

Principle #1: Keep It Dry

Review of the Evidence

Ventilation and moisture control are typically related. Both ventilation and dehumidification help to reduce humidity levels and exposure to dust mites. A national survey found the use of a dehumidifier predicted lower levels of some asthma triggers and mold.⁷ Additionally, installation of a whole-house mechanical ventilation system can reduce humidity, thus decreasing dust mites and improving clinical outcomes.^{8, 9} Effective dehumidification in temperate climates can be achieved with air conditioners and/or dehumidifiers.¹⁰ In climates with high humidity, whole-house ventilation has been less effective.^{11, 12, 13} Climate zone must therefore be considered when making decisions about dehumidification.

Ventilation can improve indoor air quality when the outdoor air has lower levels of humidity and contaminants than the indoor air. Conversely, families in housing near pollution point sources such as industrial sites, high-pollen forested sites, and high-traffic roadways may need to filter or otherwise clean the outdoor air that enters the home environment.

Structural Interventions

Structural deficiencies related to moisture include water intrusion through the building envelope, plumbing leaks, drainage problems, and condensation. Key structural control methods are shown in Figure 5.2. Chapter 4 identifies a number of structural factors central to moisture control and how to assess when these controls have failed. The HUD/CDC *Healthy Housing Reference Manual* describes maintenance practices, proper insulation, and how to prevent moisture intrusion from a home's foundation, walls, and roof. The Reference Manual also provides information on the operations and maintenance of plumbing systems, venting requirements for plumbing systems, and methods to conserve water.

Figure 5.2 Key Structural Controls for Moisture

1. Limit water entry (e.g., maintain gutter systems).
2. Dehumidify damp spaces such as basements.
3. Repair leaks and assure that drains work properly.
4. Clean or properly remove wet or moldy building components.
5. Manage ventilation systems so that moisture is removed at the source.

Finished basements require special consideration regarding moisture control. In general, such spaces should not use sheetrock or paneling to cover exterior walls or wall-to-wall carpeting, both of which can lead to moisture and mold problems. Capillary breaks are discussed below as one way of controlling moisture in basements.

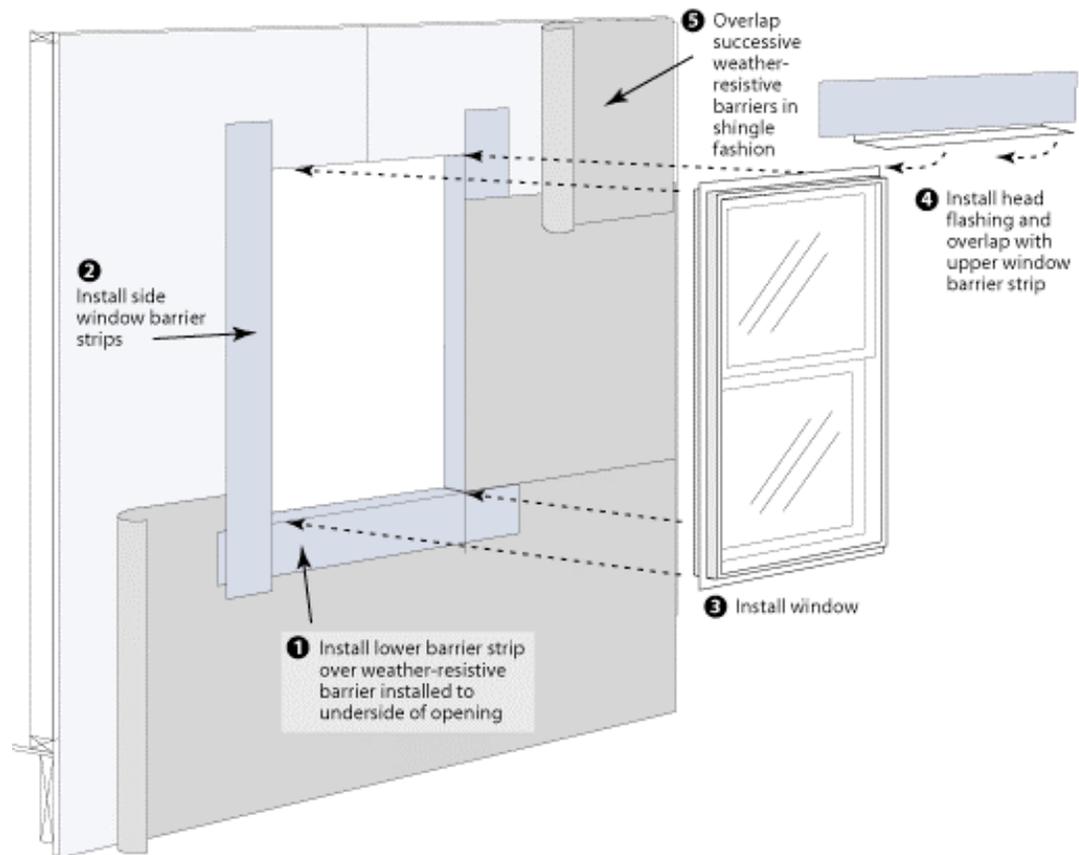
Controlling Building Envelope Leaks

Ensuring that roofs, walls, and foundations shed water effectively helps to control leaks. Absence or deterioration of flashing is a common building deficiency associated with water leakage through the building envelope. Flashing refers to thin continuous pieces of sheet metal or other impervious material installed to prevent water from passing into a structure through an angle or joint (Figure 5.3).

When new building components such as windows are installed, they should be accompanied by pan flashing to shed water away from the wall penetrations and prevent water from entering the structure. Flashing at the base of structures should allow water that has been repelled by the flashing to escape the plane of the building surface. The principle of flashing should be extended to all penetrations in structures. In other words, all of them should be sealed to prevent moisture as well as pest incursion into the living space.

Maintaining proper grading around a foundation and preventing erosion that can lead to pooling of water helps prevent moisture intrusion into

Figure 5.3 Window Flashing



Source: http://www.energysavers.gov/your_home/windows_doors_skylights/index.cfm/mytopic=13470

basements and reduces the need for expensive foundation waterproofing and excavation. This practice also promotes the durability of the structure by reducing the prospect of settling, which can sometimes lead to cracks. Specific interventions are discussed below.

- In new construction, install capillary breaks around interior foundation walls to prevent water from “wicking” up from the ground and into the building through capillary action. Capillary breaks can also be installed in existing construction. Capillary breaks are needed to prevent vertical moisture movement, such as from the foundation wall up into the wall or floor framing (only practical in new construction) and horizontal moisture movement, such as soil moisture moving through the foundation wall into the basement or crawl space. This is accomplished by water-proofing or damp-proofing the exterior side of the foundation wall during construction. While usually very expensive to carry out as a retrofit, it is sometimes the most cost-effective

way to control moisture in existing homes when combined with perimeter drainage and proper grading away from the structure. Construction information on capillary breaks is available in EPA’s Indoor airPLUS construction specifications (epa.gov/indoorairplus/construction_specifications.html).

- In existing structures, a retrofit with French drains or other means of diverting water away from foundations may be needed.
- Gutters and downspouts should drain water from the roof to the ground with no breaks in the system. Drainpipes or splash blocks should redirect water from the downspouts away from the foundation, but care should be taken not to direct the water near the foundation of the neighboring building.
- Planter boxes, decks, or other outdoor structures should be placed so that they do not obstruct rainwater flow or snowmelt from the foundation (Appendix 5.1).



Condensation can occur when warm, moist air comes in contact with a cold surface. This can lead to mold and other problems, creating health hazards and building decay. Sometimes condensation occurs within walls, ceilings and floors that separate the outside unconditioned air from the conditioned air inside the structure as warm moist air travels through the cavity. Crawl spaces, attics, and exterior walls can be affected. In some cases a vapor retarder (often called a vapor barrier) is recommended to inhibit condensation from the movement of moisture-laden air into walls, ceilings, and floors. Placing a heavy plastic sheet on the bare ground in a crawl space, carefully sealing any seams, and sealing the plastic to the foundation can minimize moisture movement from the crawl space into the structure.

Note that vapor retarders require careful thought. If an insulated wall has materials on both the interior and exterior surfaces that retard vapor movement, moisture can become trapped within the wall cavity and cause a serious problem. Walls should be designed so they dry in at least one direction.

Similarly, cold water pipes located in areas where the air is warm should be insulated to prevent condensation. One way of detecting this problem is to look for areas of discoloration where condensation from pipes has dripped onto a lower surface. The same principle applies to ductwork that carries warm or cold air through air zones with a high temperature gradient. Ductwork should be sealed and well insulated in unconditioned spaces to prevent

condensation. Insulation should be applied to the exterior of the ductwork, not the interior. While insulation of ductwork is a simpler matter in new construction, poor insulation of ductwork in existing housing can result in condensation inside ductwork and become a significant breeding ground for mold and other biological agents.

Ensure that windows are adequately installed, caulked, and insulated to prevent condensation—a cause of both mold and lead-based paint failure. Replacing old single-pane windows with modern double- and triple-pane windows can effectively eliminate window condensation problems. This intervention may be cost-prohibitive for healthy homes programs unless funds can be leveraged through partnerships, from lead hazard control and/or weatherization programs, or the private sector.

Reduce moisture sources with high quality exhaust fans in bathrooms and kitchen, and proper venting of dryers, to substantially reduce the likelihood of condensation on windows or walls. Finally, eliminate insulation voids in walls and ceilings since cold interior wall surfaces in the winter can lead to condensation and mold.

Prompt Repair of Plumbing Leaks

How water and moisture leave a home are as important as how they enter. Plumbing is often overlooked as a significant source of moisture because leaks can be slow or undetected. Drain traps can degrade or dry over time if the drain trap is not kept full of water. Basement floor drain traps should be kept full by adding water periodically to prevent harmful soil and/or sewer gases from being emitted.

Safe Cleaning or Removal of Wet or Moldy Items

Failure to correct the source of moisture that produced mold contamination guarantees the eventual failure of mold remediation efforts. There are established procedures for safely removing wet and moldy building materials and furnishings, typically involving minimizing the disturbance of such materials to prevent mold spores from becoming airborne.^{14, 15, 16} Projects requiring large areas of mold decontamination (e.g., more than ten square feet) may warrant the use of a mold mitigation professional. Improper

solutions, such as blowing air over mold contaminated items, can increase exposures and may do more harm than good. Individuals attempting to mitigate mold problems should be trained to prevent exposure to mold during the elimination process through the use of respiratory, eye and skin protection equipment.

Appropriate Design, Installation, and Management of Heating, Ventilation, and Air Conditioning (HVAC) Systems

Many kitchen fans in older homes simply recycle air coming from stoves and ranges rather than vent it to the exterior of the building. Some current building codes for new construction require that kitchen range hoods be exhausted to the outside. Check by looking above the fan or range hood to see whether there is ductwork and examining the exterior wall for a flap that would exhaust the air. Installers often forget to remove the manufacturer's tape on the flap, so it is important to ensure that the flap is not only present but functioning properly. Bathroom exhaust fans and clothes dryers must be vented to the outside.

In general, a home's relative humidity should be kept in the 30–50 percent range. Filters in clothes dryers, kitchen ranges, furnaces and bath exhausts should be cleaned and/or replaced to ensure air flow is adequate and moisture does not accumulate on the dust in the filters. Instructions on when and how to clean and replace filters properly should be part of a program's education intervention strategy.

Air conditioning or dehumidifying systems need to be checked regularly and cleaned to ensure that condensate drains do not become blocked. Blockage results in leaks from the drainage pans onto surfaces that may not be visible. Condensate pans should be properly sloped so that water runs to the drain and does not pool in other areas. Cooling coils need to be kept clear and clean to prevent blockage as well as prevent high fuel consumption due to lower heat transfer. Homeowners/residents or maintenance personnel can take care of this for window air conditioners, but for central air conditioning systems, a licensed contractor is generally needed.

Some heating, ventilation, and air conditioning systems (HVAC) are equipped with humidifiers,

especially in northern climates where indoor winter air becomes dry. In other cases, individual rooms may be equipped with portable humidifiers. In both cases, the water supply, water tank, and water wheels or other distribution systems should be kept clean. If the systems are not used for some time, they can become breeding grounds for biological agents, including mold, bacteria, and viruses. Very dry conditions in the house may be due to dry cold air entering the home during the winter. Proper air sealing may remove the need for a humidifier.

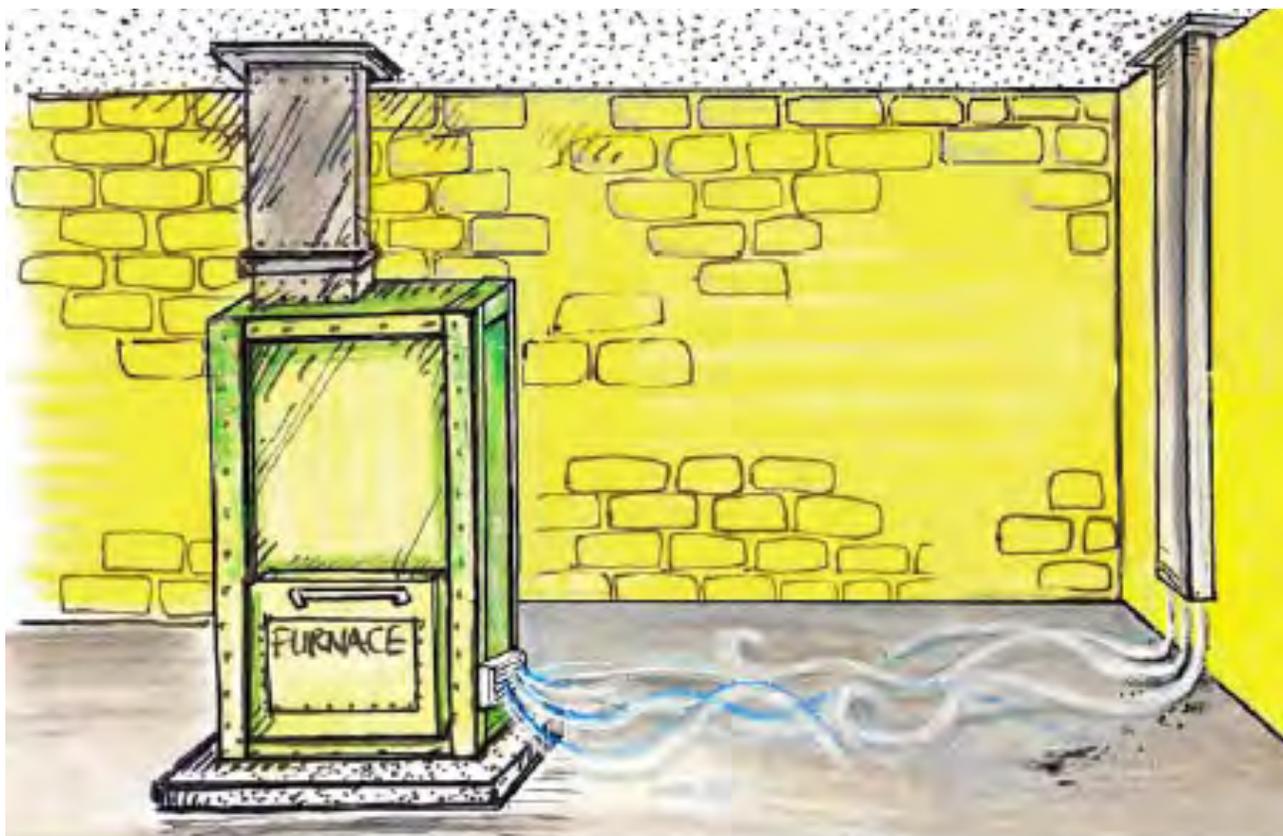
If an area has become wet, drying is typically the first step in remediation after eliminating the moisture source (Figure 5.4). However, some forms of drying can exacerbate the problem. Blowing high-velocity air streams over surfaces contaminated with extensive mold can cause mold spores and fragments to become airborne, where they can be inhaled readily or contaminate other surfaces. Use of dehumidifiers, personal protection and other measures can help to avoid these problems. In some cases, it may be necessary to discard contaminated items that cannot be properly cleaned. If the extent of damage is extensive, trained professionals should address the problem. It is equally as important to identify the moisture source and to make needed repairs to prevent reoccurrence. During catastrophic water events (e.g., pipe breaks, water heater failure, flooding), time is of the essence. Typically, water needs to be removed within 24–48 hours, after which mold begins to develop. Many restoration companies are now available to extract water following a flood using dehumidifiers, fans, and other tools.

Figure 5.4 Remediation Guidance

Mold and moisture remediation guidelines are available from the following organizations:

- EPA: <http://www.epa.gov/mold/moldcleanup.html>.
- New York City Health Department: <http://www.nyc.gov/html/doh/html/epi/moldrpt1.shtml>.
- AIHA: <http://www.conferencemedia.net/store/stores/aihce/american-industrial-hygiene-conference-and-expo-2009/perspectives-on-the-aiha-green-book.html>.

Figure 5.5 Unhealthy Heating System Using Basement Air



The illustration shows returning air entering the basement air, then supplying the furnace with air distributed throughout the house. Figure 5.6 shows a simple fix that avoids contamination of supply air.

For some moisture problems, changes to the HVAC system may be needed. For example, a ventilation system that draws air from a moist basement instead of a living area may result in dispersing moisture and mold throughout the house (Figures 5.5 and 5.6). This type of system is sometimes called “the Cleveland Drop” because it was first identified in a number of Cleveland-area houses that were investigated for mold and moisture problems. A solution is to ensure that the air supplying the furnace is supplied from the exterior or from a living area, rather than the basement. Leaky ductwork can also lead to problems because it may draw in air from unconditioned spaces. Ductwork should be sealed to prevent such leaks. For new construction, information is available in EPA’s Indoor airPLUS construction specifications: www.epa.gov/indoorairplus/construction_specifications.html.

Reporting Moisture and Leak Problems

Owner occupants and renters should be encouraged to conduct regular visual assessments to identify leaks and condensation. Tenants need to have confidence that requests for minor repairs and reporting maintenance needs are taken seriously or they will fail to report problems when they are relatively easy to correct. Tenant failure to promptly report problems and property owner failure to respond represent major problems in economically distressed rental housing. Clarifying roles and expectations and providing incentives for responsible behavior are important tools for healthy homes programs.