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## Mold in Houses What Building Professionals Need to Know to Diagnose and Solve the Problem

### Why Be Concerned About Mold

All building professionals and trades people who enter a home should be prepared to assess if a house or apartment has a potential mold and moisture problem. If you are a home inspector, building performance technician, energy auditor or rater, weatherization contractor, remodeling or HVAC contractor, plumber or electrician, you should be able to recognize the signs of moisture damage and mold growth.

If left untreated, mold growth can cause serious health problems for the residents and excess moisture may destroy the building structure. Any work you are doing or recommending could worsen the underlying moisture problem if not remedied. In severe cases, residents have had to abandon their homes and resort to lawsuits to seek compensation for their health problems and building damage.

This Bulletin is written to provide a general overview of the key issues that you, as a building professional or concerned consumer, need to know to protect yourself when dealing with a suspected mold problem. It is not intended to provide detailed instructions on how to diagnose and clean major mold outbreaks or how to remedy building defects that led to the moisture buildup. The **Resource List** that accompanies this document provides more in-depth material on the various topics discussed here.

Homeowners, renters, apartment owners and all other building owners need to recognize the signs of mold growth and repair any leaks or moisture problems as soon as they occur. Conduct regular inspections of the whole building, including attics and basements or crawl spaces, to assess if there are any hidden problems. In many cases, a simple visual inspection is all that is needed to determine the extent and cause of a moisture and mold problem. Sometimes you may need a professional moisture audit to detect what is occurring. The cost of the audit will be repaid in knowing that you are remedying the problem correctly.

Every mold problem is also a moisture problem. This paper outlines the key steps in diagnosing and treating moisture and mold problems.

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Anyone who is tackling a mold problem should follow proper safety procedures. It is essential that you identify and remedy the underlying cause behind a mold problem, not just remove the visible growth. Mold can start to grow within 48 hours of a leak or damage. Do not wait to stop leaks and repair moisture damage.

### **Examine the Causes Behind Mold Problems**

Within the last two years, mold problems in buildings have emerged as the latest “sick building” horror stories, as evidenced in media coverage and several well-publicized lawsuits and settlements. A homeowner in Texas was awarded \$32 million in a case where delays in repairing leaks caused extensive mold growth and health problems. Extensive mold claims in Texas resulted in a two-day conference in October 2001 for insurers and the legal community. Apartment residents in Delaware were awarded \$1 million for health problems attributed to mold growth from un-repaired leaks. A judge and other employees who worked in a California courthouse have filed claims for health problems from mold exposure. Insurers, builders, contractors, building owners and homeowners are wrestling with the causes, how to determine the extent of the problem, and what remedies to use to eliminate the mold and correct the building flaws.

Mold has always posed a threat to building structures and occupants. A combination of tighter house construction, new building designs and materials, and a booming housing market has created a greater potential for mold problems to surface. A flaw in the building envelope, poor siting or lack of attention to basic repairs can easily create situations where moisture enters or remains in a building and creates the perfect environment for mold to grow. Walls are now constructed with materials that provide far more nutrients for mold than plaster and solid lumber and that also slow the drying rate. This combination means that small water leaks, which were usually easy to fix and dry out, can now cause sustained mold growth. Flashing and building details, espe-

cially around roofs, windows and doors, are often causes of these leaks.

There are a myriad of causes for moisture problems and mold growth. In some housing, particularly high-rise multi-family, the most frequent cause may be plumbing leaks, which often go undetected or not repaired. For most single family houses and small apartment buildings, poorly managed rainwater is the chief culprit. Other major causes include roof leaks caused by ice dams in winter, moisture penetration or condensation in walls, damp basements, inadequate kitchen and bathroom venting and leaky ducts. Increased use of whirlpools and hot tubs, excessive use of humidifiers, unvented combustion heaters and fireplaces, and extra showers in homes all create more indoor moisture. Natural air flows or mechanical HVAC distribution systems can transfer moisture from one area to another, where it can become trapped and cause mold.

Failures or flaws in the methods used to install exterior barrier cladding, such as insulating foam systems (EIFS), can be the culprits in housing developments and commercial buildings. Failures began over a decade ago when EIFS were applied to frame walls rather than masonry walls.

Low Income Housing is often plagued by mold and poor indoor air quality (IAQ) problems. The high density of occupants, poor ventilation, smoking, inadequate maintenance, older buildings, structural conditions and limited funds to remedy basic problems, let alone the air quality, are all factors that make low-income housing more vulnerable. See the [Resource List](#) for specific details on low income housing.

### **Mold Types and Health Effects**

Molds are a type of fungi in the same kingdom as mushrooms and yeasts. Fungi are an essential component of the natural world, whose primary function is to break down sugars, starches, cellulose and lignin -- the basic building blocks of all plants and other organic materials. Most of the fungi we call molds cannot break down cellulose or lignin,

but get their nutrients from the starches and sugars in paper or wood. *Stachybotrys* and some *Fusarium* species of mold can, however, break down cellulose walls.

Molds absorb nutrients through chains of cells, called hyphae, which extend along the surface and into some host materials. Composite materials, such as oriented strand board (OSB) and particleboard, are more susceptible to structural damage because common molds can digest the adhesives, allowing the hyphae to penetrate all the way through them. Hyphae do not penetrate intact cell walls very well, so most molds are surface problems on solid lumber. If solid lumber is decomposing, a wood decaying fungi is present.

Molds reproduce by forming spores, which then disperse by air or water. Mold spores are everywhere. We bring them indoors on our clothing, shoes and bags and through open windows and air conditioning systems. With regular cleaning, proper ventilation and filters and no moisture problems, they do not normally pose a health risk indoors.

Molds need the right conditions to grow, typically a temperature between 40 and 100 degrees F. and 20 % moisture content in the surface they have invaded. Under warm, humid conditions they can quickly multiply and spread over wall surfaces and other building materials. They love the starches and sugars in gypsum board and wallpaper glues, but can also grow on cloth, carpet, leather and household dust. Many times mold growth is hidden behind wallpaper, paneling, dropped ceilings or household furnishings.

The spores, hyphal fragments and gases produced by molds can cause a variety of health effects for the occupants. Some people are more sensitive than others, but the current advice is that no one should live or work in an environment with uncontrolled and excessive mold growth.

The visible phase of mold is only the tip of the problem. A small, dark blotch on a wall

or ceiling can be a tiny sign of a large colony behind wallpaper or beneath the wall surface. All mold growth should be completely investigated and removed since even dried remnants may cause health problems for some people. Mold colonies can go dormant if a surface dries or gets cold, but will easily revive when favorable conditions return.



**Figure 1: Mold growing in closet as a result of condensation from room air.**

Opinions vary, but the most common types of household mold include: *Cladosporium*, *Penicillium*, *Alternaria*, *Aspergillus* and *Mucor*. Different types of buildings tend to have different mold species.

### **Health Risks of Exposure to Mold**

Molds can produce three types of health reactions, depending on the type, stage of growth and exposure. The reactions can be immunologic, toxic and infectious. The symptoms for these reactions can be similar, but all reactions should be thoroughly investigated to ensure proper treatment.

**Immunologic symptoms** from breathing mold include typical allergic reactions, such as sneezing, coughing, runny nose and itchy eyes. Touching the mold may cause itchy skin or a rash. Mold is also recognized as a prime suspect for causing or aggravating asthma conditions. Some medical theories suggest that infant exposure to mold and

dust mites may significantly increase the risk for developing asthma and other bronchial disorders.

Toxins produced by mold as they fend off other fungi and bacteria can produce immediate ***toxic reactions*** in people, including headaches, nausea, itchy eyes, lack of energy, and difficulty breathing. Moldy dust in grains or buildings is known to produce severe reactions with flu-like symptoms, resulting in either organic toxic dust syndrome or pulmonary hemosiderosis (hemorrhaging of the lung tissue.) The most toxic molds include various types of *Aspergillus*, *Fusarium* and *Stachybotrys*.

The death of a group of infants in Cleveland, OH in 1993 - 1994 was due to hemosiderosis, possibly caused by the mold *Stachybotrys chartarum* (black mold). Health authorities have not conclusively established mold as the sole cause for the deaths and there are conflicting views on how to interpret the original findings. New research studies are underway to assess if *Stachybotrys* could be the culprit.

The less common ***infectious*** result of mold exposure can be one of several types of fungal pneumonia, including aspergillosis and histoplasmosis. People with immune deficiencies are the most susceptible to these fungal infections.

While allergic reactions to mold exposure have been documented, the medical and research communities are just beginning to conduct systematic research on the toxic effects of exposure to indoor mold. Efforts are underway to establish how people are being exposed and the pathways for how mold enters the body. Some of the key research is being undertaken at the Harvard School of Public Health (Burgess, Rao) and the National Academy of Science. For a brief list of research on the health effects of mold, consult the Medical Findings section in the [Resource List](#).

## Diagnosing Mold Problems in a Residence

### Conduct a Visual Inspection

Mold is most often associated with bathrooms or basements and crawlspaces, but can occur in any part of the house. It may be growing in closets, cupboards or behind furniture for a long time before being detected. You may notice a moldy smell before you see any visible colonies. Small, dark patches along a baseboard or wallpaper seam may indicate a much larger problem behind the paper or wallboard. Stains on the ceiling or walls, peeling paint or bulges in the walls often indicate some type of leak has occurred.

Inspecting for mold should be part of a routine home or apartment check-up, particularly if you live in a humid climate, if there has been any type of leak, water damage or flooding, or if the basement gets damp. When purchasing a home, ask the home inspector to check for evidence of mold. Unfortunately, it is easy for sellers to disguise a problem with new paint and wall coverings.

When conducting an inspection, it's important to gauge the extent of the problem and determine whether it is a minor or possibly major outbreak. A common guideline is if the mold covers more than two square feet, it is considered a moderate or major problem and may require professional mold remediation procedures.

### Interview the Residents

If you have been called to a home or apartment to assess a possible problem or you are there for other routine maintenance or building work, it's important to question the residents about any health symptoms they may be experiencing and about any history of moisture problems and damage. If they describe any of the symptoms listed above or other undiagnosed health problems, recommend that they contact their doctor. Conduct a more thorough investigation or suggest that the resident contact someone with experience in building and moisture diagnostics if you suspect a problem.

If the residents describe any symptoms that are typical for carbon monoxide poisoning (sleepiness, lack of energy, respiratory problems) and the home has a combustion appliance, investigate or call a technician to check the heating unit. Look for unvented gas or kerosene appliances, blocked chimneys or other problems with the combustion appliances that may be releasing pollutants and moisture into the house. Question the occupants about their cooking habits, whether they use the oven for heating, if they use kitchen and bathroom fans, whether they have pets, and their water usage.

Some residents may be sensitive to other household pollutants that may cause symptoms similar to sensitivity to mold. Carpet glue, fiberboard cabinets, paints and even cleaning materials can trigger allergic or respiratory reactions in some people. If the residents have health concerns and you find no evidence of mold or heating system problems, consider getting the advice of a green building or environmental technician.

#### Follow Safety Procedures for Diagnosing Mold Problems

Wear a mask or respirator when entering any area with suspected mold, especially in confined spaces and areas where you know there is a major problem. To check out minor colonies, a N-95 mask is sufficient. For major problems or areas where you don't know the extent of the growth, you should use a rated respirator with a HEPA filter, safety goggles, gloves and protective clothing.

If mold is detected, do not attempt to remove it before sealing off the area and taking other recommended clean-up precautions. If you encounter an extensive colonization, have the occupants leave the area or even the building. Use a HEPA vacuum and appropriate containment bags to collect the contaminated materials as you remove building materials to verify the extent of damage.

#### **Safety Tips for Diagnosing Mold Problems**

- Do not touch mold or moldy items with bare hands.
- Do not get mold or mold spores in your eyes.
- Do not breathe in mold or mold spores.
- Consider using Personal Protective Equipment (PPE) when disturbing mold. The minimum PPE is an N-95 respirator, gloves, and eye protection.

#### Call In a Professional – Comprehensive Moisture Diagnosis

A basic inspection is sometimes enough to determine what is causing a moisture and mold problem. In some cases, the causes and dynamics of the building envelope and HVAC systems make it difficult to assess the exact roots of the problem.

If a home has an ongoing mold and moisture problem that can't be resolved with a visual inspection and simple remedies, or if there appear to be multiple sources of moisture that make it difficult to determine what to do, then you may want to consider having a professional conduct a moisture audit. For contractors or builders who are trying to solve a homeowner's problem, this can help prevent callbacks and wasted effort. For homeowners, a moisture audit can help to establish what work needs to be done before engaging a contractor. Some examples of "Moisture Audits", including one from Environmental Health Watch, are on the [Resource List](#) under the Moisture Control section.

#### Mold Testing - When Is It Needed?

If there has been a single leak or other known moisture problem, you should be able to determine the extent of problem without expensive mold testing. You may have to remove a section of wall, ceiling or floor to check for mold. A moisture meter, which can be purchased for as little as \$80, is a good tool for determining the moisture levels in

walls or ceilings where you suspect a problem. Hygrometers, which measure relative humidity, can also be used to pinpoint areas of high relative humidity where mold colonies could be flourishing. (See page 10 for discussion on Relative Humidity.)

Collecting samples and testing for mold spores is a complicated and expensive procedure, which sometimes may not detect any viable spores. It is usually only recommended if there are health problems or insurance claims that need to be documented or to determine the effectiveness of extensive remediation. Mold sampling may need to be performed by a qualified technician, certified by the American Industrial Hygiene Association (AIHA), to be valid for insurance purposes. Test results must be analyzed at a laboratory accredited under AIHA's Environmental Microbiology Laboratory Accreditation Program (EMLAP).

In most cases, you should not waste valuable money on trying to test for mold spores. If you can see mold and moisture damage, use your resources or your clients' to clean up the mold and fix the building flaws, not on testing.

### Causes and Remedies for Mold Growth

One hallmark of the Affordable Comfort community and home performance industry is the principle of approaching any problem or feature in a home as part of an interactive "whole house system." Sometimes you can identify a single cause, such as a plumbing leak, for a mold problem. Other times it will take extensive detective work before all the contributing factors can be confirmed.

While new building envelope features and HVAC systems have helped make homes more comfortable and energy efficient, they also have made it more difficult to diagnose the dynamics that may be causing excess moisture. Consider consulting with a home performance contractor or professional moisture auditor if you encounter complicated or interactive moisture and mold problems.

**Caution:** If you are working in a home with any type of combustion heating, assess how your remedies, particularly sealing moisture paths and ducts, will affect the air supply and pressures for the heater. You could cause dangerous back drafting or unexpected changes in the building's airflow. If you are not experienced in heating system and whole house dynamics, bring in a qualified home performance contractor to advise you.

Before cleaning and repairing damage from mold colonies, find out what has caused the moisture problem and mold growth. All homes have some level of moisture, generated by household activities and by the natural transfer of air as it moves in and out of the house. Foundation walls and slabs will also absorb moisture from the surrounding soil. The potential for mold growth arises when moisture is absorbed or diffused into a wood or cellulose material faster than it can be removed.

The factors that lead to excess moisture in a particular spot can be a single event or an ongoing process, depending on the climate, time of year and combination of building components. In solving and preventing moisture problems, the core strategies will usually involve one or more of three factors:

- keeping bulk moisture out of the home
- preventing high humidity and cool surfaces in the home, and
- incorporating designs and materials that will adapt to sporadic wetting.

These are some common causes and suggested remedies for moisture damage and mold growth in homes. Consult the [Resource List](#) for more comprehensive examples, solutions and design practices.

Plumbing leaks can be a frequent cause of moisture damage. It's important to regularly inspect all fixtures and pipes for minor drips that could lead to more extensive damage. Unfortunately, many plumbing runs are hidden and hard to inspect. Leaks or overflows in second floor bathrooms and laundries can be difficult to trace and fix.

**Suggested Remedies:** Check for and repair all plumbing leaks, however small, immediately. Provide visible and accessible shut-off valves for all appliances that use water. Use reinforced hoses on the clothes washer. Install flash pans and drains under clothes washers, water heaters and second floor showers.

When building or remodeling a bathroom, kitchen or laundry, use high quality materials and qualified plumbers. Install cement board, or fiberglass-covered gypsum board, not regular paper-covered gypsum (regardless of whether it's white, blue or green), behind all showers, tubs and tilework. Provide an access panel for any hidden plumbing or design the layout so they are accessible for inspection and repair. Don't put plumbing in outside walls where it could freeze.

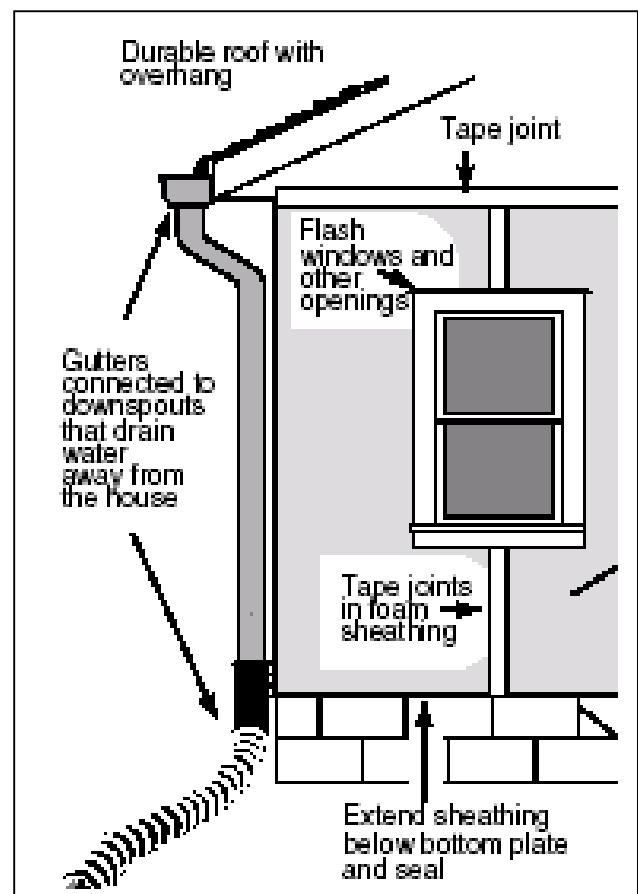
**Ice dams** are a major cause of roof failures in cold climates. Damage from roof leaks may show up as stains and mold growth on ceilings or adjacent walls. Ice dams are usually caused by inadequate insulation and air sealing between the house and roof, heat sources in the attic (chimneys, recessed light fixtures) and the combination of 30 degree F. weather, snow pack on the roof, sunshine and roof valleys. Roof valleys collect the melting ice from a very large area and concentrate it in one small spot, so even a tiny amount of melt provides enough water for ice dams.

Warm air that reaches the attic also will melt any snow on the roof and form ice dams at the eaves and gutters. The dams will block additional melted snow, forcing it between the shingles and roof decking and breaking down the roof materials. What appears to be adequate insulation may be fine until a really severe winter storm arrives. Some roofers may claim there is no permanent solution, but building performance professionals feel there is usually no reason ice dams should occur.

**Suggested Remedies:** Make sure wall and attic insulation completely fills each cavity. Seal around all openings (plumbing

vent pipes, wiring) that penetrate the wall and ceiling. Cap all wall chases that end in the attic, including stair walls. Check and seal all top plates. Use recessed light fixtures that are airtight and IC (Insulation Contact) rated or eliminate them all together in top floor ceilings. Use protective membranes under the roofing material (Ice and Water Shield) in valleys. You may need to insulate chimneys in accordance with the local fire code.

**Moisture problems in walls** can be more difficult to diagnose. Aside from mold growth, other common signs are peeling paint on inside or outside, stains, bulges, and moldy odors. Poor window or door flashing is a common cause of moisture in walls. Rain can penetrate any gap in the siding or wall surface, particularly when it's windy. If there's no way for this moisture to escape, it will be trapped and produce mold growth.



**Figure 2: Elements of Drainage Plane Designs**

Moisture can move through a wall from inside to outside or vice versa, depending on the wall construction, climate, air pressure, and weather conditions. In cold climates, warm, moist inside air can enter the wall cavity and condense on the colder wall surface if there is inadequate air sealing. In hot, humid climates and during summer in cold climates, the opposite can occur in summer as air pressure and heat drive outdoor moisture into the wall cavity, where it can condense on the air conditioned inner wall.

Pressure differences in the house, resulting from outdoor air pressure, from a forced air HVAC distribution system or exhaust fans, can transfer moisture from one location, such as a damp basement, to an adjacent or even remote wall cavity. Poorly sealed ducts can pick up moisture from the basement or attic and transfer it into walls and ceilings. Other flaws in the distribution system, such as poorly designed air returns (or none at all), can allow moist air to pool in unlikely spots.

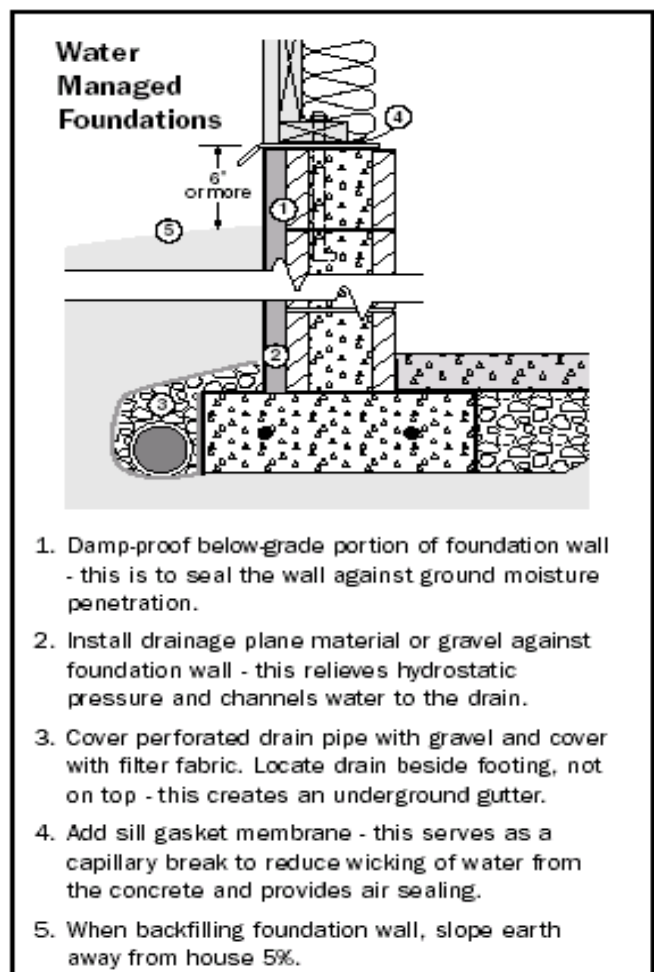
***Suggested Remedies:*** Check and repair all window and door flashings. You may need to remove the windows and install pan flashings. Repair flashings around the eaves, chimney and wall/roof intersections. Look for and seal gaps in the siding. Extend or provide a roof overhang.

Check pressure readings in the house. In warm, humid climates, balance the forced air distribution systems to avoid large negative indoor pressures; in cold climates avoid large positive pressures. In homes with central air conditioning, make sure the walls, building cavities and ducts are sealed to prevent outdoor air from being sucked into the distribution system.

Determine if the building design and construction is appropriate for the climate. Use the proper sequence of vapor barriers, insulation, air sealing, house wraps and drainage planes. The goal is to provide a way for outdoor moisture to escape if it enters the wall cavity, to prevent indoor moisture from entering the cavity, and to keep moisture from condensing on

cold surface. The remedy can be as simple as additional air sealing or insulation, but sometimes you may have to remove siding or interior wall surfaces to completely fix the problem.

Foundation walls and slabs are frequently the source of moisture problems throughout a house. Providing an effective foundation wall and proper drainage is often a low priority in a home's construction. Even with good design and drainage, a basement's walls and floor will naturally absorb moisture from the surrounding soil and release it into the home unless some type of capillary break (damp proofing, membrane or stones) is provided to keep moisture from entering the concrete. Venting the basement, which is often recommended, may actually bring more moisture in, depending on the climate and weather. One pathway that is often overlooked is the open core of the basement wall cement blocks.



**Figure 3: Water Managed Foundation**

Moisture from a basement or crawl space is easily drawn into the rest of the house through natural changes in air pressure and by HVAC equipment. Forced air heating will transfer more basement air and moisture into the rest of the house than hot water or electric baseboard heating. Damp basements are often the culprits behind hidden mold colonies in wall or floor cavities.

*Suggested Remedies:* The best strategy is to damp proof and even insulate the foundation wall on the outside when it's built. Provide proper drainage underneath and around the perimeter of the basement or crawlspace. Install a plastic (at least 6-mil) barrier and layer of stone pebbles under the concrete floor. Put sealant or a membrane between the footing and the wall. Fill and seal the cores the top courses in cement block walls and any openings that penetrate the wall.

Make sure the ground slopes away from the house (at least a 5% grade), that gutters are sealed and clear, and that the downspouting ends in a drainage system to take water away from the foundation. In areas with poor drainage, you may need to use an underground system that ends in a drainage pit or storm drain. (See W. Rose or L. Janesky articles in [Resource List](#).)

You can waterproof an existing foundation from the outside, but it will be expensive. Start by making sure all water is diverted away from the foundation. If the home has a dirt basement or crawlspace, install heavy plastic on the floor and partway (6 inches) up the wall. Seal the barrier along all edges. Cover the plastic with stones and even a thin layer of concrete to provide a walking surface. A semi-permeable layer of rigid insulation (polystyrene) on the inside wall may help to diffuse any moisture that percolates through. Crawlspace or basements in certain areas may require a radon type sub-membrane exhaust or a dehumidifier.

Close crawlspace and basement vents when the outdoor dew point is greater than 65 degrees F. In humid climates, don't ventilate the basement. Seal all joints or gaps in ducts that run through the basement. Depressurize the basement with a fan to reduce upward airflow. If you depressurize the basement, don't run a dehumidifier in the basement.

Running a dehumidifier in the basement will reduce the moisture levels during occasional damp periods or following a leak, but it is expensive to run continuously. If you need a dehumidifier, buy one with a built in humidistat that will control when it runs. Set it to keep the humidity level below at least 60% and keep it at that setting. If you need to run one for an extended period, purchase a large-capacity unit that has a higher energy factor (>2.75 pints/kWh) and moisture removal rating.

Often people run into problems when they convert a basement into living space. This is not a good idea if the basement is damp or has leaks. Damp basements also should not be used for storage, especially clothing, cardboard or paper.

These are some basic solutions for damp basements and crawlspaces. Each situation will probably require a variety of solutions. If a basement or crawlspace has extensive moisture problems or you're unsure about what will work, consult with a home performance contractor. If the basement is flooded, follow flood remediation procedures for drying it out. For more details on how to design or correct foundation walls problems, see the [Resource List](#).

The popularity of [cathedral ceilings](#) in new homes presents another challenge for moisture control. There is no intermediate ceiling to keep warm, moist air from rising to the cathedral peak. Recessed light fixtures, other openings and natural airflows in the room make it difficult to keep air from entering the ceiling cavity, where it can condense

on the cold roof decking. The commonly used ridge and soffit venting system may actually exacerbate the problem, not solve it. In severe cases, efforts to upgrade the insulation, seal all openings and reduce the sources of indoor moisture have not solved the problems with cathedral ceilings.

*Suggested Remedies:* Installing an effective air barrier is essential for cathedral ceilings. Eliminate recessed lighting or use Airtight Rated fixtures. Make sure the fixtures are sealed with gaskets. Follow appropriate designs for wall/ceiling connections and for foundation sealing. Some experts now suggest using foamed in place insulation and eliminating the roof venting altogether in cathedral ceilings, but don't try this without expert help. Depressurize the basement or crawlspace, which may help to counteract the natural upward airflow enough to reduce moisture migration.

Improperly sized air conditioners can be an unrecognized source of moisture problems, particularly in hot, humid climates. Oversized units will only run for short time periods before they reach the temperature setting, which doesn't allow enough time to remove the moisture from the air. This moisture can then condense on the cold interior walls and ceilings, often resulting in mold growth. Sometimes by insulating and weatherizing a home or reducing duct leakage, you may cause the air conditioner to operate more effectively, making it "oversized."

*Suggested Remedies:* Follow proper guidelines (Manual J) for sizing the air conditioning units. More tons are not better. Verify the insulation levels and tightness of the house before determining the AC sizing. For existing oversized systems, lowering the temperature setting may help somewhat, but replacing the unit may be the best option. If you're uncertain of the correct sizing, have a home performance contractor verify the requirements, particularly if the home seems muggy in the summer or you have upgraded your homes' insulation.

In humid climates, don't overcool the house. Lowering the flow-rate through the AC unit to something like 350 cfm per ton reduces the coil temperature, increases run-time and results in better humidity control. Another option is to manually adjust the thermostat to a higher temperature to allow the house to get warmer and then setting it back to a cooler temperature so the unit runs longer. Do not set the fan to run continuously, as this can significantly increase operating costs.

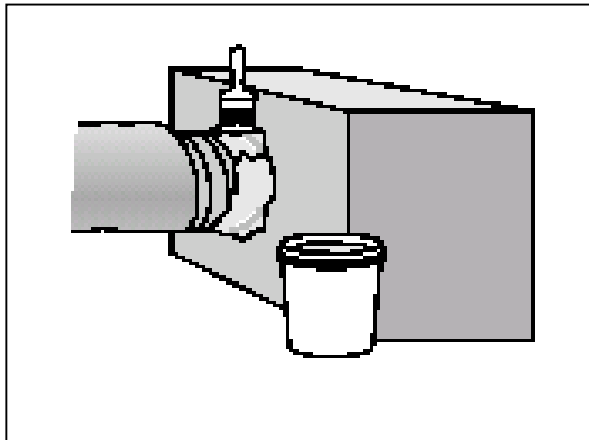
Make sure that air conditioner drain pans are properly sloped and the condensate lines drain to the outside or to a waste line. Check and clean the lines regularly.

Unvented (Vent-free) combustion appliances, such as gas fireplaces or kerosene heaters, produce not only heated air, but also a large amount of moisture. The moist, warm air will readily condense on windows and cold exterior walls and can be drawn into the walls and ceilings by natural convection and other forces. Unvented heaters also release unhealthy combustion gases, such as nitrogen oxides, and carbon monoxide if they are not operating properly. Opening a window near the heater can dilute the gases and moisture, but defeats the purpose of using the space heater.

*Suggested Remedies:* Don't use or buy an unvented heater or fireplace. If you have one, replace it with a totally sealed and vented unit. If the heater or fireplace is being used to compensate for what seems to be a chilly room, have a heating technician check the controls and distribution system on the main heating system. Also look for gaps in the insulation and air sealing that could be making the room drafty.

Leaky heating and air conditioning ducts can transfer warmer, moist air from one part of the building to colder surfaces where the moisture can condense on cooler surfaces. Besides wasting energy, this creates another hidden potential for mold growth. Leaky

ducts also contribute to air infiltration that brings dry outdoor air into the house in winter (or moist air in summer), making the indoor relative humidity uncomfortable. People then run humidifiers in winter to increase their comfort, thereby adding to the indoor moisture concentrations, or in summer run their air conditioners more.



**Figure 4: Seal duct connections with mastic**

Mold can also enter and grow on surfaces of the ducts and then be distributed through the house when air is blown through. Some types of duct tapes and sealants may be more susceptible. Regular duct cleaning will do little to eliminate the mold and may actually make it worse. Fiberglass ducts that have been invaded by mold are virtually impossible to clean and may have to be removed.

***Suggested Remedies:*** Inspect ducts or use a duct tester to check for leaks. Seal all joints and connections with mastic, not duct tape. Reconfigure duct runs so they don't go through unconditioned space. Re-design duct connections so they don't contribute to moisture problems. Sealing ducts will also help counteract pressure differences. Check all returns and test and balance the system.

Clean mold growths with recommended procedures. Remove liners inside the

ducts. Remove and replace seriously contaminated ducts. Change filters regularly.

Exterior insulated foam wall systems (EIFS) present a difficult challenge for moisture control. The EIFS design, which is composed of layers of sheathing (sometimes gypsum board), insulation, housewrap (air retarder) and stucco, is more frequently used in commercial buildings, but also was marketed as an energy efficient wall system for apartment complexes and some houses. Frequent failures and extensive moisture problems in EIFS-clad houses caused them to be banned in certain areas and resulted in numerous lawsuits.

The EIFS problems appear to result from designs that did not provide a drainage plane for trapped moisture to escape. In some cases the stucco was applied directly to the air retarder instead of leaving a gap and drainage plane. In others, poorly installed flashing around windows, doors and other connections allow moisture to get behind the insulation layer. Contrary to popular belief, an air retarder will absorb moisture under the right conditions, so this problem is not limited to EIFS walls. NAHB and members of the industry have developed a protocol for how EIFS walls should be constructed to avoid problems. For details, see the Resource List under "Model Quality Plan..."

***Suggested Remedies:*** Obtain and follow the NAHB protocol for EIFS. (See Resource List.) Check and seal flashings in existing walls. Walls without a drainage plane may have to be replaced. Carefully evaluate the use of EIFS walls, particularly in damp climates.

Adequate ventilation and humidity control is critical for preventing moisture and mold problems, as well as removing other air pollutants. Basic household activities generate a certain amount of moisture that must go somewhere.

Outdoor moisture can be drawn into the house depending on the weather. If other moisture control strategies have not achieved a suitable result, some type of whole house mechanical ventilation may be needed.

***Suggested Remedies:*** Vent the clothes dryer to the outside. Use kitchen and bathroom fans regularly. Select fans that are quiet so they will be used. Run the fan on the heating or cooling system to circulate air, but not if the outdoor humidity is high. Consider the use of a whole house ventilation system but it should include a heat recovery system in cold climates and some type of dehumidification in humid climates. It may not be cost effective to add a heat recovery ventilation system to an existing home. In warm climates, enthalpy recovery ventilators (ERVs) can be used to improve the dehumidification effects of air conditioning systems.

Thoroughly investigate and understand all moisture sources and HVAC components before designing and installing a ventilation system. Moisture and gases from combustion appliances can be drawn into the house if the ventilation system doesn't have an isolated air intake. All fuel-based heating systems, except sealed combustion systems, require a source of make-up air in order to prevent backdrafting of the furnace or boiler. Ensure that ALL combustion appliances vent completely to the outdoors!

This has covered some of the major causes of moisture and mold problems. For other suggestions and details on how to diagnose, prevent and correct building problems, consult the [Resource List](#).

### **Treating the Mold Colonization**

The following section outlines the key elements in treating mold colonizations. You can treat minor, irregular occurrences of mold with some basic materials and procedures. If you are handling more than a minor problem, you should obtain and follow more extensive guidelines or one of the comprehensive protocols that have been developed.



### ***Building Science Spotlight***

**Relative Humidity (RH)** is a measure of the amount of water vapor in the air relative to the maximum amount it can hold at a given temperature. Warm air can hold more moisture than cold. High indoor relative humidity can be a problem and cause moisture condensation on windows and wall surfaces, depending on the climate and weather conditions. When designing HVAC systems, factor in not only a comfortable temperature range, but also a recommended relative humidity range. In really cold outdoor conditions, the indoor relative humidity may need to be as low as 25 - 35%. In moderate, cool conditions, the recommended range for indoor relative humidity is 30 - 50%. In warm or hot conditions with no indoor air conditioning, the RH level could safely go as high as 70%. For homes with air conditioning in warm or hot conditions, the relative humidity should be no higher than 55 - 60%.

At the 30 - 50 % RH level, people experience fewer respiratory problems. In cold climates, indoor humidity levels may go below this because the cold, dry outdoor air is drawn into the house through gaps in the building envelope. In warm, humid climates, the negative pressures created by the air conditioning system will draw in the moist outdoor air. By proper air sealing, following the strategies in this Bulletin and other correct building system designs, it should be possible to keep humidity at healthy and comfortable levels without causing moisture and mold problems. Energy efficient windows or storm windows can also help prevent condensation problems in both cold and warm climates.

If someone has a health problem that requires a higher humidity, intermittent use of a humidifier in one room should be acceptable. Hygrometers can be used to track relative humidity and to signal if there is a problem in a specific area. It's important to keep monitoring the humidity level in the room so it doesn't go too high.

These procedures provide a valuable guide to all the safety and technical problems you may encounter. Major moisture damage and mold problems caused by flooding, roof failures or other extensive damage should be handled by qualified restoration contractors.

### **Basic Steps to Follow in Handling Mold Problems**

1. Get rid of the water and dry things quickly.
2. Identify:
  - Extent of contamination
  - Moisture dynamics in the building,
  - Containment and personal protection required.
3. Implement remediation:
  - Contain outbreak and protect residents and building.
  - Dispose of contaminated material.
  - Salvage things that can be saved.
  - Pass clearance - white glove clean and dry to target moisture content, meaning there is no visible mold, dust or debris when wiping a surface with a white glove or cloth, and the moisture content of wood is 15% or less and concrete is 3.5% or less.
4. Put things back together so it doesn't happen again.

### Basic Cleanup/Precautions

The goal of mold clean-up is to eliminate the mold and any spores that may have dispersed through the area. Wear a respirator with HEPA filter, gloves, goggles and protective clothing. Use disposable clothing if you will be exposed to a lot of mold. Always wear the respirator and use caution when opening cavities that may contain mold.

Seal the area from the rest of the living space and seal off any heating or cooling vents in the room. Consider cleaning or even removing ducts in areas with extensive outbreaks. Bag and remove any household items that

show mold growth or are close to a visible growth. Discard severely damaged items.

The standard recommendation for removing mold has been bleach and water, primarily because people thought it was necessary to kill the mold. However, inhaling a lot of bleach fumes can be dangerous and many people are sensitive to the fumes. If you clean and dry the area thoroughly and eliminate the moisture source, the mold should not resurface. Some professionals now use baking soda and vinegar for basic clean-up and only resort to strong detergents for serious cases. When using strong detergents or bleach, ventilate the area by opening two or more windows. Never combine bleach with an ammonia detergent. You'll produce a dangerous gas.

You can wash small mold patches on wall-board and wood without damaging the wall. If there is more extensive damage, the wall-board or wood surfaces will need to be replaced. Check for and clean off any mold behind the wall or ceiling.

Black stains on wallpaper or vinyl wall coatings can be signs of larger growths. Peel off the paper or coating and clean or remove the underlying surface. Check for other colonies throughout the room.

Wipe and vacuum all surfaces in the room to remove any spores. For safety, use a HEPA vacuum or one that exhausts to the outdoors. Seal and dispose of the bag and any rags when done. Remove and clean any area rugs, drapes, pillows, bedding and other furnishings where spores may have been deposited. Upholstered furniture, mattresses and other dense items usually can't be salvaged if they are soaked.

### Protocols for Moderate or Extensive Damage

For anything other than a minor mold problem, you will need to follow more rigorous procedures for securing and cleaning the colonization. Government and health agencies have established protocols for how mold remediation work should be done to ensure

the safety of the occupants and workers. Several good examples include those from California, New York, University of Minnesota, Canada Housing Mortgage Corporation (CMHC) and EPA's Guidelines for Schools and Commercial Buildings. To review these protocols, see the [Resource List](#).

For extensive damage, you will need to use a professional service with the proper equipment and training, which are usually firms that also deal in fire and flood restoration.

### **Avoid the Scam Artists**

With the recent surge of mold problems, the usual contingent of "entrepreneurs" has surfaced, looking to make money on a homeowner's distress. As with any home improvement, it's important to verify the claims and qualifications of anyone who is offering to solve the problem. These are some questionable practices that have shown up so far:

- Companies that recommend testing a home for mold as the first option. Mold testing is usually not needed, unless there are legal or health concerns that need to be verified.
- Contractors who are giving expensive estimates for minor damage that could be repaired by the homeowner or at a more reasonable cost. Get a quote for the same work without mentioning the mold problem for comparison.
- Companies that are offering novelty equipment or materials to supposedly eliminate or remove mold. No filter or trap can remove mold from a surface or the air.
- Lawyers who are offering to obtain settlements before the extent or cause of the problem has been determined. Concentrate on assessing the causes and remedying the problem before thinking about legal action.

### **Assessing the Insurance and Legal Fallout**

Homeowners and building occupants have won settlements against insurance companies, primarily when they have refused to cover the cost of repairing damage from

moisture problems. Most insurance firms are trying to limit their liability by rewriting or clarifying what types of moisture damage are covered. People with more expensive, comprehensive policies may have more recourse than homeowners with general policies. The trend seems to be for insurance companies to limit their liability to damage caused by normal storm damage or specific drainage problems and to exclude building designs or installation flaws.

If you think you have a valid claim for moisture damage, insist that the insurance adjuster come immediately. Do not delay in having a leak or other moisture damage repaired. Keep in mind that extra flood insurance is always required for any property in a flood-prone or risk area. For some insights on how the insurance industry is addressing mold claims, check out the insurance groups on the [Resource List](#).

A homeowner's other legal recourse is to sue the builders or contractors who built or worked on the house. This will involve determining if the builder or contractor used defective practices or materials. Several builders who had built major developments have gone bankrupt as a result of trying to remedy problems in multiple houses, leaving the homeowners with no options but to pay for the costs themselves.

### **Your Next Steps**

Several lessons and recommendations can be drawn from the mold suits:

- For home performance contractors, get all the training you can. Check your insurance coverage to make sure your "errors and omissions" coverage is sufficient. Be prepared for higher rates as the insurance industry figures out how to limit their exposure.
- For builders and contractors, learn everything you can about moisture control and home performance or "house as a system" building techniques. Conduct regular inspections to determine if your workers are following the guidelines. Consult with

other home performance professionals to assess if your homes are healthy and energy-efficient. Update your insurance coverage.

- For homeowners, pay more attention to critical building science and home performance credentials when selecting a builder or contractor. Find out how they will monitor and inspect the home's construction. Determine if they understand the whole house or "house as a system" concept. Check your home insurance to see what moisture damage is covered. If you experience flooding or any kind of moisture damage, make sure you or your contractors investigate and repair all damaged areas, not just visible surfaces.
- For insurers, learn more about how "high performance" energy efficient and healthy homes can be safer, more durable and less of a risk to insure. Consider constructive ways to work with the "home performance" industry to encourage homeowners and builders to adopt these practices.
- For lawyers, get all the facts before urging a client to sue. Pursuing unfounded claims doesn't help anyone. Take time to figure out what makes a healthy, durable house and how to help clients a potential deathtrap.

Diagnosing and resolving moisture and mold problems in houses can be an opportunity for contractors and building trades. With the necessary skills and training, you can build and renovate homes that resist moisture penetration and condensation, reduce call-backs for repairs and create a marketing advantage for your business. More importantly you will be providing a healthy, safe, durable, comfortable and energy-efficient home for your customers. For homeowners and landlords, by taking the time to see that your houses are built and renovated correctly, you will greatly reduce the risk of moisture problems and provide a safe, dura-

ble and energy efficient home for your family or tenants.

To find out how you can become part of the network of home performance professionals, contact Affordable Comfort, Inc. (see below.) If you're a homeowner or renter, contact ACI to find out to locate home performance contractors and other resources for making your home healthy.

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### Figures:

Figure 1: *Mold Remediation Schools & Commercial Buildings*, EPA (Terry Brennan)

Figure 2: *Wall Insulation: Provide Moisture Control*, DOE Fact Sheet (Southface Inst.)

Figure 3: *Insulating Foundations and Floors*, Southface Inst.

Figure 4: Southface Institute

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