TechNote

Humidity Control: Supplemental Dehumidification in Hot-Humid Climates

Managing indoor humidity in hot-humid climates is more important than ever for new, energy efficient homes equipped with whole-house mechanical ventilation. In these homes, air conditioning systems are less effective at removing humidity from the air, particularly during part-load conditions or shoulder seasons when cooling is normally not required (e.g., November-March). Yet, more humid outdoor air is brought into the house as a result of increased ventilation rates. Although tighter construction practices help reduce air infiltration, the net effect is an increased supply of humid outdoor air into the house [1].

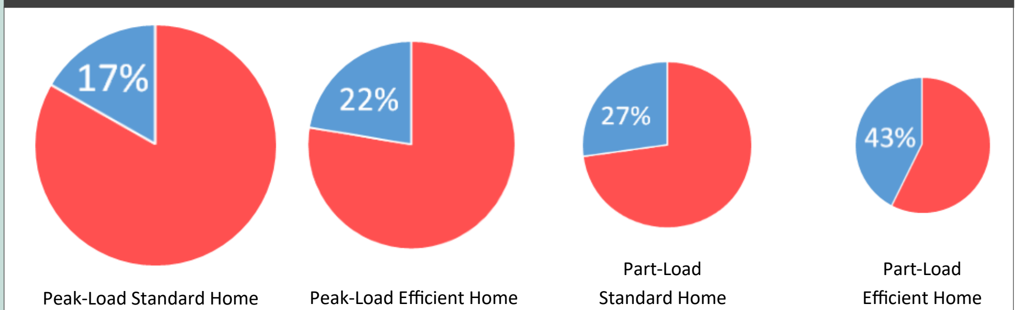
These conditions tend to lead to increasing the risk for musty odors, mold-mildew, and comfort complaints (e.g., cold and clammy feeling). In addition, high indoor humidity can result in increased energy use because occupants tend to compensate by using a lower thermostat setting in the summer [2].

This TechNote provides an overview of strategies for improving humidity control in hot-humid climates (applicable as well in other humid climates). The focus is on supplemental dehumidification methods using commercially available equipment. Supplemental dehumidification is not intended to be used as a means for compensating for over-sized HVAC equipment or excessive building leakage rates. A strategy to improve humidity control can include combinations of the following:

- **Air Conditioning**. Air conditioning systems perform two functions: cooling (to reduce the temperature of the air) and dehumidification (to remove moisture from the air). Air conditioning controls are commonly designed to control temperature, not humidity. Two- or multi-stage systems may improve dehumidification depending on equipment and air flow selections [3].
- **Air Conditioning with Enhanced Dehumidification**. Optional controls can improve the ability of an air conditioning system to dehumidify during part-load conditions, typically by operating the air handler at a lower than normal air flow and/or over-cooling by 2-3 degrees. Generally requires a specific thermostat and compatible air handler with a variable speed fan.
- **Supplemental Dehumidification**. A dehumidifier (most commonly) can be installed to complement the air conditioning system during part-load conditions and to operate without air conditioning during shoulder seasons. A dehumidifier controls humidity rather than temperature. Inlet air is drawn in by a blower where it is filtered and dehumidified – outlet air is typically 15-30 degrees warmer than inlet air. A dehumidifier can be standalone or ducted – independently to conditioned space, or integrated with the HVAC duct system.
- **Exhaust Fans**. Bath and kitchen exhaust fans provide humidity control at these sources of moisture.

Air conditioning equipment is sized based on peak-load outdoor design temperature, determined by the home's location. A home's total cooling load consists of a sensible load (temperature component) and a latent load (humidity component). Conventional systems generally dehumidify well during peak-load temperatures when the system operates for extended periods.

Figure 1. Latent Loads Increase as a Percentage of Total Loads at Part-Load Conditions.



During part-load conditions, when the temperature is lower than the design temperature, the sensible load can be greatly reduced, but the latent load tends to remain relatively constant, so the latent load makes up a larger proportion of total load. At lower temperatures, the system cools the house relatively quickly, and cycles off, but provides proportionally less dehumidification. As a result, indoor humidity levels tend to rise. Figure 1 shows example loads for example homes.

This effect is exacerbated during cloudy or more humid days and also for new, energy efficient homes with lower sensible loads but with latent loads that can be the same or higher due to ventilation requirements.

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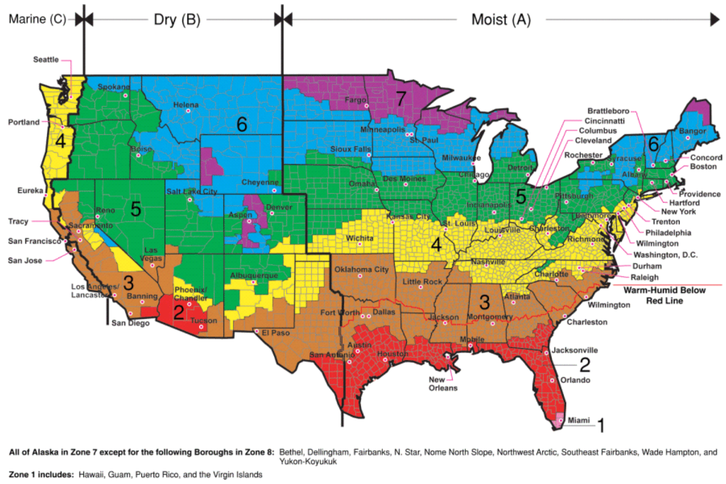
Code Considerations

The International Residential Code (IRC) defines warm-humid climates as Zones 1A, 2A, and portions of 3A below the warm-humid line as shown in Figure 2 (N1101.7). This TechNote focuses on these climates but is applicable as well in other humid climates. The IRC has requirements pertinent to humidity control (2015 IRC Sections indicated):

- The capacity of heating and air conditioning equipment must be selected in accordance with ACCA Manual S [4] based on load calculations in accordance with ACCA Manual J, or other approved methods (N1103.7; M1401.3) and the minimum interior design temperature used for cooling load calculations shall be 75°F (N1101.9). These requirements limit over-sizing the equipment, with the intent to control humidity during cooling at part-load conditions.
- Ducts must be sealed and insulated where not in conditioned space (N1103.3). Applicable to ducted dehumidifiers.
- Since 2012, whole-house mechanical ventilation is generally required (N1103.6; M1507; R303.4).
- Equipment condensate drainage requirements are specified; auxiliary drain pan is required in or above finished space (M1411.3).
- Return air for the HVAC system may not be taken from a closet, furnace room, or unconditioned attic (M1602.2). May limit dehumidifier configurations in mechanical closets.

Figure 2. Climate Zone Map. Source: DOE.



Design Considerations

Relative Humidity (RH). RH is key to thermal comfort and closely related to temperature—a lower RH at the same temperature can feel cooler and more comfortable. For most people, the upper limit for comfort during the cooling season ranges from about 55% to nearly 70%RH depending on the temperature [5]. The corresponding upper limit at 75°F is about 65%RH. A target of 60%RH is a common design goal for indoor air quality [6] and optimum comfort [4].

Whole-house mechanical ventilation. The intentional exchange of indoor air with outdoor air, at a controlled rate using fans, with the intent to improve indoor air quality. Increased RH due to ventilation can be particularly noticeable when air conditioning is not operating. Ventilation air can be integrated with the HVAC duct system or a dehumidifier designed to accommodate ventilation air. An energy recovery ventilator (ERV) can reduce the RH of incoming outdoor air but does not dehumidify indoor air.

Air Conditioning. Select system capacity based on the load for the specific house – oversized systems provide less effective dehumidification due to shorter run times. Also ensure proper system air flow—high air flow reduces dehumidification. HVAC systems with enhanced dehumidification capability improve RH control during part-load conditions but the system will operate longer and may use more energy.

Supplemental Dehumidification. Dehumidifiers are relatively simple and effective. Other methods tend to be complicated and expensive, do not provide significant energy savings, and are not common for residential applications.

Dehumidifier Controls. Dehumidifiers come with a built-in RH sensor (measures RH of air flowing through the dehumidifier), control board (most can be wired to turn on the air handler during dehumidifier operation and control ventilation hardware), and control (user interface/display). Optionally, install a remote, wall mounted humidistat control or compatible thermostat to measure RH within the living area.

Dehumidifier Ratings. Capacity and Energy ratings are measured at 80F/60%RH inlet air at 0.0 ESP (no ducts). **Capacity** is rated by pints per day (PPD) of water removed (commonly available in 30-90 PPD for portable, 70-130 PPD for ducted, and up to 155 PPD for larger standalone units). **Efficiency** is rated by Energy Factor (EF) in liters of water removed per kilowatt-hour of energy consumed (L/kWh). Current ENERGY STAR™ criteria: ≥ 1.85 L/kWh for models less than 75 PPD; ≥ 2.80 L/kWh for models 75-185 PPD [7]. **Noise** is rated by decibels (dBA). Portable dehumidifiers tend to be loud. Many ducted models have reasonably low sound ratings (e.g., 50/60 dBA ducted/unducted).

Selecting Dehumidifiers. The Association of Home Appliance Manufacturers (AHAM) provides guidance on selecting dehumidifier capacity based on house square footage and indoor dampness conditions. Manufacturers provide recommendations based on house square footage, but recommendations vary by manufacturer. ACCA Manual S provides a method that uses the already required Manual J load calculation. Selection is limited by the number of different capacity models offered by manufacturers (typically offer three different capacity models).

Standalone Dehumidifier (Figure 3):

- Closet location: the closet door must be louvered for air transfer. Noise and heat from the dehumidifier through the louvers may be objectionable to the occupants.
- Basement or unvented attic/crawl space location: does not directly dehumidify living areas although can contribute to reducing overall moisture load.
- Living area location (not a closet): likely not a marketable option (due to noise, heat, drainage requirements, or home buyer general expectations).
- Mechanical closet (with HVAC air handler) note: applications that rely on an HVAC return within a closet may not be code compliant – a ducted configuration is recommended.
- A wall mounted humidistat control is recommended to measure room RH and reduce dehumidifier short-cycling.

Independent Ducted Dehumidifier (Figure 4):

- The dehumidifier is ducted directly to conditioned space.
- Dehumidifier can be installed in an attic, basement, crawl space, mechanical room, or closet and ducted to conditioned space.
- Does not rely on the central HVAC system – ideal for homes with ductless HVAC systems.
- Inlet and outlet grilles should be separated as practical to improve air distribution.
- Locate the outlet grille so warm outlet air does not affect occupant comfort or a thermostat/remote control.
- A wall mounted humidistat control is recommended to measure room RH and reduce dehumidifier short-cycling.

Integrated Ducted Dehumidifier (Figures 5-9):

- Dehumidifier inlet/outlet ducts are integrated with HVAC ducts.
- Dehumidifier can be installed in an attic, basement, crawl space, mechanical room, or closet.
- Recommended configurations vary by equipment manufacturer. (Examples are applicable to horizontal or vertical air handler applications.)
- Return-to-return (Figure 5) and dedicated inlet-to-return (Figure 6) configurations: dehumidifier should be wired to activate the HVAC blower during dehumidifier operation (or dehumidified air would simply recirculate during off-cycles).
- Return-to-supply (Figure 7) and dedicated inlet-to-supply (Figure 8) configurations: require a back-draft damper to prevent reverse flow through dehumidifier when dehumidifier is off; HVAC supply duct static pressure must not exceed dehumidifier specifications; HVAC blower operation is ideal but not required (dehumidified air tends to distribute through the supply ducts). Figure 9 shows a mechanical closet example.

Whole-House Mechanical Ventilation (Figures 10-11):

- Outdoor air (indicated by blue arrow) can be ducted to the HVAC return (Figure 10) or a ventilation dehumidifier (Figure 11).

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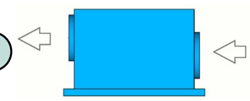

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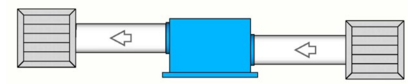

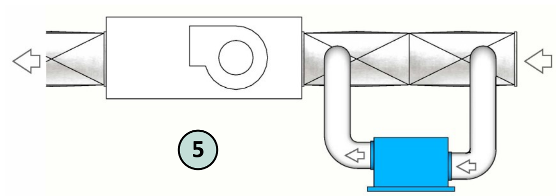

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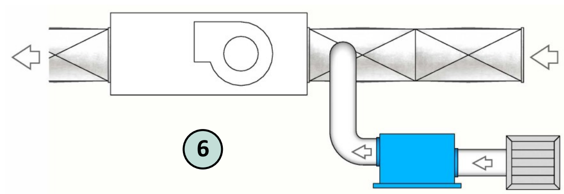

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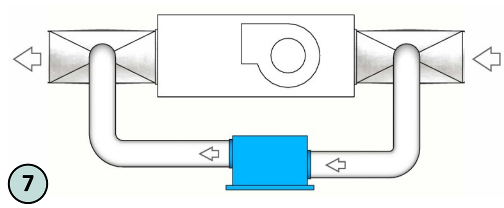

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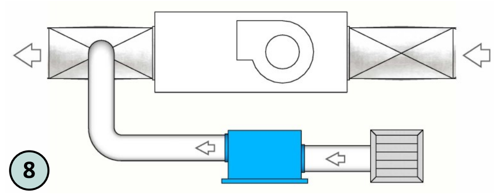

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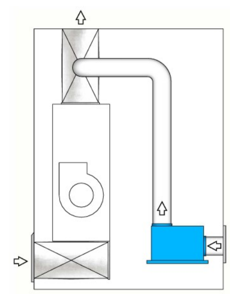

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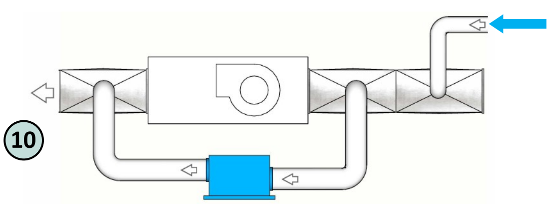

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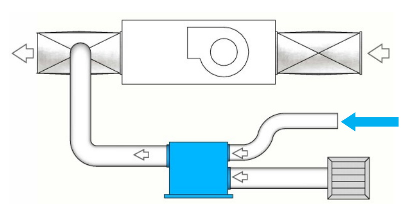

Table 1. Summary of Enhanced/Supplemental Dehumidification Strategies		
Strategy	**Pros**	**Cons**
Enhanced Dehumidification	• Improves dehumidification during cooling at part-load conditions • Good distribution of dry air • Low incremental cost if already installing a high efficiency air handler/furnace	• Does not dehumidify during shoulder seasons • Over-cooling component may be a comfort issue • Incremental cost can be high if not already installing a high efficiency air handler/furnace
Standalone Dehumidifier	• Simple and can be effective • Low installed cost for portable models, intermediate cost for some other models	• Limited distribution • Limited location options • Portable models may be considered objectionable
Independent Ducted Dehumidifier	• Effective during all conditions/seasons • Ideal for homes with ductless HVAC • Flexible location options	• Limited distribution depending on duct layout • Warm outlet air may be objectionable • Relatively high installed cost
Integrated Ducted Dehumidifier	• Effective during all conditions/seasons • Good distribution particularly during HVAC air handler operation • Flexible location options • Operation is typically quiet	• Relatively high installed cost • Increased energy cost if HVAC air handler is wired to operate with the dehumidifier during cooling off-cycles

Recommendations

Design Phase

- Develop a humidity control strategy based on climate that will maintain RH levels acceptable to occupants.
- Include recommended control set points, as required, for enhanced dehumidification (e.g., initiates at 55%RH) and supplemental dehumidification (e.g., dehumidifier initiates at 60%RH).
- Show equipment and installation details on plans, specifications, and scopes of work for subcontractors.
- Supplemental dehumidification is not intended to be used as a means for compensating for over-sized HVAC equipment or excessive building leakage rates.
- Avoid exhaust-only ventilation as it tends to depressurize a house that in turn may increase infiltration of outdoor air and indoor humidity [8].

Occupied Phase

- Balance comfort and energy use—operating a dehumidifier at a higher RH set-point will use significantly less energy [3].
- Continuous HVAC air handler blower operation may improve air mixing but may also increase indoor humidity during the cooling season when the compressor is off (due to evaporation from a wet coil/drip pan) [4].
- Comfort level criteria include temperature, RH, air movement, and individual metabolism. RH levels can vary greatly by occupant behavior. Caution homeowners on bringing potential large moisture sources, such as an aquarium or numerous plants, into the home.
- Caution homeowners on the effect of turning off the HVAC system or using a high set point (e.g., 80°F) that could allow RH to rise (unless supplemental dehumidification is installed).
- Don't over-ventilate—some controls can be set to limit ventilation during extreme hot/humid conditions.

References and Resources

[1] Home Innovation Moisture Management Series (www.HomeInnovation.com/MoistureManagementVideos) Water Vaper Flow

[2] Whole House Dehumidification for Occupant Comfort and Energy Savings. June 2009. Madison, WI: Research Products Corporation.

[3] Rudd, A. Measure Guideline: Supplemental Dehumidification in Warm Humid Climates. Building Science Corporation. Golden, CO: NREL. October 2014. http://www.nrel.gov/docs/fy15osti/62677.pdf

[3] Rutkowski, H. Manual S: Residential Equipment Selection. Second Edition, Version 1.00. ANSI/ACCA 3 Manual S – 2014. Arlington, VA: Air Conditioning Contractors of America.

[4] ANSI/ASHRAE Standard 55-2010: Thermal Environmental Conditions for Human Occupancy. Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

[5] Indoor airPLUS Version 1 (Rev. 03) Construction Specifications (October 2015). Washington, D.C.: United States Environmental Protection Agency.

[6] ENERGY STAR™ efficiency criteria, accessed June 2016. https://www.energystar.gov/products/appliances/dehumidifiers

[7] TechNote: Whole-House Mechanical Ventilation: Code, Safety and Performance Considerations. October 2013.