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OREGON DEPT OF HUMAN SERVICES
HEALTH SERVICES
ENVIRONMENTAL SERVICES AND CONSULTATIONS
ENVIRONMENTAL TOXICOLOGY PROGRAM

Fact Sheet: Household Mold

ABOUT HOUSEHOLD MOLD AND MILDEWS

Mold and mildew are simple, microscopic organisms that can grow virtually anywhere if they have adequate moisture, nutrients and appropriate temperatures. Depending on the particular mold or mildew, growing colonies can be almost any color from white to black. Most household molds and mildews are black, grey, or charcoal colored. Spores of dozens of kinds of mold and mildew are present at all times in indoor and outdoor air. These spores can settle, germinate and grow wherever good growth conditions are found. They can grow on soil, plants, dead plant materials, foods, fabrics, paper, wood and many other materials. Most molds are not harmful. In fact, molds have important roles in the environment and in living systems. In soil, molds play a crucial part in decomposition of organic matter and in making nutrients available to plants.

Molds and mildews can be very destructive to materials on which they grow, and are usually unwelcome and unhelpful in homes. They cause staining, decomposition (rotting of materials) and objectionable, musty odors. Where colonies are extensive, they can also produce enough spores, and by-products to be harmful to health. Many of the by-products of mold and mildew are irritating to skin, eyes and respiratory tracts. Some molds produce true allergic sensitization and allergic reactions in susceptible people. Some molds produce toxic by-products that could be harmful to skin, and poisonous if ingested or inhaled in quantity.

SHOULD I BE CONCERNED IF I HAVE MOLD OR MILDEW IN MY HOME?

Yes. Mold and mildews are harmful at least to the materials on which they grow, and they usually produce objectionable odors, stains and discolorations. If mold conditions are allowed to exist for long in a wood structure, the wood can quickly become weak and rotten. Fabrics and paper can be seriously damaged or destroyed in days by damp, moldy conditions. If molds grow extensively, they may produce enough airborne irritants to cause coughing and cold-like symptoms. Allergic persons may react to very small amounts of mold.

WHAT CONDITIONS PRODUCE MOLD AND MILDEW IN HOMES?

Mold needs to have moisture on which to grow. In most cases, household mold is due to moisture problems. Mold also needs food and nutrients. Most materials found in homes will support the growth of mold and mildew if they become damp.

WHAT ARE SOME CONDITIONS THAT CAUSE OR AGGRAVATE MOLD?

Flooding, leaking water pipes or fixtures, backed-up or faulty drain plumbing, leaky roofs, use of humidifiers, extensive use of hot water indoors (laundering, cooking, bathing) without adequate exhaust venting for steam, damp basements or crawlspaces, houseplant water or aquarium leakage, indoor clothes drying, and unvented combustion appliances are all important sources of indoor moisture, and can encourage mold growth. Heavy condensation ("sweating") of windows, exterior walls or other cold objects indicates excessive moisture and inadequate venting.

SHOULD I TEST FOR MOLD OR HAVE MOLD SAMPLES FROM MY HOME TESTED?

Generally it is not necessary or helpful to test molds found in homes. Usually damp areas in homes will have a large number of molds growing together. Even though many molds produce toxic or potentially toxic substances, merely finding such a mold in a home does not mean that the mold poses a serious or extreme hazard to people in the home. There is very little known about the health significance of most household molds. If one has a specific mold allergy and needs to know if that particular mold is present, then testing may be helpful. General tests to determine total numbers of molds or spores in air samples may be useful in determining if there is a significant but unidentified indoor source of mold. There are private testing firms that offer such evaluations commercially. County and state agencies in Oregon do not have resources for inspecting private homes or testing them for mold.

WHAT SHOUD I DO IF I HAVE MOLDY CONDITIONS IN MY HOME?

Often rooms, closets or other spaces that are inadequately ventilated and/or heated, or articles stored in such areas will develop mold problems. The most important thing to do is to determine where the excessive moisture is coming from, and correct that problem. Molds cannot grow on dry materials even if all other conditions are ideal for mold growth. Conversely, mold and mildew cannot be controlled where moist materials exist. Growing colonies of mold can be killed by swabbing or spraying with a strong solution (11/2 cup per gallon of water) of household bleach. However, if the material remains moist, the mold will grow back very quickly. Once the material is dried and the mold has been killed, loose mold and damaged material should be removed with standard household cleaning materials. Washing with soap and water is frequently sufficient. Often repair of surfaces and refinishing is required. Damaged paper or fabrics such as carpets, rugs, drapes, stuffed furniture, bedding, and clothing may not be salvageable at all. Damp sheetrock and loose or spongy floor covering may indicate that the interior of a wall or floor is wet or moist. This could indicate serious internal structural problems.

HOW CAN MOLD BE SAFELY REMOVED?

When removing mold or handling moldy materials, it is wise to avoid direct skin contact with the mold. Impervious gloves, long pants and long sleeves should be worn. It is best to handle moldy materials when they are damp. Dry materials release many more spores and small particles into the air. If the materials are dusty, it is advisable to wear a fabric or paper dust mask over the nose to filter out dust particles. Make sure the area where you are working is well ventilated. Moldy materials should be tied tightly in plastic bags and placed in the garbage before they dry out.

WHAT SHOULD I DO IF SOMEONE IN MY FAMILY HAS AN ILLNESS THOUGHT TO BE CAUSED BY MOLD?

If you believe that you or anyone in your household is suffering from mold-related illness, it is important to seek medical attention. A physician can confirm irritant symptoms, can diagnose infection or determine if symptoms are indicative of an allergy. Many of the symptoms caused by mold irritants and by mold allergies can also be caused by other agents commonly found in homes.

IS IT LIKELY THAT MOLD IN MY HOME IS LIFE-THREATENING?

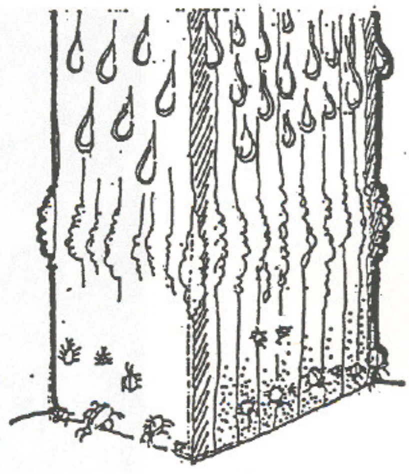
No. Even though there are some molds that could produce life-threatening illness under the right growth and exposure conditions, serious mold-related illnesses caused by household mold exposure are very rare. Toxigenic molds such as Stachybotrys, Aspergillis, Penecillium and others are commonly found in homes, but rarely cause severe or life-threatening illness.

WHO CAN I CALL FOR ADVICE AND ASSISTANCE?

If you are ill, contact your health care provider. For general information and advice about household mold, you can call your county health department. If you are interested in commercial inspection or testing in your home, you can contact firms listed under “Environmental Services”, “Laboratories-Analytical” and “Industrial Hygiene” in your local telephone business listings.

Technical contact person: Kenneth Kauffman
kenneth.w.kauffman@state.or.us
Telephone: 971-673-0435; Fax: 941-673-0457

Moulds in the Home



Many types of bacteria have been found in indoor air, sometimes in high concentrations. Most of these are species normally associated with skin and nasal surfaces and do not contribute to disease or otherwise affect indoor air quality when found in normal concentrations.

Generally the range of fungi in normal indoor air is identical to that found outdoors. If fungi start to grow indoors to the point they fruit and give off spores, it will affect human health, as there is consensus that fungi should not be allowed to grow in buildings.

High concentrations of bacteria and fungi are normally a sign of poor ventilation. In the last five years fungi have been identified as the most important biological aerosols that affect health in indoor air. There is no single mould that is a concern; a group of "indoor moulds" have been noted in buildings in several parts of the world.

Optimum conditions for the development of moulds can develop many ways. It is easy to understand that catastrophic events such as floods are generally followed by mould growth, but we don't realize that building methods or management practices can also contribute to mould growth. Fungal growth on a building material increases the chances of exposure to a single species of mould, its allergens and toxins and this, in turn will affect the health of occupants.

The whole area of fungi inside buildings is a new area for research. Up to now, most studies have generally looked at the relationship of moulds and dampness to various respiratory and non-respiratory symptoms. However there have been some advances in our understanding of the harmful effects of unusual, but not necessarily extreme exposures to fungi. Toxins present in fungal spores have long been known to affect respiratory functions as inhaling fungal spores can trigger allergic responses. Some compounds have powerful even toxic effects on the immune system. In the extreme, some species are suspected to be carcinogens.

Fungi will grow on various building surfaces at various moisture levels. Monitoring of mould growth on inferior walls has shown there can be a succession of moulds on poorly insulated walls which become progressively wetter with condensation as winter advances. For example, water loving species will grow where materials are very wet. Drying a wet area will not eliminate all moulds, but will result in a succession of other species that survive in dryer conditions. Several recent studies have found that xerophillic ("dry loving") species that are able to grow at low moisture levels can form an appreciable percentage of the population.

Until recently, the thinking has been that moisture content (MC) and relative humidity (RH) are the determining factors for microbial growth that affect indoor air quality. However, microorganisms don't obtain the moisture they need from the atmosphere but from the moisture contained in the material on which they grow. The moisture in the material is absorbed from the atmosphere. In other words, the relative humidity of the air has only an indirect effect on fungal growth by affecting the moisture content of the solid surfaces.

Most materials always contain a certain amount of water held in place by chemical bonds. This moisture is not influenced by the RH, and is not available to microorganisms; rather, humidity determines the amount of "free" water present in the material. The free water is that which may be absorbed when condensation takes place and is the moisture that becomes available for microbial growth.

The relationship between air temperature and relative humidity is known, but walls or other surfaces in a building are often cooler than the air within the building. For example, in a still room with no air circulation the air temperature in the centre may be 20°C with the RH at 60%, but the wall temperature could be 15°C with a RH of 80% at the wall surface. As a result, over time moisture from the air will be absorbed by the wall surface and could create conditions that sustain microbial growth.

To determine if microbial growth is possible or not, it is necessary to know at what relative humidity the air is in equilibrium with a given moisture content in a material. For any material, this equilibrium relative humidity is referred to by scientists as its 'water activity' (a_w). Air and surface temperatures have a bearing on the moisture content and the a_w.

Because of different microscopic structures and varying affinity for moisture, different materials with the same a_w may have quite different actual moisture content. For example, at a_w 0.80 the moisture content of gypsum plaster is only about 0.7%, bricks 0.1 - 0.9% but wallpaper 11% and softwood around 17%.

Although fresh gypsum does not supply the nutrients for mould growth, dirt on the wall may contain enough inorganic and organic nutrients so that at a moisture content of 0.7% it could support as much microbial growth as wallpaper with a MC of 11.3%.

It is important to remember that there are many species of fungi, some of which are able to grow at low moisture levels. The condensation which happens when the temperature of a surface is at or below the dew point can allow mould spores to geminate and grow regardless of the ambient relative humidity, so that once they start growing, they keep going.

Infrared mapping and surface-sampling for moulds in homes has shown that where there was an uneven distribution of water in gypsum coated walls the pattern of mould growth varied with location, as well as time.

Recent building practices and occupancy habits have increased the risk of condensation because there is a greater temperature difference across the building envelope, and in fact thermal bridging may accentuate these conditions. This means that when moist air permeates a porous construction material which is at a temperature below the dew point, the resulting condensation within the material can act as a reservoir of water which will permit the mould growth to continue even when the moisture level and relative humidity drops have dried the surface so that in theory growth is prevented. A wet substrate can support growth until it's moisture content falls to a level at which growth is not possible.

This means that night setback of thermostats, or lowering the temperature for a few days when occupants leave for a winter vacation could allow the development of moulds that will persist for a long time after the residents return. This could be a major problem in electrically heated houses, where each room is on it's own thermostat, and owners have a tendency to zone the heating system, with "cool rooms" and warm areas (typically, it is the bedrooms that will be kept coolest, this ensuring optimum conditions for condensation and moulds).

Every microorganism has its own characteristic moisture and temperature requirements. Most moulds that are a concern in buildings have minimum temperature needs in the 5 - 10°C range and optima of 25 - 35°C, with limited or no growth above 40°C. This coincides with the temperature range of all our buildings.

Since growth of moulds that affect human health is avoidable, it is our duty to use building techniques and materials and to manage buildings in a way that prevents their growth.

Adapted from Humidity and Fungal Contaminants, a paper by Brian Flannigan (Dept. of Biological Sciences, Heriot-Watt University, Edinburgh) and David Miller (Plant Research Centre, Agriculture Canada) and presented at the Bugs, Mold & Rot II Conference.

Humidity Meters

Humidity is an important criterion for assessing indoor air quality and the effects of moisture on building materials and contents. Moisture is also major problem in all buildings. In winter buildings can be too dry, so humidifiers are used in some areas. At other times, you can have too high a humidity. The optimum humidity range is 40 to 60% but depending on the time of year, 30 to 70% will be acceptable.

To know if there are moisture problems in the home and what kind they may be, you have to know what the humidity level is. Homeowners with moisture related problems are often advised to check the relative humidity in their homes. A simple, inexpensive humidity sensor, which provides a reasonable measurement of humidity, is needed. However humidity is a difficult environmental condition to measure accurately.

Humidity is measured with a hygrometer. There are two types of meters: those that measure fundamental properties of air, and those that measure wet bulb temperatures and dew points, such as psychrometers and chilled mirror devices.

The simplest and not inexpensive hygrometer measures the effect that moisture has on a material, and are known as strain hygrometers. Variations in humidity cause the moisture content of materials to change resulting in expansion or contraction of materials (materials such as human hair, cellulose and synthetic fibres are used). The dimensional changes of the material are calibrated to provide humidity readings.

Strain hygrometers are inexpensive and are not greatly affected by the presence of airborne contaminants. However, they have a tendency to undergo deformation over time resulting in long-term drift of the readings.

Resistive hygrometers have sensors that use either salt-saturated filaments or metal grids embedded in a casing. The resistance of the probe varies with the amount of moisture. The voltage or current passing through the probe is a function of the

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ENERGY NOTE

Solving Indoor Moisture Problems

By David Brook, Extension Energy Agent

November1998

Many daily activities add moisture to the air: bathing, laundry, cooking, dishwashing and cleaning. Breathing alone contributes half the moisture added to indoor air in most homes.

Moisture from outside can also contributeto high indoor humidity levels. Common sources of outside moisture are damp crawl spaces or basements caused by poor drainage around the foundation. In some cases indoor moisture problems are the result of very low rates of outside air exchange.

Condensation of indoor humidity occurs when warmer indoor air comes in contact with cooler surfaces, such as single pane windows and uninsulated walls. The air is cooled down below it's dew point (100% relative humidity) and excess humidity becomes liquid.

Condensation leads to growth of mold and mildew. Allergies and other health problems may follow. Severe moisture problems lead to structural wood decay, commonly called "dry rot."

Solving indoor moisture problems is a three-step process: clean up mold and mildew, eliminate any outside moisture sources, and control moisture produced indoors.

During winter, keep indoor air at 30 to 50 percent relative humidity (RH). Check indoor RH levels with a low-cost indicator. RH indicators are included with many indoor-outdoor thermometers. Digital models, such as those sold at Radio Shack and other stores, can be useful to diagnose problems.

Clean Up Mold and Mildew

Mold spores are always present in the air. Mildew — a thin black or sometimes white growth produced by mold — requires a constant source of moisture, such as high relative humidity or condensation near a cold surface; organic matter, such as dirt on furniture, walls or clothing; and air. Cleaning up existing mold is the first step and will not prevent its reoccurance. You must correct source of excess moisture as well.

Woodwork and walls - Clean with a solution of 1 part household (chlorine) bleach to 4 parts water. Use rubber gloves, let stand for 10-15 minutes, rinse thoroughly and ventilate area to dry.

Rugs and carpets - Shampoo rugs and carpets. Ventilate room to dry. Hang rugs to dry in the sun, if possible. Check underside of rugs, carpets and pads. Use spray cleaner containing fungicide to get rid of mildew. Remove carpet from basement or other cement floors.

Upholstered furniture and mattresses - Take outdoors or garage and brush off mold. Then vacuum slowly to draw out more mold. If mildew remains, sponge lightly with detergent suds and wipe with clean, damp cloth. Useas little water on the fabric as possible. Dry using an electric heater, fan or, if possible, in the sun.

Clothing and fabric - Remove mildew spots by brushing off the surface outdoors to prevent scattering of mildew spores indoors. Air fabrics thoroughly, in the sun if possible. For machine washable garments, launder according to care label instructions and dry in the sun. If the stain remains, follow care label for using an all-fabric or chlorine bleach.

Keep Outside Moisture Out

✓ Clean gutters, downspouts and foundation drains so they don't back up. Be sure downspouts divert water 3 to 5 feet away from the foundation. Eliminate any standing water near the house.

✓ Eliminate dampness or standing water in crawl space or basement. Install 6 mil black plastic sheeting on the ground in crawl spaces. Overlap sheets about 1 foot. If downspouts empty into a pipe in the ground, make sure footing drains around the outside of the foundation aren't clogged. If standing water in a crawl space or basement persists, install a sump pump.

✔ Check for roof leaks in the attic. Look for water stains on sheathing, especially around chimneys and pipe penetrations. Trace stains up to the source of the leak and patch from the outside.

Control Indoor Moisture

✔ Vent clothes dryer outside. Check dryer vent hose for clogs and remove any lint. Don't line-dry clothes indoors. Hang laundry to dry outside, in the garage or on an outside porch.

✔ Exhaust humidity produced during bathing and cooking. Opening a window is probably not enough. Install and use exhaust fans in bathrooms and kitchens. Fans must be vented outside — not the attic.

✔ Reduce other sources of indoor moisture. Gas ranges and unvented kerosene heaters produce a lot of moisture, as well as other pollutants. Don't store firewood indoors. Cover aquariums.

Problems in Confined Areas

Sometimes moisture problems occur in only one or two rooms. Problems may be the result of local moisture sources, such as bathroom showers. Or they can be caused by cold surfaces, such as in closets or furniture against outside walls.

If moisture problems occur only in bathrooms, the best solution may be to install and use an exhaust fan. If you already have a fan, be sure it's really moving air. The fan should be able to hold a square of toilet tissue up to the grille while operating. Check the ductwork in the attic for blockages. Be sure the fan vents directly to the outside, not the attic.

If you're installing a new fan, buy one rated to move at least 80 cubic feet of air per minute (cfm)and with a noise rating of 2.5 sones or less, which may motivate more frequent use. Controlthe fan to a twist-timer switch rather than the light switch. Tell household members to operate the fan for an extra 20 to 40 minutes after bathing to vent excess moisture.

Lowering the temperature to save energy in parts of a house may cause condensation and mold problems in these areas. Be sure the relative humidity in all areas of the house is below 50% RH. Maintaining slightly warmer temperatures may solve these problems.

Closets and confined areas of some homes may have chronic mildew problems. Warming up the surfaces where mildew forms may solve the problem. Try opening the closet door to allow better circulation of warm air or leaving a 40 or 60 watt light bulb burning. Air-drying chemicals may help but only in confined areas.

If Problems Persist

In some cases, no matter what you do, you can't prevent high indoor humidity. Homes with low air exchange rates may not remove the normal moisture produced by household members. This can be the case when many people live in a small house.

Some homes have low air exchange rates. Houses built on cement slab foundations tend to have lower air exchange rates than crawl space or basement homes. And homes with electric baseboard heat tend to have lower rates than homes with ductwork. Apartments and townhouses typically have lower air exchange rates than single-family homes. That's because single-family homes have more outside walls where air exchange occurs.

One option to control humidity is a dehumidifier, particularly for homes in coastal areas. Install the dehumidifier in an area open to most of the rest of the house, such as hallway. Install the unit in a basement to minimize musty smells there. Select models that allow a permanent drain connection so you don't have to remember to empty the tank. A dehumidifier rated to remove 24 pints of water per day adds only $6 to $10 per month to your electric bill during the winter.

Another solution may be to install a mechanical ventilation system to bring in outside air. Such systems cost as little as $250 and are installed like a bath fan. Annual electricity costs are about $35.

Illustration courtesy of U.S. Department of Energy.

IAQ Tools for Schools Kit - IAQ Coordinator's Guide

Appendix H - Mold and Moisture

Molds can be found almost anywhere; they can grow on virtually any substance, providing moisture is present. There are molds that can grow on and within wood, paper, carpet and foods. When excessive moisture accumulates in buildings or on building materials, mold growth will often occur, particularly if the moisture problem remains undiscovered or unaddressed. There is no practical way to eliminate all mold and mold spores in the indoor environment; the way to control indoor mold growth is to control moisture.
Molds produce tiny spores to reproduce. Mold spores waft through the indoor and outdoor air continually. When mold spores land on a damp spot indoors, they may begin growing and digesting whatever they are growing on in order to survive.
There are many different kinds of mold. Molds can produce allergens, toxins, and/or irritants. Molds can cause discoloration and odor problems, deteriorate building materials, and lead to health problems such as asthma episodes and allergic reactions in susceptible individuals.
The key to mold control is moisture control. If mold is a problem, clean up the mold and get rid of excess water or moisture. Maintaining the relative humidity between 30%-60% will help control mold.

Condensation, Relative Humidity, and Vapor Pressure

Mold growth does not require the presence of standing water, leaks, or floods; mold can grow when the relative humidity of the air is high. Mold can also grow in damp areas such as unvented bathrooms and kitchens, crawl spaces, utility tunnels, gym areas and locker rooms, wet foundations, leaky roof areas, and damp basements.
Relative humidity and the factors that govern it are often misunderstood. This section

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The ability of air to hold water vapor decreases as the air temperature falls. If a unit of air contains half of the water vapor it can hold, it is said to be at least 50% relative humidity (RH). The RH increases as the air cools and approaches saturation. When air contains all of the water vapor it can hold, it is at least 100% RH, and the water vapor condenses, changing from a gas to a liquid. The temperature at which condensation occurs is the "dew point."

It is possible to reach 100% RH without changing the air temperature, by increasing the amount of water vapor in the air (the "absolute humidity" or "vapor pressure"). It is also possible to reach 100% RH without changing the amount of water vapor in the air, by lowering the air temperature to the "dew point."

The highest RH in a room is always next to the coldest surface. This is referred to as the "first condensing surface," as it will be the location where condensation happens first, if the relative humidity of the air next to the surface reaches 100%. It is important to understand this when trying to understand why mold is growing on one patch of wall or only along the wall-ceiling joint. It is likely that the surface of the wall is cooler than the room air because there is a gap in the insulation or because the wind is blowing through cracks in the exterior of the building.

Mold and Health Effects

Molds are a major source of indoor allergens. Molds can also trigger asthma. Even when dead or unable to grow, mold can cause health effects such as allergic reactions. The types and severity of health effects associated with exposure to mold depend, in part, on the type of mold present, and the extent of the occupants' exposure and existing sensitivities or allergies. Prompt and effective remediation of moisture problems is essential to minimize potential mold exposures and their potential health effects.

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Taking Steps to Reduce Moisture and Mold

Moisture control is the key to mold control. Respond to water damage within 24-48 hours to prevent mold growth.
Mold growth can be reduced if relative humidity near surfaces can be maintained below the dew point. This can be done by: 1) reducing the moisture content (vapor pressure) of the air, 2) increasing air movement at the surface, or 3) increasing the air temperature (either the general space temperature or the temperature at building surfaces).
Either vapor pressure or surface temperature can be the dominant factor in a mold problem. A vapor pressure dominated mold problem may not respond well to increasing temperatures, whereas a surface temperature dominated mold problem may not respond very well to increasing ventilation. Understanding which factor dominates will help in selecting an effective control strategy.
If the relative humidity near the middle of a room is fairly high (e.g., 50% at 70° F), mold or mildew problems in the room are likely to be vapor pressure dominated. If the relative humidity near the middle of a room is fairly low (e.g. 30% at 70° F), mold or mildew problems in the room are likely to be surface temperature dominated.
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Vapor Pressure Dominated Mold Growth

Vapor pressure dominated mold growth can be reduced by using one or more of the following strategies:

- use source control (e.g., direct venting of moisture-generating activities such as showers to the exterior)
- dilute moisture-laden indoor air with outdoor air at a lower absolute humidity
- dehumidify the indoor air

Note that dilution is only useful as a control strategy during heating periods, when cold outdoor air contains little total moisture. During cooling periods, outdoor air often contains as much moisture as indoor air.
Consider an old, leaky, poorly insulated school in Maine that has mold and mildew in the coldest corners of one classroom. The indoor relative humidity is low (30%). It is winter and cold air cannot hold much water vapor. Therefore, outdoor air entering through leaks in the building lowers the airborne moisture levels indoors. This is an example of a surface temperature dominated mold problem. In this building, increasing the outdoor air ventilation rate is probably not an effective way to control interior mold and mildew. A better strategy would be to increase surface temperatures by insulating the exterior walls, thereby reducing relative humidity in the corners.
Consider a school locker room that has mold on the ceiling. The locker room exhaust fan is broken, and the relative humidity in the room is 60% at 70° F. This is an example of a vapor pressure dominated mold problem. In this case, increasing the surface temperature is probably not an effective way to correct the mold problem. A better strategy is to repair or replace the exhaust fan.
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Surface Temperature Dominated Mold Growth

Surface temperature dominated mold growth can be reduced by increasing the surface temperature using one or more of the following approaches:

- raise the temperature of the air near room surfaces
- raise the thermostat setting
- improve air circulation so that supply air is more effective at heating the room surfaces
- decrease the heat loss from room surfaces

California Department of Health Services

Indoor Air Quality *Info Sheet*

Mold in My Home: What Do I Do?

March 1998

This fact sheet provides information to people who have experienced water damage to their home and presents the health concerns related to mold exposure. It also provides general guidelines on mold detection, cleanup & removal of mold contaminated materials.

ABOUT MOLD

What is it? Molds are simple, microscopic organisms, found virtually everywhere, indoors and outdoors. Molds can be found on plants, foods, dry leaves, and other organic material. Molds are needed for breaking down dead material. Mold spores are very tiny and lightweight, and this allows them to travel through the air. Mold growths can often be seen in the form of discoloration, ranging from white to orange and from green to brown and black. When molds are present in large quantities, they can cause allergic symptoms similar to those caused by plant pollen.

Should I be concerned about mold in my home? Yes, if the contamination is extensive. When airborne mold spores are present in large numbers, they can cause allergic reactions, asthma episodes, infections, and other respiratory problems for people. Exposure to high spore levels can cause the development of an allergy to the mold. Mold can also cause structural damage to your home. Similarly, when wood goes through a period of wetting, then drying, it can eventually warp and cause walls to crack or become structurally weak.

What does mold need to grow? For mold to grow, it needs:

- food sources - such as leaves, wood, paper, or dirt
- a source of moisture
- a place to grow

Can mold become a problem in my home? Yes, if there is moisture available to allow mold to thrive and multiply. The following are sources of indoor moisture that may cause problems:

- flooding
- backed-up sewers
- leaky roofs
- humidifiers
- mud or ice dams
- damp basement or crawl spaces

- constant plumbing leaks
- house plants -- watering can generate large amounts of moisture
- steam from cooking
- shower/bath steam and leaks
- wet clothes on indoor drying lines
- clothes dryers vented indoors
- combustion appliances (e.g. stoves) not exhausted to the outdoors

CAUTION: If you see moisture condensation on the windows or walls, it is also possible that you have a combustion problem in your home. It is important to have sufficient fresh air available for fuel burning appliances, such as the furnace, water heater, stove/range, clothes dryer, as well as a fireplace. A shortage of air for these appliances can result in *back drafting* of dangerous gases such as **carbon monoxide** into the home. To prevent back drafting of air, you need either open vents or a ventilation system that brings fresh air into the home to replace air that is exhausted out. *Have your local utility company or a professional heating contractor inspect your fuel-burning appliances annually.*

HEALTH EFFECTS

How am I exposed to indoor molds? Mold is found everywhere, indoors and outdoors. It is common to find mold spores in the air of homes and growing on damp surfaces. Much of the mold found indoors comes from outdoor sources. Therefore, everyone is exposed to some mold on a daily basis without evident harm. Mold spores primarily cause health problems when they enter the air and are inhaled in large number. People can also be exposed to mold through skin contact and eating.

How much mold can make me sick? It depends. For some people, a relatively small number of mold spores can cause health problems. For other people, it may take many more. The basic rule is, if you can see or smell it, take steps to eliminate the excess moisture, and to cleanup and remove the mold.

Who is at greater risk when exposed to mold? Exposure to mold is not healthy for anyone inside buildings. It is important to quickly identify and correct any moisture sources before health problems develop. The following individuals appear to be at higher risk for adverse health effects of molds:

- Infants and children
- elderly
- immune compromised patients (people with HIV infection, cancer chemotherapy, liver disease, etc.)
- pregnant women
- individuals with existing respiratory conditions, such as allergies, multiple chemical sensitivity, and asthma.

People with these special concerns should consult a physician if they are having health problems.

What symptoms are common? Allergic reactions may be the most common health problem of mold exposure. Typical symptoms reported (alone or in combination) include:

- respiratory problems, such as wheezing, and difficulty in breathing
- nasal and sinus congestion
- eyes-burning, watery, reddened, blurry vision, light sensitivity
- dry, hacking cough
- sore throat
- nose and throat irritation
- shortness of breath
- skin irritation
- central nervous system problems (constant headaches, memory problems, and mood changes)
- aches and pains
- possible fever

Are some molds more hazardous than others? Allergic persons vary in their sensitivities to mold, both as to amount and type needed to cause reactions. In addition, certain types of molds can produce toxins, called *mycotoxins*, that the mold uses to inhibit or prevent the growth of other organisms. Mycotoxins are found in both living and dead mold spores. **Materials permeated with mold need to be removed, even after they are disinfected with cleaning solutions.** Allergic and toxic effects can remain in dead spores. Exposure to mycotoxins may present a greater hazard than that of allergenic or irritative molds. Mycotoxins have been found in homes, agricultural settings, food, and office buildings.

DETECTION OF MOLD

How can I tell if I have mold in my house? If you can see mold, or if there is an earthy or musty odor, you can assume you have a mold problem. Allergic individuals may experience the symptoms listed above. Look for previous water damage. Visible mold growth is found underneath materials where water has damaged surfaces, or behind walls. Look for discoloration and leaching from plaster.

Should I test my home for mold? The California Department of Health Services does not recommend testing as the first step to determine if you have a mold problem. Reliable sampling for mold can be expensive, and requires equipment not available to the general public. Residents of individual private homes must pay a contractor to carry out such sampling, as it is not usually done by public health agencies. Mold cleanup is usually considered one of the housekeeping tasks of the private citizen, along with roof and plumbing repairs, sweeping and house cleaning.

Another problem is that there are few available standards for judging what **is** an acceptable quantity of mold. In all locations, there is some outdoor levels of molds. If sampling is carried out, an outdoor air sample needs to be taken at the same time as the sample indoors, to provide a baseline measurement. Since the susceptibility of individuals varies so greatly, sampling is at best a general guide.

The simplest approach is: if you can see or smell mold, you have a problem. Once you know the problem exists, follow the procedure given next.

Unless the source of moisture is removed and the contaminated area is cleaned and disinfected, mold growth is likely to reoccur.

GENERAL CLEAN-UP PROCEDURES

- Identify and correct the moisture source
- Clean, disinfect, and dry the moldy area
- Bag and dispose any material that has moldy residues, such as rags, paper, leaves, or debris.

What can I save? What should I toss? Substances that are porous and can trap molds, such as paper, rags, wallboard, and rotten wood should be decontaminated and thrown out. Harder materials such as glass, plastic, or metal can be kept after they are cleaned and disinfected.

Ultimately, it is critical to remove the source of moisture first, before beginning remedial action, since mold growth will return shortly if an effected area becomes re-wetted.

Removal of Moldy Materials After fixing the moisture source and removing excess moisture, the cleanup can begin:

- Wear gloves when handling moldy materials
- Remove porous materials (examples: ceiling tiles, sheetrock, carpeting, wood products)
- Carpeting can be a difficult problem -- drying does not remove the dead spores. If there is heavy mold, disposal of the carpet should be considered
- Bag and discard the moldy substances
- Allow the area to dry 2 or 3 days
- If flooded, remove all sheetrock to at least 12 inches above the high water mark. Visually inspect the wall interior and remove any other intrusive molds. (This step may have to be carried out by a licensed contractor).

CAUTION: Spores are easily released when moldy material is dried out.

Soap Cleanup

Before disinfecting contaminated areas, clean the areas to remove as much of the mold (and food it is growing on) as possible.

- Wear gloves when doing this cleanup
- Use a non-ammonia soap or detergent, or a commercial cleaner, in hot water, and scrub the entire area affected by the mold
- Use a stiff brush or cleaning pad on block walls or uneven surfaces
- Rinse clean with water. A wet/dry vacuum is handy for this.

Disinfect Surfaces

- Wear gloves when using disinfectants
- After thorough cleaning and rinsing, disinfect the area with a solution of 10% household bleach (e.g., 1½ cup bleach per gallon of water). Using bleach straight from the bottle will not be more effective
- **Never mix bleach with Ammonia - the fumes are toxic**
- For spraying exterior large areas, a garden hose and nozzle can be used
- When disinfecting a large structure, make sure the entire surface is wetted (floors, joists, and posts)

- Avoid excessive amounts of runoff or standing bleach
- Let disinfecting areas dry naturally overnight -- this extended time is important to kill all the mold.

CAUTION: Bleach fumes can irritate the eyes, nose, and throat, and damage clothing and shoes. Make sure the working area is ventilated well.

Can cleaning up mold be hazardous to my health? Yes. Exposure to mold can occur during the cleaning stage. Mold counts are typically 10 to 1000 times higher than background levels during the cleaning of mold damaged materials. Take steps to protect your health during cleanup:

- When handling or cleaning moldy materials, consider using a mask or respirator to protect you from breathing airborne spores. Respirators can be purchased from hardware stores; select one for particle removal (sometimes referred to as a N95 or TC-21C particulate respirator). Respirators are not as effective removing bleach fumes, so minimize your exposure when using bleach or other disinfectants.
- Wear protective clothing that is easily cleaned or discarded
- Use rubber gloves
- Try cleaning a small test patch of mold first. If you feel that this adversely affected your health, you should consider paying a licensed contractor or professional to carry out the work
- Ask family members or bystanders to leave areas when being cleaned.
- Work over short time spans and rest in a fresh air location.
- Air your house out well during after the work

CAUTION: Never use a gasoline engine indoors (e.g. pressure washer, generator) -- you could expose yourself and your family to carbon monoxide.

Can Air Duct Systems become Contaminated with Mold? Yes. Air duct systems can become contaminated with mold. Duct systems can be constructed of bare sheet metal, sheet metal with an exterior fibrous glass insulation, sheet metal with an internal fibrous glass liner, or made entirely of fibrous glass. If your home's air duct system has had water damage, first identify the type of air duct construction that you have. Bare sheet metal systems, or sheet metal with exterior fibrous glass insulation, can be cleaned and disinfected.

If your system has sheet metal with an **internal** fibrous glass liner, or are made entirely of fibrous glass, the ductwork normally will need to be removed and discarded. Ductwork in difficult locations may have to be abandoned. If you have other questions, contact an air duct cleaning professional, or licensed contractor.

After I've cleaned everything as thoroughly as possible, can I still have mold odors? Yes. It is possible that odors may persist. Continue to dry out the area and search for any hidden areas of mold. If the area continues to smell musty, you may have to re-clean the area again (follow the cleaning steps given in this sheet). Continue to dry and ventilate the area. Don't replace flooring or begin rebuilding until the area has dried completely.

How can further damage to my home be prevented? Check regularly for the following:

- moisture condensation on windows

- cracking of plasterboard
- drywall tape loosening
- wood warping
- musty odor

If you see any of the above, seek out and take steps to eliminate the source of water penetration, as quickly as possible.

Can Ozone air cleaners help remove indoor mold, or reduce odor or pollution levels? Some air cleaners are designed to produce ozone. Ozone is a strong oxidizing agent used as a disinfectant in water and sometimes to eliminate odors. However, ozone is a known lung irritant. Symptoms associated with exposure include cough, chest pain, and eye, nose, and throat irritation. Ozone generators have been shown to generate indoor levels above the safe limit. Furthermore, it has been demonstrated that **ozone is not effective in controlling molds and fungi,** even at high concentrations far above safe health levels. Also, ozone may damage materials in the home. For these reasons, **the California Department of Health Services strongly recommends that you do not use an ozone air cleaner in any occupied residential space.** Refer to the CDHS IAQ Info Sheet: *Health Hazards of Ozone-generating Air Cleaning Devices* (January 1998).

USEFUL PUBLICATIONS

Biological Pollutants in Your Home, 1990. Available from local ALA or U.S. EPA's IAQINFO. *Concise booklet aimed at concerned or affected homeowner*

Mold, Moisture & Indoor Air Quality: A Guide to Designers, Builders, and Building Owners, 1994. Available from Building Science Corp. (978) 589-5100 or info@buildingscience.com.

Moisture, Mold and Mildew *in Building Air Quality (Appendix C),* 1991. Available from U.S. EPA's IAQINFO. *Illustrative and useful resource guide.*

Repairing Your Flooded Home. Available from American Red Cross and FEMA offices. *Excellent resource with details on technical & logistical issues.*

Clean-up Procedures for Mold in Houses. Available from Canada Mortgage & Housing Corp. 800-668-2642. *Effective, hands-on information for affected homeowner.*

NIOSH Warns of Hazards of Flood Cleanup Work. National Institute of Occupational Safety and Health (NIOSH) Update. *Aimed at flood emergency workers.* 800-356-4674.

Factsheet on Stachybotrys atra (chartarum). CDHS Environmental Health Investigations Branch, April 1997. *Summarizes information on S.A. and includes NYC recommendations for evaluating and remediating microbial contamination.*

REFERRALS TO OCCUPATIONAL & ENVIRONMENTAL CLINICS

Association of Occupational & Environmental Clinics. 202-347-4976; *http://gilligan.mc.duke.edu/oem/aoec.htm*

American College of Occupational & Environmental Medicine. 847-228-6850; *http://www.acoem.org.*

FOR FURTHER HELP OR INFORMATION:

Contact your County or City Department of Health or Environmental Health

American Red Cross Disaster Response Tel: 213-739-5200 or call local chapter

U.S. EPA's IAQ Information Clearinghouse (IAQ INFO) Tel: 800-438-4318 or 202-484-1307 Phone assistance (9 am to 5 pm, EST) *http://www.epa.gov/iaq/*

CA Department of Health Services

Environmental Health Investigations Branch, 1515 Clay Street, 16th Fl., Oakland, CA 94612, 510-622-4500

Indoor Air Quality Section, 2151 Berkeley Way (EHLB), Berkeley, CA 94704, *www.cal-iaq.org* 510-540-2476

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Home moisture problems

D.M. Brook

Moisture problems can occur in many places in homes for many reasons: when high levels of moisture enter building cavities or get inside, when excessive moisture is produced indoors, or when indoor air comes into contact with cold surfaces such as single-pane windows or uninsulated walls. Excess moisture often originates outside the structure, as with foundation drainage problems, or it may be the result of activities by the occupants indoors. Cold surfaces usually are the result of air leakage or inadequate insulation in building cavities, or in rooms where less heat is provided in the winter.

Solving home moisture problems usually starts with a little detective work—looking for moisture sources outside the house and determining how to control them, minimizing production of humidity inside the house, and installing ventilation where needed. Localized moisture problems often can be solved by warming up interior surfaces. In some cases, moisture problems may be not be easily or cheaply solved, and use of a dehumidifier or whole-house ventilation system may be part of the solution.

What causes moisture problems?

The amount of water vapor that air can hold depends on its temperature. Since warm air can hold far more moisture than cold air, we talk about "relative humidity" (RH). During the winter, condensation occurs when warm indoor air is cooled down as it comes into contact with a cold surface, such as a single-pane window or an uninsulated wall. Since the moisture-holding capacity of the cool air is less than that of warm air, the excess moisture condenses, usually on the first cold surface. The temperature at which the air can hold no additional moisture is called the "dew point."

Indoor humidity is the result of the amount of moisture produced inside, the relative humidity of the air outdoors, and the building air-exchange rate. Depending on the building air-exchange rate, the same amount of moisture may cause no moisture problems in one house, while resulting in serious mold and mildew in another. In coastal areas, where the outside relative humidity may be quite high year round, outside ventilation air may produce little drying effect.

Lack of humidity can be a problem in houses with very high air-exchange rates. Houses "dry out" when cold winter air enters the house through infiltration and is warmed up by the heating system. Since the total amount of moisture cold air can hold is small even at 100 percent RH, when it is warmed up indoors, its relative humidity is lower and it feels dry to us. This is why houses with serious air leakage problems in areas east of the Cascades often require humidifiers to maintain a comfortable level of indoor humidity. After weatherization or in new construction, houses should not require humidifiers to maintain 30 to 50 percent RH, which minimizes indoor air pollution problems and which most people find comfortable.

Indoor relative humidity levels between 30 and 50 percent RH are comfortable for most people, and minimize health and

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Inside:

OREGON STATE UNIVERSITY EXTENSION SERVICE

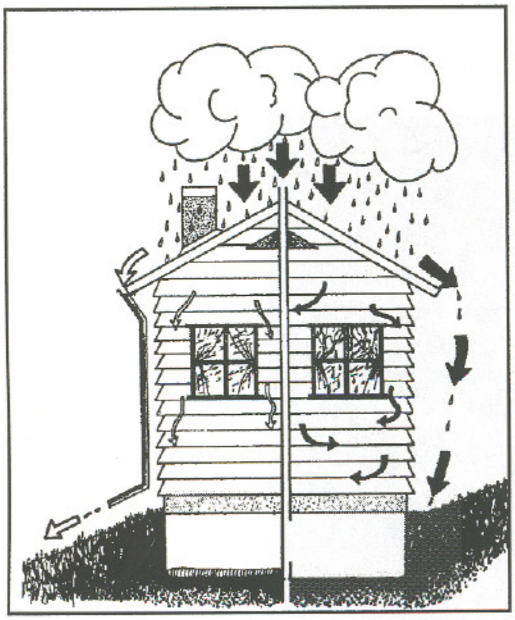

Figure 1.—Gutters, a slope away from the house, and drainage tile in the foundation keep the left side of this house dry. No gutters, a slope toward the house, and no drainage tile expose the right side to moisture damage.

structural moisture problems. High humidities lead to mold, mildew, and high concentrations of biological microorganisms such as bacteria and dust mites, which can affect the health of occupants. Condensation causes discoloration of ceilings and walls. High humidity in the building's structural cavities, such as attics, walls, and foundation area, can lead to wood decay and eventually structural failure. If the wintertime relative humidity is above 50 percent, you should takes steps to control sources of excess moisture in your home as described in this publication. Low indoor humidity may prevent moisture problems in localized areas, such as closets or building cavities, but it doesn't ensure that moisture problems won't occur elsewhere in the house.

When you understand the sources of the moisture in your home and the way moisture moves, you should be able to effectively control it.

Symptoms of excess indoor moisture

Many signs of moisture problems and excess moisture are readily apparent while others are difficult to detect. Here are some common clues of indoor moisture problems:

Odors. Odors increase in intensity with high relative humidity. Musty smells may signal mold, mildew, or rot. Everyday household odors that seem to linger may be a signal of too much moisture in the air.

Frost and ice on cold surfaces. Frost or ice on windows, attic framing, or any surface is an indication of trouble. Condensation can be a sign of excess moisture in the air, indicating a need to stop air leaks cooling the cavity or to warm the surface with insulation.

Damp feeling. The sensation of dampness is common in areas with high humidity.

Surface discoloration, staining, texture changes. These usually indicate some moisture damage, no matter what the material. These changes may appear as black or dark streaks or lines bordering a discoloration. The area may or may not feel wet.

Mold and mildew often appear as a discoloration, which may be white, orange, green, brown, or black. Surface conditions that may indicate decay often are noticed as a musty odor. They can be found under carpets, behind cupboards, on framing between subfloors, in crawl spaces, and in attics. Mold and mildew can get a start whenever the relative humidity of air near a surface is above 70 percent RH. They grow fastest at temperatures above 40°F.

Deformed wood surfaces. Wood swells when it becomes wet, and warps, cups, and cracks when it dries.

Wood decay. Wood rot and decay indicate advanced moisture damage. Unlike surface mold and mildew, wood decay fungi penetrate the wood and make it soft and weak. Look for any type of rot or mushroom-like growths. (See page 11 for more information on detecting wood decay.)

Sweating pipes, water leaks, and dripping. Water vapor may condense and drip off cold pipes, or the pipes may be leaking.

Peeling, blistering, cracking paint. Moisture may be moving from outside or inside the home to damage paint.

Crusty, powdery, chipping concrete and masonry. A buildup of salt or other powdery substance indicates that water has evaporated after moisture has moved through it. Freeze-thaw cycles speed the process of deterioration, causing chipping and crumbling.

High indoor humidity. Indoor humidity levels are best when maintained between 30 and 50 percent RH. They can easily be measured with a "hygrometer"—a low-cost relative humidity indicator, sometimes coupled with a thermometer, available at hardware stores and home centers. Remember, low indoor humidity does not ensure the absence of moisture problems elsewhere in the house.

Outdoor sources of moisture

Poor foundation drainage around the house often is the major source of exterior moisture getting into the house (Figure 1). Proper drainage is a critical first line of defense against moisture problems. Precipitation, surface water, ground water table, and outdoor water use can change seasonally, creating problems that may show only at certain times in the year.

Foundation drainage. Plugged downspouts and blocked foundation footing drains are common sources of outdoor moisture getting into the house. If indoor moisture problems suddenly develop, these areas are prime suspects. Ground sloping toward the house also may contribute to wet basements or crawl spaces.

Slabs. If no moisture barrier was installed underneath the slab when it was poured, water in the ground may permeate through it and then evaporate into the air inside the house. This often is the source of the problem when a garage has been converted to living space.

Below-grade walls. Moisture may move up through cement block foundations, dampening the walls above and raising indoor humidity levels even though the basement or crawl space is dry. If ground water is a suspect, use the capillary test on page 4 to determine if moisture is wicking up through the ground and coming from the interior space.

Splashback. When siding is within 12 inches of the ground, raindrops can splash upward, soaking the bottom edge of the siding. This moisture can move into the wall through capillarity, wetting far more than the bottom edge. If there is sufficient slope to the ground around the foundation, remove soil to increase clearance between the siding and grade—2 feet is preferable. The bottom edge of the siding should be painted and sealed to prevent moisture from rising by capillarity. If necessary, install wedges in the siding to provide a capillary break.

Construction details. Flat ledges, inadequate drip edges, and other construction details also can allow exterior moisture to enter the house. Old roof shingles and missing flashing around chimney and plumbing vent stacks may allow moisture into attics or walls for many years before it is discovered.

How moisture gets into houses

- Bulk moisture—in the form of rain, snow or ground water, leaking into basements, crawl spaces, roofs and walls.
- Capillary action—movement of water through a porous material, such as vertical movement through cement block wall, like a sponge or paper towel absorbing moisture.
- Air movement—water vapor transported through air leakage.
- Vapor diffusion—moisture permeating through solid surfaces, such as cement, gypsum board or wood.

Blocked exterior air circulation. Foliage close to the dwelling or items stored next to the house, such as firewood, can block air circulation and cause localized areas of high humidity. Roof and soffit vents can become clogged by dust, leaves, or tree flowers.

Indoor sources of moisture

Many sources of excess moisture can lead to high indoor humidity and cause a wide variety of problems (Figure 2 and table on page 11). Some indoor moisture production is normal. Whenever possible, sources of excess indoor moisture should be removed or vented outside at the source. Check each possible moisture source—the problems may have one or more causes—and take the corrective actions outlined in the table on page 6.

Occupants. Most of the moisture produced indoors in a normal house is a result of normal respiration of people and pets. When there are many occupants in a limited space, such as less than 250 square feet of living space per person, moisture could be a problem.

Domestic activities. Baths and showers, cooking without lids, and hanging wet clothing and towels inside to dry can produce excessive moisture. Uncovered aquariums and large numbers of house plants also produce a considerable amount of moisture.

Clothes dryer vented into the living space. Clothes dryers sometimes are exhausted into the living space to save the heat. This is a very bad idea for both gas and electric dryers. In addition to the excess moisture, air pollution may result from combustion by-products, lint, and residual detergent, fabric softeners, and bleach products vented into

Capillary test

To determine if moisture is coming through the foundation walls or floor to the inside, or whether moisture is coming from inside the dwelling itself, do the following:

(1) Identify the damp interior surface. Testing of multiple locations on the floor or walls may be necessary to locate external sources of moisture.

(2) Dry a portion of the damp area approximately 2 feet by 2 feet. (A hair dryer can be used.)

(3) Cover the dried area with a piece of plastic, firmly attached and sealed with tape around the edges.

(4) Check the underside of the air-vapor barrier after a couple of days. If there are beads of moisture under the barrier, there is water seeping or wicking through the surface into the dwelling.

However, if the air-vapor barrier is wet on the room side and dry underneath, the dampness is from condensation of room air on the cold surface of the plastic. It is possible for both sides to be damp, which indicates both external seepage and internal condensation problems.

This test sometimes is difficult to interpret. Seasonal variations in surface water flow patterns and the ground water table can cause confusion. You may need professional advice.

the living space. Hanging clothes to dry indoors during the winter has the same effect.

Combustion appliances. Gas ranges, ovens, and unvented kerosene or propane space heaters produce large quantities of moisture—as well as dangerous combustion byproducts—if used extensively without the exhaust fan. In some cases, the chimney for an oil or gas furnace, boiler, or water heater may be blocked by a bird's nest or debris, forcing the exhaust gases into the living space. Corrosion near the flue connection to the furnace or water heater is a sign that exhaust gases are not being vented properly. In other cases, negative pressures may be created in the furnace or water heater area by exhaust fans or forced air ductwork in the house, pulling exhaust gases into the house.

Wood. Storing firewood in the house can lead to problems. Though seemingly dry, wood can contain a great deal of water, which will evaporate into the house as the wood dries.

Attics. Attic bypasses are passageways where warm air escapes from the house into your attic. If water vapor escapes to the attic and is trapped there, it may condense on surfaces and freeze during cold weather. When it thaws, the water may damage ceilings and walls and contribute to humidity problems. Bypasses can allow enormous amounts of warm, moist air to leak into the attic (Figure 3). These include plumbing chases, spaces around chimneys, up interior walls, and around light fixtures, etc. Sealing them can save on winter heating expenses while preventing moisture damage.

Crawl spaces. If the ground is not covered by a vapor barrier, high humidity can build up in the crawl space. This may lead to wood decay and contribute to high humidity in the house.

Construction materials. Lumber and other building materials used in construction contain a large volume of water, which is released into the house during the first few months as the materials dry. If the house is properly—that is, tightly—built, some steps should be taken to control internal moisture, especially during the first 2 years. Running exhaust fans continuously should help increase the air-exchange rate of the house while the building materials dry out.

Inadequate use of exhaust fans. Poor ventilation of high moisture areas, such as kitchens and baths, commonly leads to damage in those areas. If kitchen and bath fans are not installed or not used, moisture problems may be the first clue. Adequate spot ventilation usually corrects these moisture problems. (See page 7 for information on installing exhaust fans.)

Aquariums and house plants. Tropical fish tanks and extensive indoor house plants can add large amounts of moisture to the air. Unless properly sealed with a vapor barrier, attached greenhouses can cause moisture problems in the wall they share with the house, because of condensation. In addition, drainage may be a problem.

Humidifiers. Continuing to use a humidifier after a house has been weatherized can produce excess moisture since the house air-exchange rate is lower. A humidifier generally is unnecessary in a properly weatherized house. A poorly maintained humidifier also may be a breeding ground for bacteria and other microorganisms.

Air conditioners. Air conditioners cool the air, raising the relative humidity. Occasionally, an air conditioner that has too much capacity for the space it is cooling can make the problem worse. Air conditioners should be properly sized to avoid this problem.

Plumbing leaks. Sometimes, moisture problems are the result of plumbing leaks causing puddles in a basement or crawl space, or they may be hidden in building cavities such as walls or underneath toilets or bathtubs. One way to check the plumbing is to run each faucet for 5 to 10 minutes while watching and listening for leaks.

Solving home moisture problems

The solution to many indoor moisture problems begins outdoors. Look for sources, mechanisms, and pathways for outdoor moisture to get indoors. These include unclogging downspouts and foundation drains causing a wet basement or crawl space, installing a missing or torn ground moisture barrier in a crawl space, and fixing roof or wall leaks dampening the house framing (see page 8).

Then look for ways to control indoor moisture generation. Hang clothes to dry outside or on a porch. Cover fish tanks. Don't use unvented kerosene space heaters indoors. If you see rust or corrosion near the flue connection of a gas or oil water heater, the chimneys may be blocked. Turn off humidifiers, and don't boil kettles of water on stoves or radiators in the winter.

Finally, use spot ventilation to remove moisture where it is produced. Vent clothes dryers outside. Install and use ducted vent fans to exhaust moisture from the kitchen and bathrooms, where large amounts of moisture may be produced (see page 7).

This three-step approach should control home moisture problems. If it doesn't, consider installing a dehumidifier or a whole-house ventilation system.

If your home moisture problem is localized, the cause may not be excessive humidity, but rather, a cold surface. You can reduce window condensation by installing storm windows, or by replacing single-pane windows with double-pane high performance windows. Mold and mildew on a wall or ceiling may be caused by poor insulation or by significant air leaks, which cool the surface down. Seal outside air leaks and install insulation.

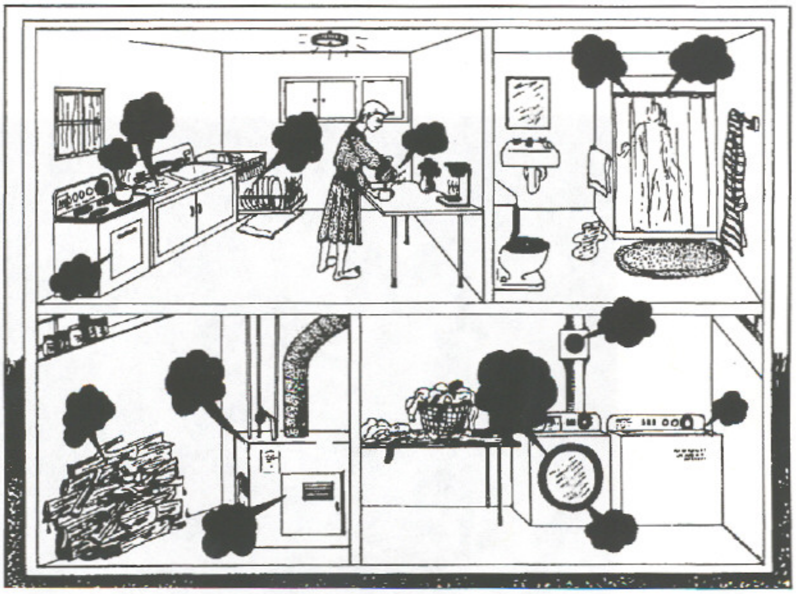

Figure 2.—Common indoor moisture sources.

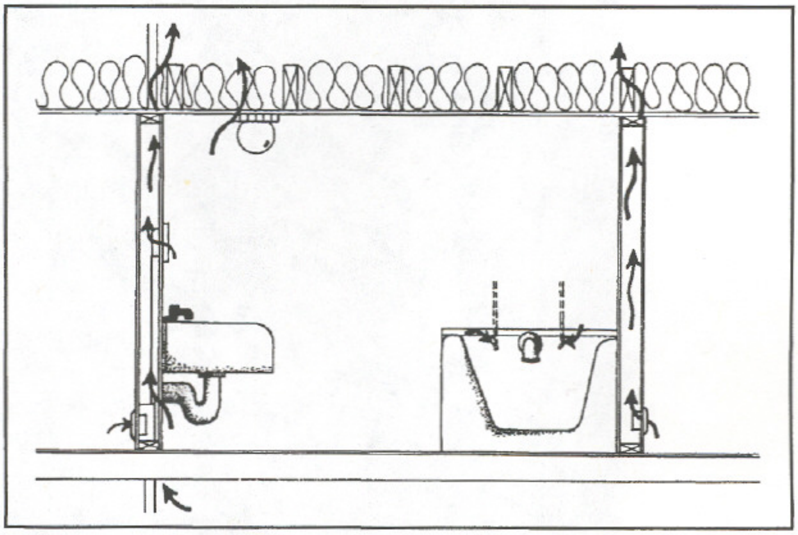

Figure 3.—Attic bypasses.

Three kinds of ventilation

There are three types of ventilation in homes: building cavity ventilation, to control moisture in crawl spaces and attics; spot ventilation, to remove moisture and other indoor pollutants where they are produced; and, if needed, whole-house ventilation, to ensure adequate fresh air for occupants.

Building cavity ventilation. This type of venting may be important for crawl spaces, attics, and other unconditioned spaces. Reducing the entry of moisture into these cavities by sealing air bypasses from inside

Symptoms and solutions to home moisture problems

Symptoms and causes	Possible solutions
Drainage around house	Slope the ground around the foundation so that water will drain away from the house. Check for blocked downspouts and gutters. Install rain gutters where necessary. Check for cracks in foundations, and install proper perimeter footing drains, if necessary.
Inadequate interior ventilation	Install quiet, externally venting fans in kitchens and baths. Become aware of moisture-generating activity and reduce moisture production. If a significant amount of ventilation is needed, a whole-house ventilator system also could be considered.
Inadequate attic or crawl space ventilation	Install any needed vents in attics, crawl spaces and other areas. Check insulation to see if it is blocking ventilation routes.
Many occupants in a small area	Try to reduce interior moisture sources. Add whole-house ventilation. As a last resort, consider dehumidification.
Wood piles	Do not store more than a few days' supply of wood in the house.
Clothes dryer vented into the living space	A very bad idea. While there is a small heat gain, there also is a large amount of moisture and other airborne pollutants. Don't do it.
Cold surfaces, lack of insulation	Seal infiltration leaks first, then insulate, employing proper vapor barrier techniques. Check existing insulation. Insulate windows with additional glazing or other treatments that seal around all edges. For closets or other out-of-the-way places, leave doors open or install louvered doors for better air and heat circulation. A light bulb may warm up a confined space.
New construction, retrofit, remodeling	To speed the drying process, increase ventilation and circulation, both during construction and during the first months of occupancy. Avoid using a humidifier. It may be necessary to dehumidify.
Unvented heaters, faulty heating plants	Check for blocked furnace vents, chimney blockage, a chimney that is too short, insufficient combustion air or whether the system is vented at all—**do not use an unvented kerosene or gas heater indoors.** Make sure your home has an adequate supply of combustion air. If you suspect the heating plant is faulty in any way, call for help from the local utility or a heating contractor. **Don't wait.**
Air conditioners, humidifiers	Use humidifiers only when needed. Otherwise, avoid them. An unnecessary central humidification system can be disconnected. The main overall action for air conditioners is to keep the thermostat setting at 75°F or above, to help save cooling dollars and to keep surface temperatures above the point at which condensation will occur. Drain air conditioning condensation to the sewer system or the outdoors, not the crawl space.
Plumbing leaks	Run each part of the plumbing system for 10–15 minutes while watching and listening for leaks. Check all accessible connections. Leaking pipes may be buried in a concrete slab floor or hidden in the house.
House plants, aquariums	Provide adequate air circulation and ventilation. Avoid excessive watering. Keep the greenhouse at recommended humidity levels. If the humidity is high, avoid venting into the home. Provide proper exterior drainage away from the house and the greenhouse. Use proper vapor barrier and insulation techniques.
Dampness or standing water in basement or crawlspace	Add a ground moisture barrier and ventilate the crawl space. Fix basement drainage with drain tiles, drain pipe, or sump pump. Try fixing cracks in the foundation and use foundation waterproofing. In new construction, lay down a moisture barrier before pouring concrete slab floors.
Splashback on siding	Paint and seal bottom edge of siding. Install wedges to provide capillary break. Move soil away from foundation to provide 2-foot distance to siding if slope away from house can be maintained.
Blocked exterior air circulation	Cut back foliage to allow for circulation. Move stored items away from the house to avoid reducing circulation. Keep vents clean.

the house is an often overlooked first step. See page 8 for information on insulating attics, floors, and walls.

Spot ventilation. The first preventive and corrective action for kitchens and bathrooms is to install fan venting systems that pull moisture out quickly. The recommended minimum ventilation rate for bathrooms is 80 to 100 cubic feet per minute (cfm); and for kitchens, 150 cfm or more. To minimize the tendency of occupants to turn noisy fans off, bath fans should be rated at 2 sones or less. (A sone is a common industry measurement of noise level.) Bath fans should be connected to a crank or twist timer that allows the fan to operate for 15 to 30 minutes.

Always vent exhaust fans directly to the outside—do not dump the air into the attic, basement, crawl space, or garage. Extensive damage can result when moisture condenses on cold surfaces. Ductless kitchen and bath recirculating fans, although they may meet code, simply filter the air and do not remove any moisture.

Installing an exhaust fan in the ceiling and running duct to a vent on the roof or soffit is common. To reduce the amount of warm air that escapes through the bypass into the attic, seal all joints in the exhaust duct and gap where the fan housing meets the ceiling. Use at least 4" duct and run it to the roof or soffit vent—metal vents are more durable. Minimize the number of elbows in the duct run. Be sure the backdraft damper in the fan and vent, if it has one, operates freely.

Running the exhaust duct down an inside wall and venting the air out through the rim joist prevents cold air coming back through the duct.

Through-the-wall exhaust fans for bathrooms and kitchens also are available and may be easier to install, since no additional ducting or vents are needed. Exterior-mounted fans are much quieter, making them excellent for kitchen fan systems. Kitchen hoods should have a filter element to keep grease from accumulating in the duct work.

Some bathrooms have an overhead infrared heat lamp with a blower to help circulate the air. The heat lamps only reduce visible signs of condensation and increase comfort—they do not remove moisture. A ducted exhaust fan is a better solution.

Exhaust fans can cause problems with the proper venting of woodstoves, fireplaces, and gas or oil heating equipment. To check, turn on all exhaust fans and the appliance while holding a stick of burning incense where the flue connects to the equipment. If the smoke does not go up the chimney within 1 minute after the furnace or waterheater fires, have a heating contractor inspect the venting system.

Whole-house ventilation. If problems persist after other moisture control strategies are undertaken, you may wish to install a whole-house ventilation system to provide a controlled amount of fresh air. Whole-house ventilation may be the best strategy for controlling moisture in high-occupancy buildings such as apartments.

A whole-house ventilation system (Figure 4) consists of a very quiet, centrally located exhaust fan with air inlets to supply fresh air and a control to operate the fan at least 8 hours per day. The system should be sized to

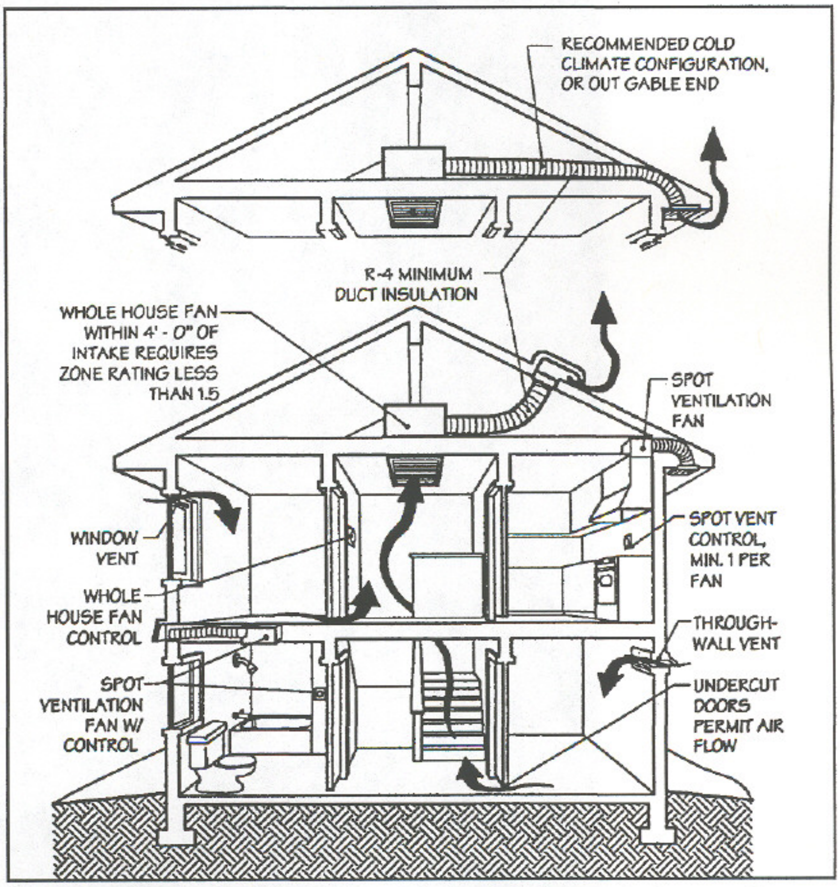

Figure 4.—Spot and whole-house ventilation, based on typical state code. (Courtesy Washington State Energy Office).

provide 30 cfm of air to the master bedroom and 15 cfm for each additional bedroom and main living area. The whole-house fan, which can double as a spot ventilator, must have the capacity to move sufficient air and be very quiet so occupants will not be tempted to shut the system off. Air inlets may be mounted through the wall or are available in many new windows. You must ensure air flow from the inlets in each room to the fan by undercutting interior doors, installing transom grilles, or another method to allow the air to flow between rooms.

Another option is a heat recovery ventilator, sometimes called an air-to-air heat exchanger. It transfers much of the heat from outgoing stale air to the fresh air coming into the house. Such units are centrally located and may have their own ductwork or be incorporated in a forced-air heating system. In cold climates, a heat exchanger must have an automatic defrost cycle to prevent condensation from blocking the exhaust air flow.

Fixing drainage problems

Excess surface water, high ground water table, and clay soils are common problems around foundations. When combined with poor construction details, drainage problems can quickly cause moisture problems throughout the house, from basement to roof. Tackle foundation water problems from the outside first.

Many drainage improvements are fairly simple, such as unclogging footing drains or adding downspouts and replacing flashing. Others are costly or require a lot of labor for retrofit applications, such as installing a sump pump or excavating around the basement walls to install a drain tile system, to get at the source of a severe ground water problem. Paint-on interior foundation coatings applied on the inside may be sufficient in some situations. If foundation drainage problems are not severe and repair would be expensive, installing a dehumidifier to control indoor humidity may be worth trying.

In some cases, installing a drain system around the perimeter of the basement floor is the only available option.

Even in systems where the foundation is tied into the drain tile system, a cement block wall still may be wet enough to allow a significant amount of moisture to migrate up into the frame walls through capillary action.

Moving the soil around the foundation to achieve a good slope away from the house is a basic treatment. A 6-inch slope over a 5-foot run is recommended. Maintain a 2-foot clearnace from the siding. Where cost or lack of space prohibit meeting the recommended slope, slope the soil as much as possible, and try to channel water away (Figure 1).

Downspouts should have a splash block or extension to channel water 3 to 5 feet away from the house. Ground-level drains also can be installed at the drip line. Inspect and repair flashing details all around the house.

Heavy rains may cause seasonal back-up of storm sewers, and if soil is heavy, it may retain water for long periods even though high ground water isn't normally a problem. In general, if the soil type is sandy and gravely, and ground water is below the foundation level, natural drainage should be adequate.

Insulating attics, floors, and walls

Hidden moisture problems can be created when water vapor, usually carried by air movement, condenses inside building cavities such as attics and walls. This can lead to wood decay—commonly mislabeled "dry rot." Water vapor moves into wall cavities both by air movement and by diffusion. However, most of the moisture is carried into building cavities by air leakage. Attics and crawl spaces are ventilated to remove any moisture that does get into the cavity.

Preventing the entry of moisture into these cavities by sealing air leaks from the inside of the house is the most effective way to minimize moisture problems in attics and walls. In some cases, moisture can be transferred from basements or crawl spaces through plumbing chases and wiring holes through interior walls. Sealing these bypasses will reduce moisture movement as well as heating costs.

Vapor barriers—correctly called vapor retarders—are installed to control the diffusion of moisture through a surface. These are commonly 6-mil polyethylene ("Visqueen™") underneath the gypsum board, the kraft or foil backing of batt insulation, or vapor retarder paint or primer on the surface.

Attics. Eliminating air bypasses into the attic is the best strategy to avoid moisture problems in attics. Attic bypasses should be sealed before installing insulation. Seal around all penetrations into the attic, such as plumbing pipes, chimney chaseways, and electrical wiring. For more information, see *Finding and Fixing Hidden Air Leaks*, EC 1286 (ordering information on page 11).

Attics should be ventilated with passive vents located to promote good air circulation. Half of the vents should be placed high on the roof, at least 3 feet higher than the lower vents, which should be as close to the eaves as possible (Figure 5). Using a fan for attic ventilation is costly and can draw moisture and heated air into the attic.

When adding insulation to the attic, be sure the insulation doesn't block the vents. Cardboard or plastic baffles can be installed on the underside of roof sheathing to maintain at least 1 inch clearance allowing airflow. A common moisture problem occurs where the wall and ceiling meet below an attic. Depending on how the soffit vents are installed and the amount of insulation, cold ventilation air also may cool down interior surfaces at this junction, in turn causing persistent mold growth.

Use loose fill or unfaced batt insulation over any existing attic insulation, since the backing can act as an unwanted vapor barrier, possibly resulting in condensation inside the insulation.

Crawl spaces. A ground moisture barrier is needed to stop moisture migrating up from the soil into the crawl spaces. The moisture barrier usually is a tough, puncture-resistant material, often 6-mil polyethylene, laid over the soil and held in place with weights or bricks. For best protection, overlap the sheets of plastic about 12" and seal together with butyl rubber caulk or with tape designed to adhere to plastic sheeting. Do not allow the plastic to touch any wood framing. Storing household items and allowing pets in crawl spaces usually reduces the effectiveness of the ground moisture barrier.

The state building code requires at least 1 square foot of net free ventilation areas for each 150 square feet of under-floor area. Vent openings must be arranged to provide for cross ventilation, and must be distributed approximately evenly along two opposing sides. If there is an approved ground moisture barrier in place, building code officials may reduce the amount of ventilation required to 1 square foot for each 1,500 square feet of under-floor area. Check with your local building code official. Crawl space vents should be closed in the winter and opened in the spring, summer, and fall.

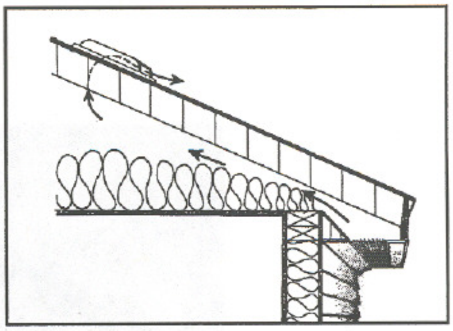

Figure 5.—Passive attic vents.

Walls. Insulating walls of older homes is commonly done by blowing in cellulose or similar loose insulation into the cavities, usually through small holes drilled from the outside. Since the walls of older homes usually have been painted many times, it is unusual to have to retrofit a vapor barrier. Condensation problems usually are localized in an area of high moisture generation, such as the bathroom, or where there is air leakage from the house into the wall.

Seal all penetrations into the walls, such as around windows, doors, and electrical outlets and switches. Built-in cabinets and baseboards are other potential areas of condensation because of air leakage.

If the wall cavity will be open as part of a remodeling or renovation effort, a vapor barrier can be installed easily at that time. Vapor barrier paints, kraft or foil-faced batt insulation, or 6-mil polyethylene are appropriate.

Reducing window condensation

Since windows have such low insulation value, they are cold surfaces in the winter, causing many indoor condensation problems. They can be upgraded by adding a storm window or replacing the entire sash with double- or triple-pane sealed insulating units. Many new windows have an argon or krypton gas between the panes, or a coating called "low emissivity" or "low E," for even better insulation value.

Closing drapery, blinds, and shades at night can aggravate window condensation because they insulate the window surface from room heat, making it colder. Since most window coverings don't provide for a tight seal around the edges, room air can circulate next to the window and is more likely to condense.

When adding an outside storm window, make sure it has small weep holes at the bottom to allow moisture to escape. Exterior storm windows should not be installed airtight. If the prime window does not fit as tightly as the storm window, condensation and light frost on an exterior storm window can occur. However, if the buildup is heavy and remains on the storm window for an extended period, it is probably a sign the prime window should be weatherstripped, or the indoor humidity is too high, or both.

With interior storm windows, make sure the seal is tight around all edges to reduce condensation problems. Newer interior window insulation products, such as the popular "shrink film" and "snap track" systems, provide a tight seal around all edges to reduce condensation problems.

Double-hung windows allow warm, moist air from inside the house to get next to the window through holes where the sash counterweight cord enters the wall, or along edges of the interior window trim. Caulk around both edges of the interior window trim where it meets the wall and window frame. Special covers can be used to seal the pulley holes, while allowing the cords to operate. You can use clear tape for a low-cost temporary seal.

Avoiding condensation on inside surfaces

at 20°F outside, 70°F inside temperatures

	Inside surface temperature	Maximum indoor Relative Humidity (RH) to avoid condensation
Walls/ceiling[1]		
2x 4 uninsulated	58°F	65% RH
R-11 insulation	67°	90%
R-19 insulation	68°	90%
Windows[2]		
single pane (U-1.13	31°	20%
storm/double pane (U-0.55)	51°	50%
triple/low-E (U-0.36)	57°	65%

[1]RH recommendations do not take into account surface cooling at localized air leakage sites.

[2]Since glass temperatures are colder near edges, condensation may occur there at much lower RH for storm/double and triple/low-E windows.

Source: Axel Carlsen, Extension engineer, University of Alaska.

Dehumidification

If humidity is still a problem after you've tried some of these moisture control strategies, another option is to dehumidify indoor air. This is common in basements.

Mechanical dehumidifiers remove moisture by cooling the air. Moist air is pulled past cooling coils and water vapor condenses on the coil, then drips into a collection pan. The drier air is then exhausted back into the house. Humidifiers can't lower the indoor humidity levels much below 50 percent RH, a comfortable winter indoor humidity level.

At room temperatures of 65 °F or below, frost or ice can form on the cooling coils, and dehumidification stops until the unit is defrosted. Some units have an automatic defrost cycle. Others must be manually defrosted by shutting down the unit until the ice melts.

Select a dehumidifier with a permanent drain connection rated for at least 24 pints of water per day. Install the dehumidifier so there is good air circulation around the front of it. Since the humidity level will equalize throughout the house, the unit does not have to be centrally located as long as interior doors are open. Select a location near a drain so you don't have to empty the condensate pan. Or connect a hose from the unit through a hole in the floor to a drain in the basement. For best efficiency, check and clean dust from the coils monthly. If your unit is not plumbed, empty and clean the drainage pan regularly. Stagnant water can grow mold and bacteria, and be a health hazard.

Chemical dehumidifying agents, known as "desiccants," absorb moisture in the air. Desiccants may be an option for slight problems confined to small areas like closets. But they can be dangerous to children and pets. Some desiccants are corrosive and must be handled with extreme care. Others are reusable and nontoxic, but you should wash your hands thoroughly after handling even the nontoxic variety.

Remember that dehumidification, whether mechanical or chemical, is treating the symptom and not the problem. Dehumidify only if you cannot solve the problem by reducing the amount of moisture in your home.

Paint problems

Peeling, blistering, or cracking exterior paint can point to an indoor moisture problem, especially if the raw surface or wood is visible. Often, paint problems are severe on outside walls of rooms with high humidity, such as bathrooms or rooms with major air leakage.

Some paint problems are not recognized as being caused by interior moisture, and the problem is simply covered up with a new coat of point or new siding. Of course, some paint problems are caused by poor surface preparation or application, or use of a paint that wasn't meant for a particular job.

For further reading

Finding and Fixing Hidden Air Leaks, EC 1286. No charge. (See ordering instructions below.)

How to Prevent and Remove Mildew in the Home, EC 1174. $1.00. (See ordering instructions below.)

"Wood Fungi: Causes and Cures," by Stephen Smulski, *Journal of Light Construction*, May 1993, pp. 15–19.

Ordering instructions: To order EC 1174, *How to Prevent and Remove Mildew in the Home*, EC 1286, *Finding and Fixing Hidden Air Leaks*, or additional copies of EC 1437, *Home moisture problems*, send the amount shown to:

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Wood deterioration

Decayed wood is more permeable to moisture and more subject to further damage and decay. Recognizing wood decay is a skill that comes with practice, but several symptoms stand out.

White rot is probably the worst form of wood decay, and often the most difficult to recognize. Wood infected with white rot appears somewhat whiter than normal, sometimes with dark lines bordering the light discoloration. Because the wood doesn't visibly shrink or collapse, people sometimes miss the fact that wood with white rot is seriously weakened and possibly ready to collapse. In advanced stages, some cracking across the grain occurs.

In contrast, **brown rot** readily shows as a brown color or brown streaks on the face or end grains. In advanced stages, the wood appears damaged, with cracks across the grain, and the surface shrinking and collapsing.

White and brown rot are serious forms of wood decay that deserve treatment or wood replacement.

Soft rot and **blue stain** are less damaging forms of wood decay that tend to be more active on the surface. Soft rot is recognizable because the wood surface appears soft and profusely cracked, resembling driftwood in color. Soft rot decay is slower acting than white or brown rot. Blue stain indicates somewhat weakened wood, with a blue, brownish black, or steel-gray colored staining. The discoloration actually penetrates the wood cells and is not a surface stain.

Household moisture sources

Moisture source	Estimated amount (pints)
Bathing:	
tub (excludes towels and spillage)	0.12/standard size bath
shower (excludes towels and spillage)	0.52/5-minute shower
Clothes washing (automatic, lid closed, standpipe discharge)	0+/load (usually nil)
Clothes drying:	
vented outdoors	0+/load (usually nil)
not vented outdoors, or indoor line drying	4.68 to 6.18/load (more if gas dryer)
Combustion (unvented kerosene space heater)	7.6/gallon of kerosene burned
Cooking:	
breakfast (family of four, average)	0.35 (plus 0.58 if cooking with gas)
lunch (family of four, average)	0.53 (plus 0.68 if cooking with gas)
dinner (family of four, average)	1.22 (plus 1.58 if cooking with gas)
simmer at 203°F, 10 minutes, 6-inch pan	less than 0.01 if covered, 0.13 if uncovered
boil 10 minutes, 6-inch pan	0.48 if covered, 0.57 if uncovered
Dishwashing:	
breakfast (family of four, average)	0.21
lunch (family of four, average)	0.16
dinner (family of four, average)	0.68
Firewood storage indoors (cord of green firewood)	400 to 800/6 months
Floor mopping	0.03/square foot
Gas range pilot light (each)	0.37 or less/day
House plants (five to seven average plants)	0.86 to 0.96/day
Humidifiers	0 to 120+/day (2.08 average/hour)
Respiration and perspiration (family of four, average)	0.44/hour (family of four, average)
Refrigerator defrost	1 .03/day (average)
Saunas, steambaths, and whirlpools	0 to 2.7+/hour
Combustion exhaust gas backdrafting or spillage	0 to 6,720+/year
Evaporation from building materials:	
seasonal	6.33 to 16.91/average day
new construction	10+/average day
Ground moisture migration	0 to 105/day
Seasonal high outdoor humidity	64 to 249+/day

Source: Minnesota Extension Service, University of Minnesota.

Adapted from *Home Moisture Problems*, by the Minnesota Department of Public Service; and *Moisture and Home Energy Conservation*, by the National Center for Appropriate Technology. Prepared with the support of the U.S. Department of Energy, Grant No. DE-FG02-76CS60014. However, any opinions, findings, conclusions, or recommendations expressed herein are those of the author and do not necessarily reflect the view of the Department of Energy.