s):** Southwest Energy Efficiency Project
   - **Organization(s):** Southwest Energy Efficiency Project
   - **Publication Date:** January, 2007
     
     Report discussing the benefits of modern evaporative cooling systems for use in hot dry climate zones.

   - **Author(s):** National Fire Protection Association
   - **Organization(s):** National Fire Protection Association
   - **Publication Date:** January, 2018
     
     Code outlining minimum safety requirements for the design and installation of fuel gas piping systems in homes and other buildings.

19. **WaterSense Labeled New Home Inspection Checklist**
   - **Author(s):** U.S. Environmental Protection Agency
   - **Organization(s):** EPA
   - **Publication Date:** July, 2014
     
     Resource that provides a checklist of program criteria for water-efficient new homes under the U.S. Environmental Protection Agency’s (EPA’s) WaterSense program.

20. **WaterSense New Home Specification**
    - **Author(s):** U.S. Environmental Protection Agency
    - **Organization(s):** EPA
    - **Publication Date:** July, 2014
      
      Resource that establishes the criteria for water-efficient new homes under the U.S. Environmental Protection Agency’s (EPA’s) WaterSense program.

*Publication dates are shown for formal documents. Dates are not shown for non-dated media. Access dates for referenced, non-dated media, such as web sites, are shown in the measure guide text.

**Contributors to this Guide**

The following authors and organizations contributed to the content in this Guide.

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