That Dangerous Damp –

Dealing with Water Inside

4.0 PDH/ 4 CE Hours/ 4 AIA LU/HSW

AIAPDH153

PDH Academy
PO Box 449
Pewaukee, WI 53072

www.pdhacademy.com
pdhacademy@gmail.com
888.564-9098

PDH Academy

Final Exam

1. WBDG is an anacronym for _______________.
   a. Western Building Design Guild
   b. Whole Building Design Guide
   c. Waterproofing Barrier Designations Guidelines
   d. Worldwide Barometric Delineation Guild

2. Prolonged exposure to water, makes building components hospitable to ______________.
   a. Ants, weevils, and rodents
   b. Mold, heat, and sprouts
   c. Bacteria, ants, and mold
   d. Strand orientation, security breaches, and termites

3. Invading moisture destroys concrete by _________.
   a. Depositing sub-surface salts
   b. Leaching cement out of the mixture
   c. Creating water stains that cannot be removed
   d. Redistributing soil beneath

4. Estimated medical costs in the U.S., for the treatment of asthma related illness, is estimated to be in the range of ________.
   a. 100-200 million
   b. 3-4 billion
   c. 400-500 thousand
   d. 28 dollars per person

5. The decision to use building materials, that do not accept or hold moisture is ___________.
   a. Generally requested by the building owner
   b. Mandated by most building codes
   c. A decision with severe financial consequences
   d. Made during the design process

6. Mold is also sometimes called _____________.
   a. Mildew
   b. Shrooms
   c. Wart-root
   d. Scale

7. One factor that has influenced the design of buildings that are more airtight, is ________________.

a. American Medical Association guidelines for design
b. Energy code enforcement
c. Better damper technology for HVAC units
d. Higher humidity levels than in the past

8. The __________ is the rate at which all indoor air, is completely replaced by an equal amount of outside air.

a. ARF (Air Replacement Factor)
b. Diffusion Factor
c. Infiltration Gain (IG)
d. Air Exchange Rate

9. When water damage is discovered immediately, it will still be very hard to salvage water damaged materials that are _____________

a. Metallic
b. Porous
c. Hardwood
d. Masonry

10. The source of radon, rising through the soil, is ________________

a. Decaying vegetation
b. Gasses from magma far below the surface
c. An indication of cave systems below
d. Decaying uranium

Course Description

Despite our best efforts to keep it out, water has found its way inside the building. This course examines the question of what to do next. Since abandoning the building to its eventual collapse, is not usually an option.

The material briefly examines design and construction methods of systems designed to withstand water penetration. An understanding of these systems, gives us a starting point for finding sources of intrusion, and a discussion of how to best repair them and prevent further damage. Sealing a failed envelope is the first step in remediation.

Once the source of the problem has been addressed, steps can be taken to reclaim full use of the built environment. Assessment of moisture damage must be done next, to best determine and prioritize steps to be taken toward repair or replacement of damaged components. Immediate and critical remedies are examined, as well as those which can be addressed after a couple days have passed. Then, for the sake of health, moisture driving the growth of mold must be found and eliminated, as well as the mold itself.

Because of its power, and the many paths it utilizes into our buildings, water intrusion with accompanying mold growth, is one of the most discouraging building maintenance issues to address. But we have enough accumulated experience from past battles, to handle it far better moving forward.

This course is intended to equip others with that knowledge.

Learning Objectives

Learning Objective 1:
Upon completion of this course, the student will be familiar with terminology and principles governing site design to prevent groundwater from infiltrating buildings to prevent moisture and mold problems and secure the welfare of occupants.

Learning Objective 2:
The student will learn basic design and construction systems for effectively controlling moisture infiltration into built environments and why controlling moisture is important for user health purposes and building safety.

Learning Objective 3:
Best maintenance and weatherproofing practices, will be learned, that minimize potential for future mold growth that will impact the health, safety, and productivity of users or occupants of the space.

Learning Objective 4:
The student will be given a quick overview of indoor air quality issues, and the concerns for occupant health and importance of addressing air quality in building systems before the issues occur.

THAT DANGEROUS DAMP – DEALING WITH WATER INSIDE

FOREWORD

The chorus of one well known song, begins with the words, "Sometimes, all I need is the air that I breathe, and to love you." In some cases, the singer might be better served, to just try to live on love.

Pollution in our environments is unquestionably a poor idea. Especially when we will be inhabiting that environment in the foreseeable, if inadvertently shortened, future. Even more dangerous, is when we bring pollution of any kind inside our homes, workplaces, and schools to live with us.

More and more, we are beginning to understand that there are serious acute and chronic health problems associated with breathing in contaminated air. Placed in the context of managing our health, managing water infiltration into spaces where we live and work, also takes on great significance. Materials and furnishings that have been damaged by water, unless correctly dried or removed, can become significant sources of microbiological contamination in the air. Health problems, resulting from breathing that air, can range from simple allergic reactions to chronic pulmonary diseases.

All buildings leak in some way, at some point in their life span. Knowing this, ways and methods have been developed to deal with this intrusion of water, during design, in construction, and in maintenance. The purpose of this work is to discuss how to respond with appropriate protocols, when our environments are invaded by unplanned water. We will touch on how to deal with moisture, and the ancillary problems associated with it, should moisture make its way inside, and remain. This is not if, but when, resident dampness begins to make our built environments, less habitable. Finally, we will touch on other sources of contamination in the air we breathe, and how to respond to those as well.

OVERVIEW OF MOISTURE RELATED PROBLEMS

Don't Let the Water In

Excessive water, meaning more than we intended or allowed for, in the design of a building, creates problems for both built structures, and for their inhabitants. We learn more about moisture intrusion, with each successive failure. And the idea really is to learn from past mistakes.

All buildings, at some point in their usable lives, will develop flaws that allow moisture to penetrate in an unintended fashion. Managing that water, once it gets inside, is necessary to reduce microbial growth that could endanger the health of inhabitants. Those health issues will range from simple irritation, to allergic responses, to life-endangering diseases. Legionnaires Disease is one famous result of poor air quality, that readily comes to mind.

The same moisture dependent organisms that endanger human health, can also work to destroy the building holding the people. This can be brought into perspective by noting that those tiny creatures we generally term as mold, given a good source of moisture as well, will eat organic building components, to grow and thrive.

Mold, not yet inside the human body

Assessing what has worked, or not worked, in times past, has led to the development of effective protocols addressing unwanted moisture intrusion. In this course, we will look hard at; sources of unwanted moisture, dealing with sources of its intrusion, problems resulting from its entry, and steps to take, once a leak has been discovered. That discovery of a leak involves water observed at the actual point of intrusion, discovery by the appearance of localized physical damage, or the appearance of mold, indicating the presence of excess moisture nearby.

Before further and more in-depth discussion of this topic, it would be helpful to look at some of the terminology involving the danger of allowing water to penetrate buildings, and associated consequences of not taking immediate steps, to remedy the problem.

Glossary of Terms Regarding Dampness and Mold

Term	Definition
Air Barrier**:**	Any material, combination of materials or manufactured assemblies, intended by design, to control the movement of air across or through an exterior wall system or assembly.
Air Handler:	Equipment that includes a blower or fan, heating or cooling coils and related equipment such as controls, condensate drain pans and air filters. The description does not include ductwork, registers or grilles, or boilers and chillers.
Air Retarder*:*	A membrane with a water vapor permeance at least 5 perm, restricting air infiltration and exfiltration through an assembly, that still allows water vapor to diffuse though. Joints and seams in air retarders must be sealed to keep them effective.
Air/Vapor Retarders**:**	A membrane with both the water vapor resistance rating of a vapor retarder, and the air infiltration rating of an air retarder. These are used to restrict the flow of both air and water vapor through building assemblies. When used, joints and seams, and other openings around vents, outlets, windows, etc., should also be sealed.
Alligatoring**:**	Shrinkage cracking of the bituminous surface of built-up or smooth surface roofing. It produces a pattern of deep cracks resembling alligator hide.

ASHRAE:	An anacronym for the American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc.
Asphalt:	A highly viscous hydrocarbon, from the residue left over after distilling petroleum, used to water-proof built-up roofs.
ASTM:	An anacronym for the American Society for Testing and Materials
Ballast:	Heavy materials like rock, gravel or pavers, used to weigh down roof membranes to prevent their uplift by wind
Bitumen:	A generic term for asphalt or coal tar pitch
Blister:	A spongy raised portion of roofing membrane, caused by pressure below from entrapped air or water vapor
Built-up Roofing (BUR):	Continuous roofing formed from laminated, saturated or coated roofing felts, alternated with layers of bitumen
Cant Strip**:**	A continuous triangular strip adhered in the junction formed by a horizontal roof meeting a wall or other vertical surface. They are installed to create a more gradual slope transition for flashing and roof membranes
Capillary Break:	A slot creating an opening, which is too large to be bridged by a drop of water This stops the passage of water by capillary action
Chase**:**	A dedicated path or raceway, cut or built into building elements, to accommodate electric, plumbing, or HVAC distribution lines
Cladding**:**	A face applied panel, intended to protect a structure against impact, decay, weathering, or corrosion
CMU:	An anacronym describing a concrete masonry unit.
Commissioning:	The testing and balancing of all of a new building's systems, to ensure their proper functions as designed, and train the operations staff in the use and maintenance of those systems, before the building is occupied by intended recipients.
Coping:	A protective waterproof cap over the top of a finished wall or parapet, to resist moisture penetration. They are typically sloped to direct water away from the wall beneath.
Crack:	A break in a protective membrane that was intended to provide a continuous layer of waterproofing
Cricket:	A small ridge, extending from a vertical face like a chimney, to a nearby sloped roof, to divert water away from, and around, the junction of the vertical face and sloped roof
Drainage or Drain Plane:	Any element placed between the "wet" and "dry" zones of an exterior wall system or assembly, off which water is intended to drain
Dry Well:	A rock-filled hole, placed to hold a calculated amount of drainage water, until it can be absorbed by the earth beneath
Eave:	The portion of the lower edge of a sloped roof, that overhangs a wall below
Enthalpy:	A measure of the total energy of a thermodynamic system, including both the energy needed to create a system, and the energy needed to establish its volume and pressure, used in displacing its surrounding environment to make room for itself
EPA	An anacronym for the Environmental Protection Agency
EPDM:	An anacronym for ethylene propylene diene monomer, a synthetic rubber used for single-ply roof membranes.

Expansion Joint:	Space left between two planar surfaces, allowing for planned expansion and contraction of those adjacent surfaces, under different seasonal and thermal conditions
Fascia:	A finish placed over, and capping, the exposed edges of a roof assembly or roof overhang.
Fishmouth:	A gap that has opened up in overlapping layers of felt, due to failures in the adhesion between the overlapped felts typically utilized in built-up membrane roofing
Flashing:	Overlapping sheet materials applied over, and sealing, membrane joints, drains, gravel stops and other places, where membranes are interrupted. Base flashing normally forms an upturned edge, and a cap or counterflashing comes down from behind a waterproof finish on a vertical surface above, and laps over the base flashing, to provide positive drainage over the flashed joint.
Forebay:	A small pool located before the primary inlet of a storm basin or other water management facility, intended to trap and settle out sediment and heavy pollutants, before they enter the main basin
Gravel Stop:	An angle with a raised flanged, face applied to the top of a fascia, to provide a clean edge to the top of the roof assembly, all the while preventing loose aggregate from washing off the roof.
HVAC:	An anacronym for heating, ventilation and air conditioning.
Hygrothermal:	A term pertaining to heat and humidity.
Impervious:	Neither absorbing, nor allowing the passage of water
Micromanometer:	A tool used to measure very small differences in pressure.
Modified Bitumen:	Asphalt with polymers added to its mix, to make it more flexible in cold temperature and less subject to flow in hot temperatures
OSB:	An anacronym for oriented strand board. It is a panel product, made of strand-type flakes, purposefully aligned in a specific direction. The alignment makes the panel stronger, stiffer and with better dimensional properties, than panels made with random flake orientation.
Parapet:	A part of a wall assembly, that extends above the plane of the roof behind it.
Permeance and Permeability*:*	The speed at which water vapor transmits through a given area of a flat product, driven by a specific difference in vapor pressure between its two surfaces, is measured in “perms.”
Plenum:	A space between a suspended ceiling and the floor above it, often used for system distribution and sometimes as an air return. A plenum is usually designed to have less air pressure within it, than the space below it, so air being returned to the HVAC system will flow up into it.
Ponding:	Water that collects in depressions on a roof surface.
Psychrometrics:	Charting of the behavior and combinations of water and air, at specific temperatures. Included in this data is the dew point of moisture laden air at different moisture contents.
PVC:	An anacronym and generic term for single-ply plastic sheet membrane (polyvinyl chloride).
R-value:	The number of minutes (seconds) required for 1 Btu (joule) of energy to penetrate one square foot (square meter) of a material for each degree of temperature difference between the two sides

	of the material. This is used to measure a material's resistance to the passage of heat and the number used for the R-value is the reciprocal of that used to measure conduction (1/c)
Scupper:	An opening built in to allow water to drain through a wall, from an adjoining flat surface, usually a roof
Section:	A drawing showing the arrangement of materials comprising a structure, as though the structure had been cut through on a plane
Shingle-wise:	Overlapping materials, as is done with roof shingles, so water will run harmlessly down and over the joint, without penetrating
Slope:	The ratio between the measure of the vertical rise, and horizontal run, of any given slope
SMACNA:	An anacronym for Sheet Metal and Air Conditioning Contractors' National Association.
Soffit:	The finished surface on the underside of a roof overhang.
Spall:	A fragment, usually in the shape of a flake, detached from a larger mass by a blow, by the action of weather, by pressure, or by expansion within the larger mass.
Stem Wall:	The vertical portion of a retaining wall.
Sump Crock:	A hole, created to make a low void, where spilled or infiltrating fluids will collect for further handling
Swale:	A ditch covered with vegetation, created to channel and sometimes absorb surface water runoff
TAB:	An anacronym for test, adjust and balance
Tensiometer:	An instrument used to measure the surface tension of liquids.
Vapor and Air Retarders**:**	Materials inhibiting the flow of air and water vapor through building envelopes
Vapor Barrier / Retarder*:*	A film with a water vapor transmission rate of less than one perm, usually thin flexible materials like plastic, or coatings like paint or asphalt. These are effective in preventing condensation from occurring, when installed over the warm side of exterior assemblies.
WBDG:	An anacronym for the Whole Building Design Guide.
Weep Holes:	Small openings left in the outer wall of masonry construction, as outlets for water trapped between building components, to let it migrate back outside the wall

THE SCOPE OF THE PROBLEM

With some basic terminology defined, let's look at moisture damage to buildings, and their inhabitants, in a bit more detail. We will get far more specific shortly.

Moisture Damage to Buildings

In addition to causing health problems, moisture will damage building materials and components. That facility damage occurs at multiple levels. Since water and food are what most organisms need to thrive, prolonged exposure to moisture encourages infestation, within and on, organic building materials and HVAC system components. Molds, bacteria, and wood-decaying pests, like termites and carpenter ants, will suddenly feel right at home. Water interacts chemically with building components, causing structural fasteners, wiring, metal roofing and conditioning coils to corrode, making wood to rot, and causing adhesives used in flooring, sheathing, and roofing to fail. Wood will also swell or warp when it becomes wet. Water-soluble building materials, like drywall, can essentially dissolve. Masonry can be damaged by expanding ice during freeze-thaw cycles. The integrity of concrete can be destroyed by sub-surface salt deposits, carried there by moisture intrusion. Paints and varnishes can be damaged and become clouded. When wet, the thermal resistance of insulation is greatly reduced.

Monetary Loss Due to Moisture Problems

All these categories of problems, generate significant price tags, attributable to buildings being exposed for prolonged periods to moisture.

The direct cost of medical problems, associated costs of treatment, and ancillary losses of productivity, must be borne by someone. Annual medical costs of just asthma-related illnesses, attributed to exposure to dampness and mold, have been estimated at $3.5 billion in the U.S. alone. There are other health problems associated with damp buildings, and each problem carries its own annual medical price tag. Those are generally passed on as higher insurance premiums, to everyone.

Damage to the building also creates huge expenses. A significant proportion of these costs is borne by tenants and building owners. Money is lost when employees call in sick, due to illnesses like asthma. Even when employees remain present, reduced productivity can be expected when there are pervasive moisture-related health and comfort problems. There is obviously a huge cost associated with repair and replacement of corroded structural fasteners, wiring, and damaged moisture-sensitive materials. Increased insurance premiums will result from excessive claims for repair, especially if a water intrusion problem was known, but not remedied in a timely fashion. Loss of the use of building space, after damage and during renovations, will make it necessary to rent additional space for a time. There will be repair and replacement costs for damaged furniture, products and supplies. Damaged records, that cannot be salvaged, will create problems down the road, requiring plenty of unscheduled time for personnel to figure out and resolve.

General Mold / Moisture Intrusion

When materials in the building, from acoustic ceiling tiles to carpets and rugs, absorb and hold that moisture, they will continually release it into air in the building, until they have been dried or removed. When examining how to reduce financial loss from excess water, understand that moisture in buildings or building envelopes, is likely coming from one of the following sources:

1. Moisture is literally absorbed straight through external envelope materials.
2. Moisture is simply a matter of precipitation, or melting snow, that drains inside through cracks and holes.
3. Moisture, like melting snow, will be sucked inside through available openings, when air pressure inside is less than that externally. Basically, anywhere air can enter, water can follow.
4. Moisture enters the building through construction flaws, poor selection of materials, poor installation methods used during construction, or adjacent selected materials being incompatible with each other.
5. More moisture enters, held in humid outside air flowing in, than the building’s HVAC system can eliminate.
6. Moisture enters in event that floods a building, like a plumbing leak, a spill, a leak in the fire suppression system, or an actual natural disaster affecting the integrity of the building envelope.
7. The last route by which water enters, is the introduction of excess moisture into the building by occupants. This is via poorly vented exhaust fans in kitchens and baths, from water spills, from water used in housekeeping tasks, humidity introduced in the breath of inhabitants, the uncontrolled entry of humidity from the exterior when doors or windows are opened, or plumbing fixtures being allowed to run or drip.

Unwanted moisture will find its way into buildings. This fact is attested to, by a proliferation of service companies, who contract to provide moisture abatement services for flooded structures. In this case, as in most others, solutions came into existence because of need.

It is easy to find sources of excess water, when materials near the leak are saturated. Leaks or burst pipes are immediately apparent. Not so easy, is when the source of intrusion is hidden from view, such as wet insulation in walls, or water entering through the foundation. Totally frustrating, is when a leak occurs in one location, but the water uses wires, ducts, etc., to travel some distance before dropping and making its presence known, nowhere near its actual point of entry.

There are straight forward steps that can be taken to reduce the chance of water intrusion. Specifying and using building materials that neither accept, or hold, moisture is one practical solution. For example, rigid insulation will not hold moisture, whereas cellulose insulation will absorb the same. Metal siding will repel it, but wood siding becomes saturated unless protected. Single ply membrane roofing offers no lapped joints, wherein moisture can reside, but that is not true of asphalt shingle roofing. Sandwich panels, containing insulation faced with steel or aluminum sheeting, are another prime example of materials, which by their nature, repel moisture.

Construction detailing is another example of forethought, taken before construction begins, to deny water entry. It is primarily based on a good imagination and an understanding of water behavior. Since precipitation tends to flow downhill, flashings below copings, below windows, above door and window openings, and above any break in the continuity of the building envelope, that lap down over the next shield in the water barrier, will help keep water from entering. If wind on the building face has potential to drive water up under flashing, then caulking should be specified, or other barriers put in place to prevent that. Capillary breaks can prevent water from bridging gaps. If there is a cavity into which moisture can enter and collect, weep holes should be provided to let that collected water drain from that cavity, back to the exterior. The devil is in the details, but unwanted moisture intrusion can be in the lack of them.

Material specification and detailing decisions are choices made during the design process. The idea is to create a continuous envelope of materials that repel water and will not allow moisture to diffuse through them into the interior.

Another useful tool is to find and eliminate any gaps in the envelope, through which moisture can get inside. Inspection during construction is the best time to do this, but this is also part of ongoing maintenance inspections. Indoor sources of moisture (other than the breath of inhabitants,) can be found and fixed or eliminated. Uncontrolled air movement, that pulls humid air in from the exterior, can be controlled with airlocks or other known design devices.

By far, the best approach to indoor air pollution by mold, is to do whatever it takes to just keep moisture from getting inside. Because once it gets a foothold, the growth of mold can follow.

The Mold / Moisture Connection

Unlike with moisture, there is no way to keep mold out of our buildings. With thousands of strains, mold is found everywhere, both indoors and outdoors.


Mold on leaves

The mere presence of mold does not indicate a problem. It becomes problematic, only when the amount of it increases past our tolerable limits. Excessive growth begins when mold spores land on a wet or damp spot and begin generating new colonies. Spores are released into the airstream and at that point, inhabitants with sensitivity to mold begin reacting. The goal then becomes, not to necessarily eliminate all types of mold (which is impossible), but to remove what is there and limit its future growth.

In any building, there will be users who are sensitive enough to mold to react to it. In some, that sensitivity results in respiratory diseases. Molds produce allergens (substances causing allergic reactions) and irritants that are troubling to sensitive individuals. Allergic responses include hay fever-type symptoms, such as sneezing, runny nose, red eyes, and skin rash.

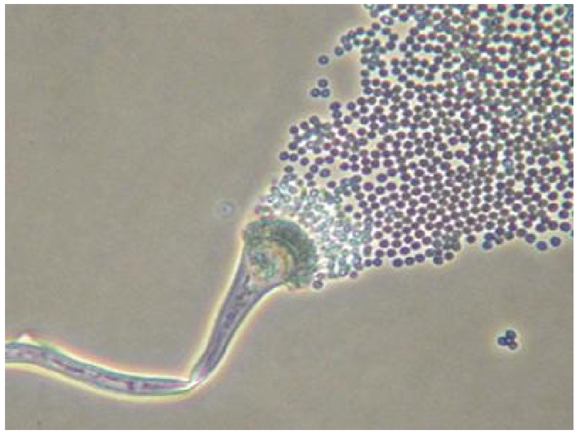
Moreover, allergic reactions to mold are more common than one might suppose. Responses to excessive mold can be immediate or delayed. Asthma attacks can be triggered in people already suffering from that disease. Mold exposure can irritate eyes, skin, nose, throat, and lungs of all users, whether they are sensitive or not. Allergic and irritant symptoms are the most common problems reported. But research on the effects of mold on health is still ongoing.

Plenty of information on health problems associated with mold, can easily be found. Health professionals are one source of data. State and local health departments are another. Detailed information can also be found on websites for the Center for Disease Control and Prevention, and the Environmental Protection Agency.

Definition of Mold

Though of differing species, all molds are fungal growths that can get a foothold and propagate on various damp organic materials. Sometimes referred to as mildew, molds are found indoors and outdoors, all year long. Exterior molds use plants and decaying organic matter, as a source of nutrition. They do the same inside, needing only moisture and a good source of carbon, found in building materials or contents. Mold growth occurs in areas of excess moisture, when tiny floating spores leave one colony, to land on a nearby moist surface and begin another colony. Moderate temperatures and nutrients are the only other conditions needed.

Molds (along with mushrooms and yeasts) are types of fungi. Molds are in the air and settle out on surfaces. Outdoors, molds are part of, and serve a significant function in nature. They break down organic matter and live in the soil, on plants, and on dead or decaying matter. Mold spores become airborne, when air moves across vegetative matter, or when plants, soil or other decaying matter is disturbed.



Magnified mold and its spores

There are thousands of species (often quantified as between 50,000 and 250,000) of mold, with more than 1,000 different kinds of molds found in homes and buildings in the United States. Molds spread and reproduce over time, when favorable growth conditions are present. These include food sources like paper facings on wallboard, wallpaper, ceiling tiles, wood, dust, and dead mold spores. All are good fuel for mold colonization. Sufficient moisture requirements will vary from one mold species to another, but generally, sustained relative humidity of greater than 70 percent, or wetted food source materials that remain that way more than 48 – 72 hours, will encourage mold colonization. It will begin first on a microscopic level, then slowly become visible. Mold growth can be any color, including black, white, green, purple or orange. Once mold growth begins, depending on the conditions and mold type, even in the absence of "visible water," the moisture in ambient relative humidity will be sufficient to sustain and maintain mold growth.

The presence of air-borne mold indoors, even when found in the types and concentrations as outdoors, are not generally considered atypical or problematic. However, mold growth (colonization) inside buildings or interstitial wall cavities, is not considered normal. Aerosolizing of these concentrations of colonizing molds, carries the potential for health problems and degradation of the integrity of the structure, should that level of growth, remain unchecked.

Mold is not a new health concern, not even in the workplace. No indoor space is ever really free of some type of mold or another, no matter how supposedly sterile. Molds are everywhere, and our exposure to them unavoidable. Some molds are considered toxigenic and are undergoing research to determine if they cause certain health problems, in and of themselves. But whether known hazards or not, accelerated growth of any strain of mold, is a sure indicator of an excessive moisture problem.

Controlling Mold Growth by Controlling Moisture

With the connection between moisture, mold, and health firmly established, we consider that mold growth involves four factors. Mold spores must be present, to be carried by air currents to other surfaces and building cavities. Once there, the spores must contact surfaces that are moist (relative humidity at or above 70%), contain organic nutrients, and are warm. In such a hospitable environment, mold will grow and gradually destroy the surfaces to which it clings. We can't change the organic nature of building components, and we can't eliminate the initial presence of mold. But we can limit factors that make surfaces hospitable, by changing the relative humidity or temperature of exposed and hidden surfaces. Both changes are very good approaches to controlling mold growth.

Controlling the moisture content in building spaces carries other dividends. Excessive moisture also creates an inviting atmosphere for unwanted bacteria, mites, cockroaches, and other pests. Excessive moisture in wall and roof construction, increases the thermal conductivity of the building envelope. That reduces the effectiveness of the insulation package by as much as one half. Keeping moisture out of insulation yields financial rewards, in lowered utility costs.

All these factors make controlling the moisture content, in and through a building envelope, a subject of great importance.

BEFORE BUILDING DAMAGE OCCURS

The best offense is a good defense. Based on this premise, the easiest way to deal with unwanted water is to make sure it can't get inside. We have touched on the use of construction detailing and what promotes water resistance. We have also discussed installation problems. Specifying the right materials to deny water residence is important. But are there any ways to keep water out, that are useful after the building has already been constructed?

Use of Rain Screens

One retrofit technology, available to stop the intrusion of water into walls, is the installation of rain screens. The best of these incorporate exterior cladding materials/panels/screens, held away from the building to create an air cavity between it and the building, with a drainage plane behind it, placed on an airtight support wall. This assembly creates multiple ways for precipitation to be channeled away from the building.

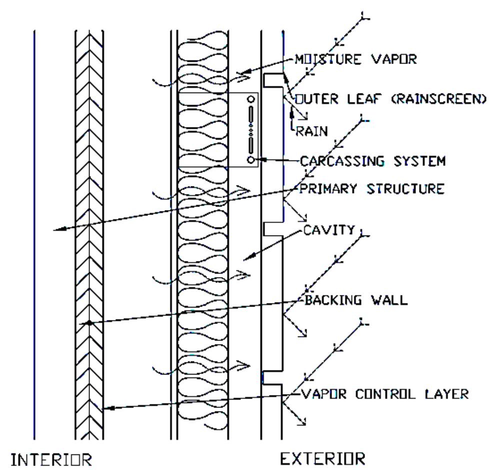


Diagram of a rain screen

The main concept of a rain screen is the creation of two separate planes. The outer plane sheds water, but still allows air to freely circulate behind it. The inner plane is relatively airtight. The circulating air around the screen, creates equal pressure on either side of the outer plane. This results in there being no external force, no pressure differential, to drive water inwards through the building envelope. Even though a difference in air pressure still exists, that would normally act to encourage water penetration through the outside face of the building, the rain screen denies precipitation access to that face. No free water will make it to the building face, to try to work its way inside.

Necessary Ventilation

Designing structures so they are airtight, is not a good approach to water resistance. It is possible to design buildings that are so airtight as to endanger occupants. I was peripherally involved in the last stages of construction of a high-end residence. Incorporating all the latest in spray foam technology, the home was so tight, fireplaces had to draw combustion air down the chimneys. There was not enough oxygen in the home to sustain the flame. Of course, when they did this, they also pulled the rising smoke down and distributed it back into the home. Fixing that problem required punching holes through the walls beside the fireplaces, to give them some fresh air. The inhabitants of the house needed some as well.

To prevent pollutants from accumulating inside a building, to the point where they cause health problems for inhabitants, some level of ventilation will be required. Fresh air from outside will need to be introduced at the same time, and in the same amount, that interior air is being exhausted. This balance and ventilation was accomplished historically with leaky, drafty buildings, where copious amounts of outside air could enter. The buildings breathed air in and out.

Air can move in and out of buildings by infiltration, natural ventilation, or through mechanical ventilation. Modern buildings, built to satisfy energy codes, don't tend to be leaky or drafty. In these, ventilation must be obtained in one of several ways:

- When outside air enters through openings, joints, and cracks in walls, floors, and ceilings, and around windows and doors, that air intake is defined by the term 'infiltration.'
- Natural ventilation occurs in larger quantities, when doors and windows are opened, with air movement in or out, powered by pressure differentials and, sometimes by wind.
- There are also many mechanical ventilation devices, used to exhaust inside air and bring outside air into a building.
- Intermittent fans, like range hoods and bathroom fans, periodically remove air from a single room upon demand.
- HVAC systems use ducts and fans to continuously exchange stale inside air for fresh, filtered, and conditioned outside air.
- Apartments that have few windows and open to interior hallways, often depend almost entirely on mechanical systems for ventilation.
- It must be understood, that all outside air carries humidity in with it, that must somehow be addressed.

The rate at which all indoor air is completely replaced by an equal amount of outside air, is known as the air exchange rate. When there is little air exchange, because of tight construction and undersized, or missing, fans and other ventilation devices, the air exchange rate is low. When this happens, levels of indoor pollutants tend to rise. If there is a pollutant source present, higher concentrations build up over time, when they are not being exhausted, and there is insufficient fresh air to dilute them.

Sources of such indoor pollution are varied. They include gasses and particulate from interior building materials, finishes and furnishings, as well as the use of products like cleaning solutions. They can also include air-borne contaminants like mold spores, other biological organisms, and gasses from interior or exterior chemical use.

Improving Air Quality and Ventilation

Poor air quality is a problem that can be tackled by various means, including additional ventilation. Sources of pollution, once identified, can be entirely removed from use and from the building. Ventilation devices can be installed to introduce fresh air, to dilute concentrations of pollutants. Air cleaning devices can be installed as part of HVAC systems. Blocked air supply vents can be reopened. Windows can be opened to temporarily relieve air quality problems (unless the source of the problem is outdoors). If certain activities are causing the problem, those activities can be curtailed. Activities that are generating indoor contaminants, can also be moved outside the building. Relocate activities like sanding or stripping furniture, or painting various items, outdoors when that option is possible. Some newer mechanical systems include air-to-air heat exchangers, that allow the introduction of outside air, but precondition that air, as it enters.

If direct action to resolve air quality issues, cannot be taken by users of someone else's facility, those responsible for building operations should be approached and concerns expressed. At that point, a plan of action to resolve the problem should be requested.

The simplest approach to lowering pollutant levels in indoor environments, is to dilute their concentration levels with additional fresh air. Since most residential HVAC systems don't include means to bring in outside air, that can be done by opening windows, operating window or attic fans, or running window AC units with the vent control all the way open. Running exhaust fans will also decrease pollutant levels by exhausting air containing them. This happens, while simultaneously lowering the air pressure inside and increasing the rate of outside air infiltration.

There are two things that must be kept in mind when introducing outside air, to solve an air quality issue. Unless it happens to be the same temperature as the desired inside environment, an additional cost will be incurred to heat or cool that outside air. Moreover, and of more concern to the primary subject of this work, that outside air will also bring its inherent water vapor, its humidity inside. Once inside, that moisture must also be addressed.

Addressing Moisture Problems in Various Building Systems

Those tasked with maintaining buildings, from tradesmen who work on components to facility managers, inherit both the good and bad characteristics of structures, from those who designed them. The maintenance staff will be the ones who will deal with excess moisture. Their maintenance concerns regarding moisture intrusion, will fall into primary categories of; site drainage systems, foundation integrity, wall integrity, roof and ceiling assemblies, plumbing systems, and HVAC system maintenance. Each of these areas of concern are addressed in more detail below.

Maintenance of each area of concern will involve; regular inspections; lubrication, cleaning and repairs prescribed during the inspection; documentation of problems and responses, and the possible development of operations plans and maintenance schedules.

The first step, the inspection step, can be simplified, using a troubleshooting guide for indoor water issues. One example is included below.

SYMPTOMS OF MOISTURE PROBLEMS	PROBLEMS	POSSIBLE CAUSES		
		DESIGN	CONSTRUCTION	O&M
Mold growth	Leakage through the envelope, due to rainwater or groundwater control	Missing or poorly designed components	Missing flashing or building wrap Surfaces slope inward to building	Ground near the foundation settled Damaged rooftop curb flashing

			Below grade drainage systems are damaged	Shingles missing or roofing damaged
	HVAC system not removing humidity	AC equipment oversized AC equipment not designed for adequate dehumidification	Humidity sensors improperly wired	Chilled water set-point too warm Economizer set-point allows humid air to enter AC running continuously
	Condensation inside HVAC system, due to dirt on surfaces	Improper condensate drain design HVAC system surfaces insulated, or hard to clean		Cooling coils have not been cleaned Drain pan is clogged
	Wet materials were installed in building assemblies	Moisture sensitive materials are in contact with porous materials, exposed to water Maximum moisture content or emissions of materials was not specified	Flooring was placed on slab while still damp No vapor emissions test was done on slab	Penetrations created, during maintenance or installation of equipment, were left unsealed
Peeling paint Wood decay Corrosion	Rain or ground water intrusion into the building	Missing or poorly designed components	Missing flashing or building wrap Surfaces slope inward to building Below grade drainage is damaged	Ground near the foundation settled Damaged rooftop curb flashing Shingles missing or roofing damaged
Plumbing leaks / spills	Poor design Poor installation Poor operations or maintenance	Water lines located in places subject to freezing Poorly designed drain or shower pans	Defective pipe joints Accidental pipe penetration, by a fastener	Failure to inspect and repair plumbing problems
Water has reached materials	Capillary action drew it in through porous materials	Moisture barriers were not specified in design	Moisture barrier not installed	

intolerant to moisture		Drainage layer beneath slab was left out of design	Drainage barrier below slab was not installed	
Condensation	Warm, moist outside air enters building through cracks and holes, during hot humid weather Warm, moist inside air leaves building through cracks and holes, during cold dry weather Vapor barriers on outside walls were installed wrong Moisture sources not vented or poorly vented	Air barrier was left out of design No positive pressure building operation was specified Air barrier was left out of design Attic assembly air barrier was too hard to install Building is not operating at a positive pressure, while it is cold outside Vapor barriers were called for on both sides of an assembly Vapor barrier was specified on the wrong side of assembly Design of HVAC system overlooked venting moisture sources Insufficient ventilation was specified	Unintended gaps in envelope were created during poor construction Air barrier installed correctly, but holes cut through it for wires and pipes Unintentional vapor barriers were installed on other side, like vinyl wall cover, blackboards, mirrors, etc. There are leaks in exhaust ducts Exhaust systems are poorly balanced Exhaust dampers are closed	Access holes were not resealed after they were created HVAC system changes created an unintended positive pressure inside Unintentional vapor barriers were added after construction on other side Exhaust fan has a broken belt Exhaust ducts or grilles are clogged
Delamination Improper curing	Wet materials were installed in the buildings assemblies	Moisture sensitive materials are in contact with porous materials, exposed to water	Flooring was placed on slab while still damp No vapor emissions test was done on slab	

		Maximum moisture content or emissions of materials was not specified		

- Problems occur when design intent is not met, because other equipment, besides that which was specified, is substituted for budgetary reasons.
- Air leaking through exterior envelopes, may be entering through holes created by tradesmen or maintenance personnel, but it could also be caused by changes in control sequences of fans and exhaust systems.
- Large sources of humidity indoors, like pools, saunas, and large showers, will aggravate problems with interior condensation.

This troubleshooting guide is just an example of what is possible. Numerous other problems and problem sources exist, which can be added to such an organizational aid. The best charts, are those which are customized by maintenance personnel assigned to each building. Because each building has its own peculiar flaws.

With or without such a chart, the following items should be considered during routine inspections of each major building system, each line of defense against water intrusion.

Maintaining Site Drainage

If drainage systems on site, meant to channel water away from the structure, are not maintained, heavy rain or snow melt can cause unexpected flooding, with subsequent property damage. To prevent this, maintenance plans should be put in place to inspect and maintain site drainage. The runoff from impervious surfaces, like walks, parking areas, and roofs, should be diverted to swales designed to carry it away. Care should be taken, that future modifications to the site do not disrupt, destroy, or overload the designed and properly working site drainage systems.

A preventive maintenance plan for site drainage systems, should be created to insure they serve, and continue to serve, the purpose for which they were created. It should include a written overview of the intended operation of the drainage system. A frequency of inspection should be specified for each site system, as well as key items to be observed and verified. Maintenance activities necessary to keep each system working, like the removal of leaves and debris from inlets, should be specified. Maintenance agreements, pertinent to any site drainage systems, should be included in the manual, along with contact information for each contractor or tradesman liable to be involved.

A preventive maintenance plan should be created to cover maintenance of impervious surfaces. Make sure the design intent is clear, for how each surface is intended to drain. Create an inspection checklist to verify design intent is being met, and that runoff is making its way into a drainage system to be carried away. Develop clear instructions to be given to workers, so plowed snow is not placed in areas that will interfere with drainage, or wind up piled against the building. Lawn care workers should be informed of drainage systems and their work done, so they do not damage or obstruct components of the system, or its proper operation. Lawn care workers are also an excellent source of real time information, concerning how drainage really occurs on site.

Care should be taken to prevent further site modifications from damaging designed drainage systems. Verify beforehand that additional paved surfaces, even those topped with gravel, will not overburden existing drainage or water infiltration capacities. Those who maintain the site drainage systems, should be included during the planning of any additional impervious surfaces on site.

In all these efforts to maintain site drainage systems, records of problems and corrections should be kept. Photographic records of site conditions, will become valuable in establishing changes in site conditions, occurring over time.

Maintaining Foundations

Building foundations, besides supporting the structure above, are intended to prevent the intrusion of rainwater and snowmelt into spaces below occupied levels. But these seeming impregnable portions of the building, are very vulnerable to attack from ground water, plumbing leaks, and condensation. Since these areas are not usually occupied, periodic inspections are especially critical to find and correct developing problems. This will reduce risk of serious damage to foundations, sometimes occurring when issues develop, but remain unresolved for a significant length of time. Tying back into the previous subject, one obvious precaution to take, is to ensure that site drainage systems always divert water away from the foundation. Periodic inspections to verify this should be scheduled and conducted. Maintenance of the foundations, should be periodically conducted as well. A checklist and work order system are useful tools for this.

Visual inspections on the exterior, can determine whether drainage systems are properly diverting water away from foundations. Soil settlement, or pooled water near the building, indicates a reason for concern. Roof drain leaders should all be in place and secured. New cracks in foundation walls are indicators of settlement, often due to the presence of water below that footing. Verify that walks and impervious surfaces, adjacent to the building, are still sloped and shedding water away from the structure. Newly planted or sprouted trees near drain lines, should be pruned or entirely removed before their roots can demolish or clog the drains. Exterior hoses and irrigation systems should be inspected and tested for leakage. Finally, inspections right after, or during, heavy rain or periods of rapidly melting snow, are always valuable to visually determine if water does indeed move away from foundations as intended.

Settling because drainage systems not maintained

Inspections on the interior of foundations can also identify developing problems. Again, newly developed cracks in foundation walls are indicators of moisture settlement below. Proper operation of sump pumps and internal drain systems should be verified. Seeping, or wicking through foundation walls, will often leave evidence of stains, damp surfaces, efflorescence, peeling paint, or surface mold. Musty odors are an olfactory warning sign of mold or rot. Check wood materials in foundation areas for swelling, warp or mold. Test and record the relative humidity and temperature in the enclosed foundation space. Check for any delamination of applied finish materials, such as flooring. Finally, look for condensation occurring on pipes and other hard surfaces.

Maintaining Walls

If interior and exterior walls are not routinely inspected, failures in their integrity can lead to invading moisture remaining unnoticed and not being repaired. Resulting problems will include expensive building repairs and potential health problems for inhabitants. It therefore becomes important to create and carry out routine inspection of walls, to detect moisture intrusion before serious problems result. Walls must also be routinely maintained, to make sure they fulfill their intended purpose of separating inside atmospheres from outside.

Inspections can pinpoint problems, before they become catastrophes. A record should be made of wall types, maintenance procedures, contact information for pertinent contractors, and a record of inspections that have been conducted. A checklist should be used for proper evaluation of each type of wall assembly. Problems should be marked on record copies of the exterior elevations, as problems are discovered. Special attention should be paid to copings, flashings, counter flashings, and the integrity of masonry walls. Photographic records should be included with details, of how each discovered problem was corrected.

Maintenance of walls includes both repairs, and ongoing periodic, visual inspections. This is especially important following heavy rains, preferably in every season, since outside temperatures can affect the performance of envelope components. Interior walls and ceilings should be checked for telltale signs of water damage. Any visible evidence of moisture, cracking, or movement should be noted. Masonry walls should be searched for cracked or spalled units, and deteriorated mortar. Mold and algae growths are sure indicators of the nearby presence of moisture. Remember that ivy and other plants, growing on masonry walls, are not only picturesque, but incredibly destructive to mortar joints. Ivy covered walls tend to leak water like a sieve. Periodically open weep holes in masonry with a stiff wire, without damaging the flashing behind them. Inspect caulking at openings and refresh or replace it, where cracked or containing voids. Inspect flashing materials for cracks, rust, open ends, or open joints. Repair any perceived problems immediately.

When done with each inspection and repairs, incorporate those notes, and attendant photographs, in a record logbook being kept for wall maintenance.

Roof leak affecting the wall below

Maintaining Roofing and Ceilings

Roof and ceiling assemblies are subject to damage from normal wear, severe weather, building movement, improper design, poor construction, and inadequate maintenance. It should go without saying, that when problems develop at the top, the intruding moisture will damage all it can successfully invade below. Uncorrected leaks, coming through the roof system, will impact inhabitant productivity, as well as quickly resulting in damage to contents and the structural integrity of the building. The focus in maintaining the weather resistance of roof to ceiling assemblies, should be on thorough maintenance plans involving periodic scheduled inspections, with immediate follow through to fix developing issues and concerns.

The first step in a preventive maintenance plan is to read and thoroughly understand, manufacturers and installation contractor's, warranty terms and conditions. That knowledge is very useful in developing a checklist and logbook to; observe and evaluate the roof, the curbs on which equipment is mounted, flashing attached to those curbs and to other surfaces with which the roofing intersects, drainage patterns on it, and traffic patterns of those who must traverse the roof. In the logbook, record roof types, their attendant drainage system components, installing contractor information, manufacturers of other systems and components affecting the roof integrity, roofing warranty information, and written and photographic records of all inspections. A roof plan should also be included in the logbook, detailing all features on the roof like scuttles, HVAC equipment, drains, gutters, downspouts, scuppers, vents and roof angle changes. Copies of that roof plan should be used each time, to locate and record, observed problems and repairs that were executed.

The purpose of periodic roof inspections should be to determine whether roofs are working as intended, to find signs of weakness, deterioration, or trouble spots, and to identify where repairs are needed. Care must be taken during the inspections, not to create damage. When ladders are typically used to inspect steep roofs, or access higher roofs, do not rest these ladders against the gutters. It can damage their sides or loosen them. When on the roof, take care to step on flat portions over structural members, and avoid stepping on side laps or standing seams of metal roofing.

While inspecting ceilings and roofs, look for these specific indicators of moisture intrusion.

- Check interior walls below them, and the ceilings themselves, for water stains or for structural distress.
- If you can easily access the bottom of the roof deck, look for water or insect damage, rust, settling, or other damage. Check the interior face of exterior walls below roofing members, for signs of movement or cracking.
- Exterior walls and roof overhangs should be checked for signs of moisture, cracking, or movement.
- Ponding on the ground, adjacent to the building, may indicate a blocked drainage component. Gutters may need to be cleaned or a downspout unstopped.
- Verify continuity of the roof edge and covering. Check for loose ends, gaps, metal deterioration, loose or missing fasteners, accumulated debris that indicates ponding, or physical damage to the roof surface. Pay special attention to flashings and counter-flashings. If caulk or roofing tar has been used for temporary repair, verify that the caulking is still intact and sealing as intended.
- Search for spots with soft roof insulation and cracked or discolored walls.
- Look for signs of moisture infiltration, anywhere surfaces intersect, like curbs, flashing, etc.
- Check for missing weather seals on equipment housings, and for damaged caulking where the supports penetrate roofing.

- If deflection of the roof was allowed for in the original design, make sure that roofing and flashing can still move independently of one another.
- Inspect the seal between caps, flashings and roofing, at hips, ridges, and valleys. Ensure there are no obstructions blocking water flow at the valley edges.
- Inspect the drainage systems to make sure fasteners are in place, sealants are still in good repair, nothing is missing, and no components are blocked. Use a snake to verify the open condition of drains suspected to be blocked. Do not use water for this. If a roof drain is blocked by ice, don't risk damaging the drain by chipping or breaking the ice.
- Inspect masonry weep holes for signs of dripping.
- Check for areas on the roof, where ponding may be occurring, especially near skylights, scuttles, curbs and other openings.
- Accumulated debris is another indication of ponding. This problem must be addressed at once, even if it is an underlying structural issue, because standing water can and will rapidly deteriorate roof surfaces.
- Granules in gutters often indicate deterioration of the roofing, to which they were once bonded.
- On membrane roofs, pay special attention to areas between roof trusses and beams, as they are likely spots for deflection to occur.
- On membrane roofs, pay attention to joints between two sheets of membrane, and to changes in the angle of the roof, to verify separate plies are still properly bonded.
- On built-up asphalt roofs, look for blisters caused by air or water vapor trapped beneath. Check for cracks in the membranes, as well as splits, ridges, and uplift at seams.
- On elastomeric membrane roofs, inspect for open seams, shrinkage, backed-out fasteners, and damage after heavy winds.
- On ballasted roof systems, inspect for missing or displaced ballast and insulation boards, beneath the roof membrane.
- On adhered roof systems, check for loose membranes, displaced insulation boards and tented insulation fasteners and plates.
- On mechanically attached roof systems, note any cuts in the membrane, displaced insulation boards and tented roof fasteners and plates. Check for loose flashing, including at curb mounted HVAC units.
- On asphalt shingle roofs, check the tops of vertical slots between tabs. This area is usually the last place on a shingle to dry. Moss allowed to grow on these roofs, will keep the roofing damp. Use a water hose and nozzle to remove any growth. Spray downward, so water is not forced up under the shingle laps.

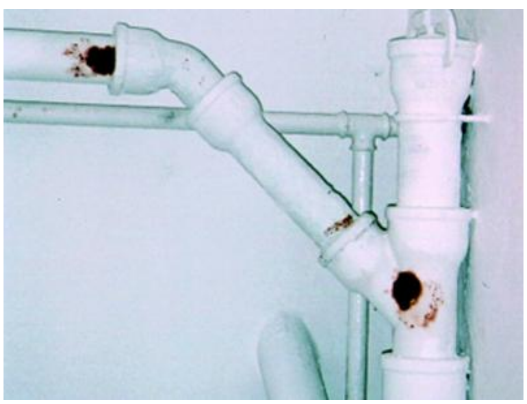
Disaster waiting to happen

Maintaining Plumbing Systems

When plumbing systems are not maintained, flooding of the building, or the buildup of condensation can occur. Unless these normally out of sight, out of mind, plumbing components are inspected regularly, minor leaks in them can foster mold growth and damage to building components. They must be uncovered, inspected and maintained.

A manual should be created, establishing a set schedule for review of plumbing systems. These inspections should check piping and other distribution equipment, pumps, valves, fixtures like sinks that use water, water heaters and storage tanks, fire sprinkler systems, drainage system components, and insulation that covers pipes. Deteriorated joints and connections, showing evidence of leakage or corrosion, are of special and probably immediate concern. To be also noted, and at least immediately insulated, are pipes carrying water that are in areas that may be subject to freezing. Or in areas that have suddenly become subject to freezing, because of current issues with a heating system. Better yet, place supplemental sources of heat in those areas. If they are not yet leaking, or have not yet burst, a bullet has been dodged.

Contact information for professionals, capable of responding to and correcting an emergency, should also be included in a plumbing maintenance logbook. As-built plans of the plumbing systems should be in there, locating shut-offs and valves that control zones and the overall plumbing systems. That is need-to-know information for at least someone on staff, at any hour of the day in the building.



Evidence of leaky pipe joints

Mold growth because of bathtub leak

Maintaining HVAC Systems

Inadequately maintained HVAC systems can become unexpected sources of water in building interiors. If humidity controls fail, more condensation occurs than was intended, or drain pans begin overflowing. Moisture damage will begin, and mold can begin to grow. Preventive maintenance plans should be created that set routine times for inspection, and compliance with equipment manufacturers' recommendations. At a minimum, inspections of HVAC system components should be conducted semi-annually. Inspections should also be conducted, following heavy rains or other events that might affect the performance of HVAC systems.

The maintenance guide / logbook should contain the following. Manufacturers' warranties, and recommendations for maintenance of their products, should be in there. Contact information for the installers of the equipment, as well as repair personnel should be included. A verifiable performance goal, set during design, should have procedures in place to determine whether the goal is being met. Records of all HVAC installations, as well as repairs to the same are important. Procedures to be followed, upon discovery of a problem, should be part of the logbook. Future replacement of equipment can be scheduled, so budgeting for the same can be included in current financial planning.

HVAC components should be inspected to insure they are properly supplying, returning, and conditioning air, and that systems set in place to remove or add humidity to the air, are still properly functioning. Specific HVAC items to be routinely inspected are numerous. Nonetheless, they should all be included in a preventive maintenance plan.

Thermostats should be checked for proper functioning, every fall and spring, or when complaints are received, that they don't seem to be working. If a thermostat is programmable, verify the time is set correctly, including for AM or PM, and the programming is for hours of occupancy. Place a calibrated thermometer next to the thermostat in question, but not touching the wall, to determine if the temperature of the wall surface is affecting the thermostat being inspected. If the thermostat reads more than one degree different than the thermometer, there is a problem. The thermostat should be cleaned, the mercury switch checked to verify it is level, and holes in the wall for control wires caulked, to prevent air in the wall cavity from affecting readings.

Control sequences should all be calibrated. All clocks on a controlled system should read the same, and have the correct time and date. Make sure that equipment operates as intended, in accordance with the programming of the control unit.

Outdoor air intakes should be inspected. Potential sources of contamination near air intakes, like idling vehicles, dumpsters, trash, or decaying materials, should be removed so odors are not pulled into the building. If it is not possible to remove them, it may be necessary to reconfigure and change the intake location. Debris screens behind intakes should be checked to verify they are free of clogging material, and no insects have nested in them. If outdoor intakes are near ground level, vegetation should be cleared away from them for a distance of at least five feet. Anyone mowing lawns, should make sure their mower discharge is directed away from any air intake, when they pass it.

The proper operation of outdoor air dampers, should be observed and verified. Trigger controls to force dampers to operate and watch to see if dampers really move. Adjustment or lubrication might be necessary to obtain proper operation. Outdoor air volumes that are entering the system, should be regularly measured for compliance with design intentions.

Cooling coils, pans, and condensate lines should be regularly checked for cleanliness, to proper function. All drain traps should be checked and filled with water whenever needed, to prevent sewer gases from entering back into the building, through floor drains. Ducts downstream from the cooling coil, should be regularly checked for mold growth, resulting from condensation blowing off the coil. If found on sheet metal, the mold should be removed by a specialist. If found in, or on insulated lining, the duct lining will need to be replaced.

Evaporative cooling equipment should be checked for cleanliness, and for evenly distributed wetting across the full face of the pad. Clogged media should be replaced, so supply air is not constricted. That would result in high velocity air flow, pulling water off the media and directing it downstream, into the ductwork. Verify that overflow drains are working, and the media is not in contact with standing water in the sump, when the unit is not operating. Verify that controls are set to prevent the unit from operating, when it is raining outside. Otherwise, incoming air will be overloaded with humidity. Finally, as above, inspect ductwork downstream from the cooling coil for mold growth, and takes steps to remediate it, if found. But first, fix the problem that led to excessive moisture being present to support mold growth.

Visually inspect and replace HVAC system filters on a regular scheduled basis. When they become clogged, filters can be sucked out of their frames by the force of the airstream, leaving unfiltered air free to flow around them and enter the indoor environment.

Ductwork should also be inspected on a regular basis. If there is significant particle build-up, or mold is discovered to be present, sheet metal ducts should be cleaned, and contaminated duct liner or insulation replaced. Dented, damaged or disconnected ducts should be repaired or replaced. All seams should be checked, and those which leak, should be resealed with appropriate materials. Dirt and dust buildup around diffusers, is a telltale sign of missing filters or dirty ducts. Even cooling coils should be inspected, to verify there is no mold growth on them, contributing to spores in the airstream.

Return air plenums, when dirt and dust collect above ceilings, can result in a steady supply of particulate being returned to the airstream. Periodically inspect return air plenums for such buildup, but also check for discolored ceiling tiles below return air plenums. Water stained ceiling tiles, can also harbor mold growth and contribute spores to the return airstream.

Humidity controls, put in place as part of an HVAC system, should be checked to ensure they are in good working order. Hot humid air pulled in from the exterior, with no modification beforehand, will result in condensation on cooler surfaces inside. Monitoring temperature and humidity inside the building, allows better tracking of humidity sources. Dehumidification equipment should be tested, to verify it is in good working order.

Condensation on air duct

Making Your Home Weathertight

There is one built-in checklist, one easy type of inspection by building inhabitants, that is a good determinant as to whether air quality inside has been impaired. Energy codes are now being enforced that require weatherization of buildings, to reduce energy being expended for climate control. The ‘tighter’ a structure, the more care needs to be taken to minimize sources of air pollution from inside the building. Inhabitants must remain alert to, and check periodically for, stuffy air, condensation on cold surfaces, and other visible indicators of inadequate ventilation. Because, although weatherization does not usually contribute to the presence of pollutants, it will keep them inside, when once they would have been diluted or exfiltrated by natural ventilation.

There is a serious health risk, posed by the aggregation of different sources of indoor air pollution. Steps have been detailed that most building owners and users can take to minimize this problem. They are found in a safety guide, available from the U.S. Environmental Protection Agency (EPA) and the U.S. Consumer Product Safety Commission (CPSC). There is also a section on air quality in offices, and what you can do if you suspect your office has an indoor air quality problem.

DEALING WITH BUILDING DAMAGE FROM MOISTURE

Suppose that despite best efforts to repel it, despite best efforts to keep all lines of defense against moisture intact and working, the water still wins? The signs are unmistakable. Our senses assure us that rot is occurring, materials are decaying, and mold growth is happening before our very eyes. We have unwanted moisture, inside our living, learning, or working environment. How do we best respond, to reclaim what we built, and get it back, free of health risks?

Testing and Remediation of Dampness and Mold

The first thing to understand, is that there are no established standards for what constitutes acceptable levels of biological agents in indoor air. Short-term air sampling for mold spores, does not tend to yield results representative of actual exposures. What part of the presence of mold and its growth, that building inhabitants react to problematically, is still pretty much unknown. It might be the mold itself, a compound produced by the mold, bacteria, compounds released into the air when organic materials are broken down by mold, or something we don't even know enough to speculate upon. Visual inspections tend to be far more reliable than tests, in establishing a correlation between the known presence of mold, and health risks in building inhabitants, who are exhibiting symptoms or voicing complaints, about the indoor environment.

No testing to verify mold, needed here

We do know steps that should be taken in general, upon the discovery of mold. The water source needs to be isolated and repairs made immediately, to prevent further intrusion. If wet materials cannot be dried within 48 hours of exposure, they need to be removed. If visible mold is identified, exposure to it by the inhabitants must be minimized, until the mold can be safely removed. Then some time must be allowed to pass, to properly verify that mold growth has been stopped.

Those remediation tasks, to be undertaken after discovering mold growth, can be expanded as follows.

Testing for Contaminants

If an area that previously contained mold has been cleaned and bleached, that may have resolved the problem. But should mold reappear, the area continues to smell of mold, or the inhabitants continue to complain about air quality in the space, further steps will need to be taken.

The first step if odors persist, or visible mold reappears, is to repeat the cleaning and bleaching process. Materials like carpet, that remain wet and exhibit mold growth, cannot be properly cleaned. They will need to be discarded and replaced. But if complaints continue afterwards, sampling and inspection should be done by a trained remediation specialist, to ensure excessive concentrations of microbes are not still present in the building. While doing so, appropriate respiratory and personnel protection should be used. Negative pressures may need to be set up in contaminated areas, to prevent spreading microbes to nearby areas during testing and cleaning processes.

Inventory Damaged Materials

To prevent the growth of mold following incursion by water, certain tasks have been found to be effective. They begin with the necessity of inspecting and inventorying, all water damaged building materials and furnishings. A written and photographic record should be made, for use with insurance claims and other financial and facility records.

This is a quick overview of how different water damaged building materials, will need remediation in different ways. Contaminated sheetrock will need to be removed and discarded with either few controls, or under controlled abatement procedures, depending on the degree of contamination. If ceiling tiles have been damaged by steam, they can be dried and monitored for future mold growth. If damaged by water, ceiling tiles will need to be discarded and replaced. Electrical system components will need to be inspected by a building inspector or electrician. Components that appear to be damaged or have their performance capability compromised, will need to be discarded. Furniture damaged by steam or potable water might be salvageable, but if other types of water damage occurred, it too will need to be discarded. Delaminated furniture will need to be replaced. Hard surfaces, which can include intact laminates and hardwoods, can simply be cleaned. If wood composites like particle board, were subjected only to steam, they can be air dried and monitored for developing problems. If they were damaged by other types of water, they will need to be removed and replaced. If carpet has been wet for less than 48 hours, it can be cleaned, disinfected, and monitored for future problems. If carpet has remained wet for more than 48 hours, it will need to be removed and replaced. Paper files, if non-essential, should just be discarded. Paper files that are essential, if they cannot be dried within the first 24 hours, can be cleaned, frozen, and then copied photographically.

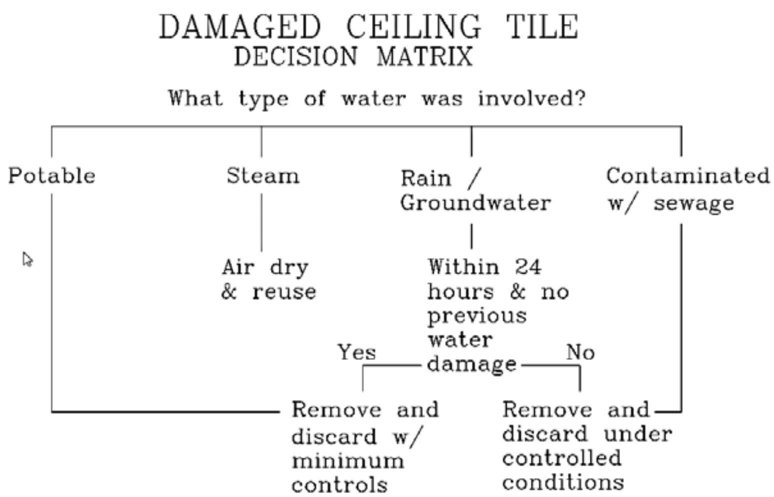
Far more detailed responses to water damage, in specific areas of loss, are discussed below. For each category, a decision matrix is included to use as a reference guide.

Inventory and Response to Ceiling Damage

As a rule, all wet ceiling tiles should be removed and discarded, within 24-48 hours of being damaged by water. If the ceiling tile was only damaged by a small steam leak, and the shape of the tile has not changed, it might be possible to air dry and reuse that specific tile.

Water stained ceiling tile

A decision matrix for dealing with water damaged ceiling tile is below.



Inventory and Response to Drywall / Plaster Damage

Time following exposure to water is the primary factor in response to drywall damage and to the insulation behind it. If restoration work can begin within 24 hours, damp drywall and insulation can be removed and disposed of, in a normal fashion. If more than 24 hours has elapsed, or there is already mold on the sheetrock from previous exposure to water, then controls will need to be put in place to prevent restorative work from spreading mold spores elsewhere. Damaged sheetrock will need to be removed up to at least 12” above the damaged areas.

A chalky surface can form on wet lathe and plaster, leaching minerals from the wall. Surface material which is loose, will need to be removed, and the remainder allowed to dry, before recoating the remaining surface with an antimicrobial paint. If a strong odor begins to develop in a plaster wall, it is damaged, will need to be removed under controlled circumstances, and replaced.

There are multiple controls that can be put in place, to contain the spread of mold spores and their dispersal into the airstream. Use of critical barriers to segregate work areas, establishing negative air pressure zones in work areas, and respiratory protection for workers, are all on the table. Handwashing while working, and showering afterwards, are recommended procedures for working with water damaged materials.

Hard surfaces that do not absorb water, can be cleaned with detergent, followed by a rinse with a bleach solution. Another rinse with clean water is not recommended, since the idea is to allow the bleach to remain on the surface and inhibit further growth. The bleach solution should not be allowed to contact metals, like those in fasteners, because the chlorine content will cause metals to rust. Bleach should only be used in a well-ventilated area, and bleach solutions should never be used in conjunction with any other cleaning solutions., especially ammonia. Potentially deadly, poisonous vapors will result. Once cleaning is complete, heaters, dryers, or fans, or a combination thereof, should be used to finish the job and eliminate any remaining moisture.

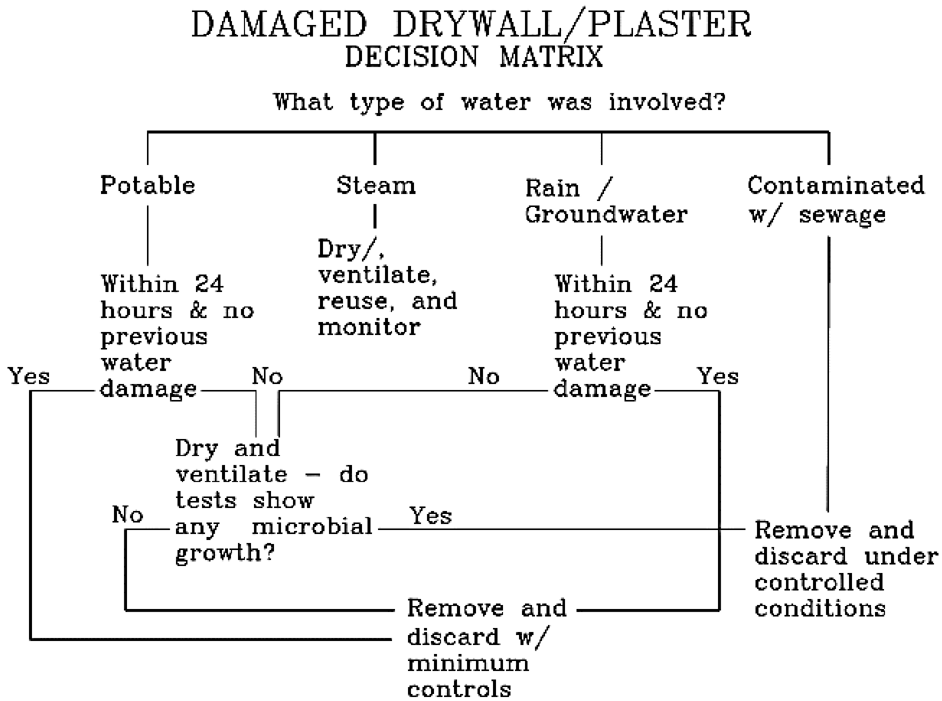

Water stains on drywall


Mold on drywall


Mold inside a wall cavity


Mold on the back side of drywall

A decision matrix for dealing with water damaged drywall or plaster is below.



Inventory and Response to Carpet Damage

Time following water exposure, and the source of water that caused the problem, both factor in how carpet damage is remediated.

If the carpet has been contaminated with water containing sewage backup, treatment will depend on the size of the affected area. Large damaged areas of carpet will need to be removed, the floor disinfected with bleach and water, thoroughly dried, and new carpet installed. If the area is small, the water should be extracted, the carpet in that area cleaned with bleach and water, that solution extracted, and the area thoroughly dried. If odors, or any other visible problems manifest, the carpet will still need to be removed and replaced.

Carpet that has become wet because of ground water, roof, steam systems or potable water system leaks, is treated in varying fashions, based on whether treatment can commence, before or after 48 hours has elapsed since the leak occurred.

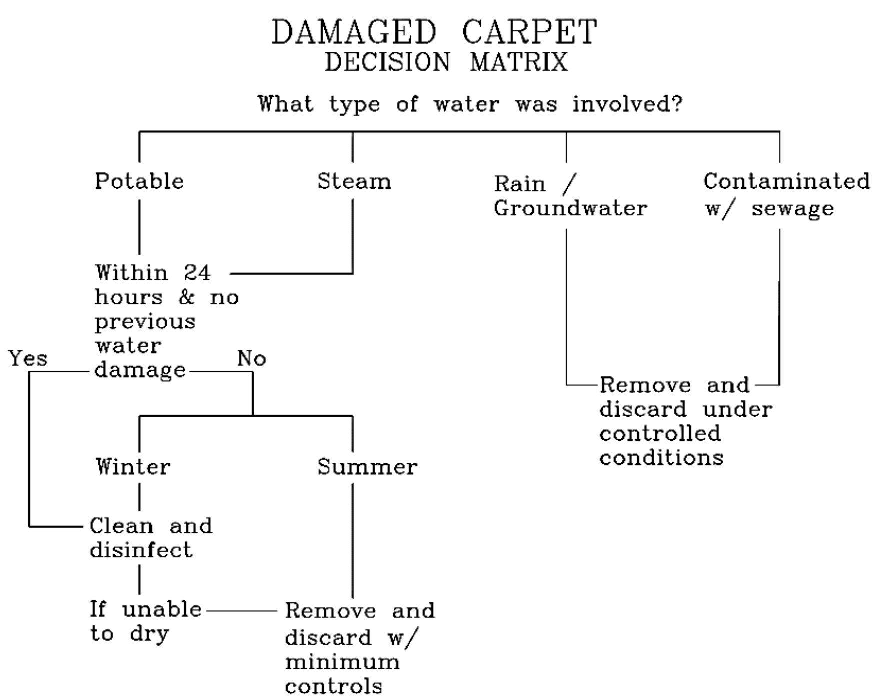
If carpet has been wet (with no sewage back-up involved) for less than 48 hours, the carpet can most likely be saved. Get everything off the carpet, then use wet vacuums to extract as much water as possible. Afterwards, shampoo the carpet. Then rewet the carpet with a bleach solution, preferably not a solution containing biocides, since people can have reactions to those as well as microbes. Steam cleaning, using water heated above the boiling point, can be used in lieu of treatment with a bleach solution. Extract excess water. Then, within 12-24 hours of treatment, carpet should be dried with dehumidifiers, dryers, and exhaust fans.

If carpet has been wet (with no sewage involved) for more than 48 hours, salvaging it will largely depend on the season. If damaged occurred in the winter, the previously described protocol can likely be used to salvage the carpet. If damaged in the summer, if the area involved is not in an air-conditioned space, and dehumidifiers were not immediately available and put into use, the best option will be to remove and replace the carpet. The problem necessitating that solution, is the combination of heat and humidity that will encourage rapid mold growth.

Following initial treatment of wet carpet to save it, should visible mold reappear, or an odor become apparent, the cleaning and drying process should be repeated only once. Afterwards, it is advisable to have expert testing done in the area, to confirm success in eliminating concentrations of mold. If such mold is still present, it will be necessary to remove and replace that carpet. As before, when damaged carpet is being removed and replaced, multiple controls should be put in place, to contain the spread of mold spores and their dispersion into the airstream.

Drying carpet

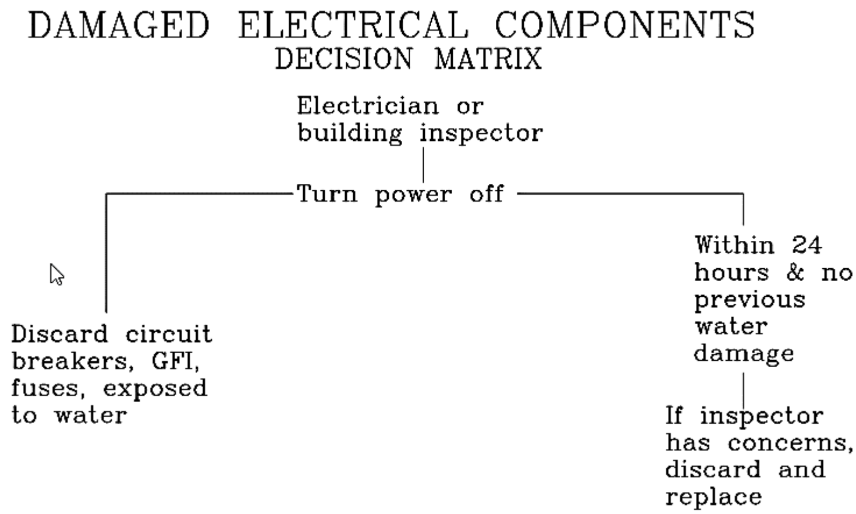
A decision matrix for dealing with water damaged carpet is below.



Inventory and Response to Electric Systems Damage

Time passage, after exposure to water, is not a factor when evaluating components of electrical systems that became wet. All such wiring, fixtures, and outlets can be considered shock hazards, until they have been checked and cleared by a qualified inspector or electrician. Until then, power to that area should be cut off, also by a qualified electrician, since the panel may also present a hazard of shock. Any breakers or fuses that became wet, should automatically be replaced. Switches and outlets might be salvageable once dried, but should any doubt exist, replace those as well. Anything like motors, fixtures, etc. that became wet, should be opened, air dried, and inspected by a qualified inspector or electrician, before being reassembled and put back into service.

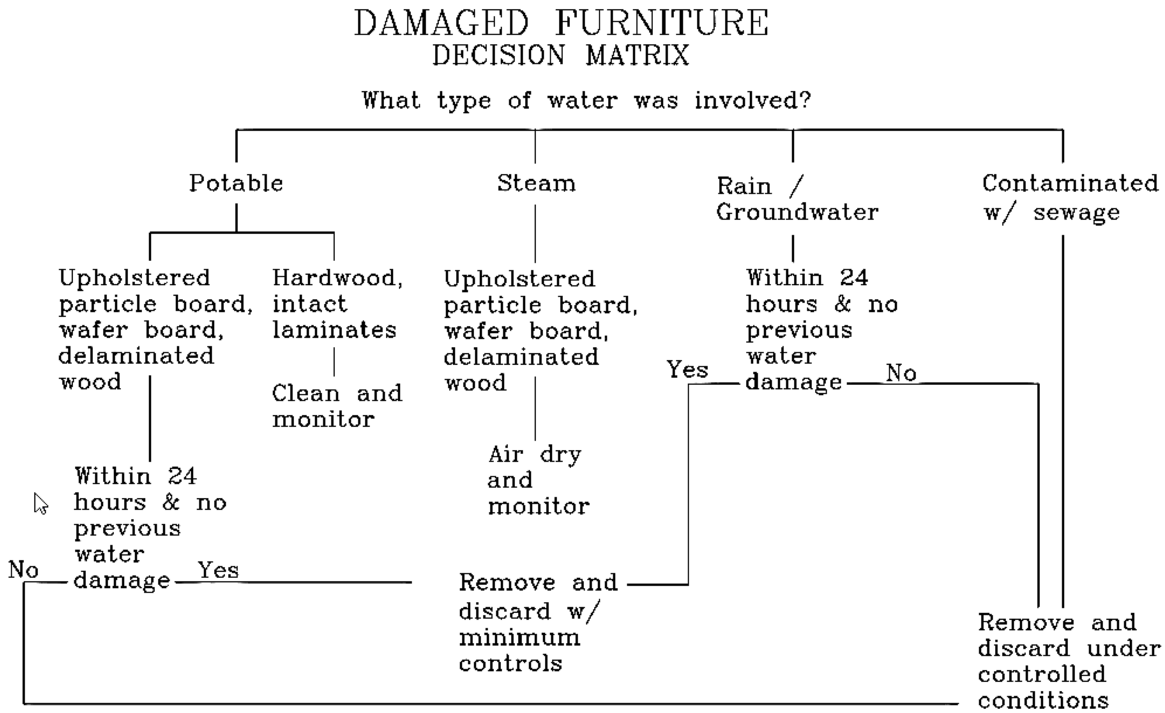
A decision matrix for dealing with water damaged electrical components is below.



Inventory and Response to Furniture Damage

The primary factor for evaluating furniture, that has been subjected to water, will be whether it is upholstered. If the water came from steam system leaks or drinking water, upholstered furniture should be dried within 24 hours and monitored in the future, for fungal growth or odor. Anything wet from other water sources should be discarded and replaced. Hardwood furniture surfaces can be air dried and cleaned with a bleach solution. Laminate furniture, that is delaminating, should always be thrown away and replaced. Likewise, furniture made of particle board should be replaced, unless it was because of a steam leak. Then, if it is still integrally sound, it should be dried, cleaned, and monitored for growth or odors.

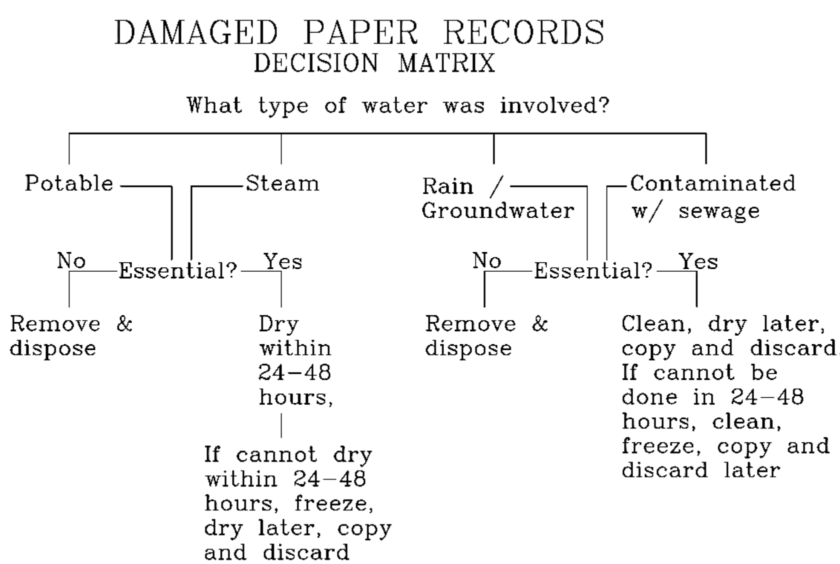
A decision matrix for dealing with water damaged furniture is below.



Inventory and Response to Paper / Records Damage

The primary factor for evaluating paper records, that have been subjected to water, will be whether the records are essential. If not, they should be discarded. If essential, they should be moved to an area where they can be dried, photocopied, and then discarded. If large amounts of essential paperwork cannot be dried immediately, they can be temporarily frozen in small batches, until they can be thawed, dried, photocopied, and then discarded. If paperwork was damaged by steam, it can be dried and monitored, until it is apparent there will be no mold growth. If mold appears, those records should also be discarded.

A decision matrix for dealing with water damaged paper records is below.



Specific Instructions for Specific Materials

Again, for use as a general checklist, the following recommendations are offered as a summary of the information above. A cheat sheet of sorts, on dealing with certain water damaged materials, after discovery of water intrusion.

- Ceiling Tiles: Get rid of them and replace them. Porous materials cannot really be cleaned. If the materials were glued on the ceiling or walls, there is a chance they contain asbestos. A material sample should be tested for asbestos, prior to full removal and disposal, to determine if special care should be taken in handling damaged tiles.
- Carpet and Backing: Relocate everything sitting on top of it, extract all possible water with a wet vacuum system, use de-humidifiers to reduce humidity levels in the space, clean the carpet with a steam cleaner or a bleach solution, dry it again, and use fans to keep air circulating in the space till everything in it, is once again dry.
- Cellulose Insulation: Throw it away, disinfect and dry the substrates to which it was attached, replace it with new insulation
- Fiberglass Insulation: Throw it away, disinfect and dry the substrates to which it was attached, and replace it with new insulation
- Electrical: All wiring, light fixtures, and electrical outlets, that have become wet, are shock hazards. Turn power off in the area. Get a qualified building inspector or electrician, to inspect all components and decide whether they can turn power back on. All circuit breakers, GFI's, and fuses that became wet, need to be replaced. All motors and light fixtures, touched by water, need to be opened, allowed to air dry, and then inspected to verify there is no moisture in them, before they are reassembled and turned back on.
- Books and Papers**:** If they are wet and are not essential, just throw them away. Important papers and records should be dried, photocopied, and then discarded. If there are too many such records, to handle in a short time, freeze them in batches in separate plastic bags, and deal with thawing, recording, and then disposing of them, as time becomes available. If wet items have a high sentimental value, there are specialists who can help with their restoration.
- Concrete or Cinder Block Surfaces: Pull as much water as possible from inside them and off their surfaces, then use heaters, fans and de-humidifiers to finish drying them as quickly as possible.
- Hard Surfaces, Porous Flooring (Linoleum, Ceramic Tile, Vinyl): Vacuum water up off these, wipe them with a damp cloth and detergent, or a solution containing bleach, and allow them to thoroughly dry. Make sure the substrate below them, is also completely dry.
- Non-Porous, Hard Surfaces (Plastics, Metals): Vacuum water up off these, wipe them with a damp cloth and detergent, or a solution containing bleach, and allow them to thoroughly dry.
- Upholstered Furniture: If discovered immediately after the water event, vacuum all water from them with a wet vacuum. Dry them using a combination of heaters, fans and dehumidifiers. If vacuuming and drying is not completed within 48 hours, the furniture will likely need to be discarded. Restoration specialists may be able to restore pieces considered very important. If furniture has remained wet for over 48 hours before the damage is discovered, it needs to be thrown away and replaced.
- Wallboard (Drywall or Gypsum Board): If discovered immediate after the event, drywall may be dried in place, if there is no swelling, no discoloration, and seams are intact. The baseboard must be removed to properly inspect drywall. It is very rare that drywall can be salvaged like this, using a combination of heaters, fans and de-humidifiers, but it does happen on occasion. If wallboard cannot be dried, before 48 have passed after becoming wet, or if more than 24 hours have passed before damage discovery, cut the drywall out up to 12" above the highest point of apparent damage. If there is any question as to whether drywall is truly dry, a moisture meter can be used to check it. Compare that reading, to an area of drywall that was not damaged. Discard

damaged, unsalvageable drywall, clean and thoroughly dry the substrate to which it was attached, then install new drywall.

Moisture meter

- Wood Surfaces: Get moisture off the furniture, paneling, or trim immediately. Finish the drying process with gentle heat, fans, and de-humidifiers. Be very careful when choosing to expose hardwood floors to heat. If they swell under the combination of heat and moisture, the wood will buckle and destroy itself. Finished wood surfaces can be cleaned with a mild detergent and allowed to air dry. Wet paneling should be pried away from the wall, so air can circulate behind it, then reattached, once it has been thoroughly dried.
- In all cases, regardless of the material involved, the repaired or salvaged products should be closely monitored for a while, to make sure no visible mold growth appears, and no odor emerges, indicating hidden mold growth.

AIR QUALITY CONCERNS

Air Quality in General

It has been well established, that excessive amounts of mold in the air in occupied structures, can be unhealthy for inhabitants. Health related issues, linked to poor air quality, can be largely abated by minimizing our exposure to mold and its contaminants. As indicated above, once mold has secured a foothold, contaminated materials must be cleaned or removed, depending on how porous they might be and how quickly treatment began.

Moreover, the source of moisture that fueled the colony growth must be found and stopped. Otherwise, additional damage will occur to the building, its components, and inhabitants. Inevitably, with a steady supply of moisture, the mold will return. Prolonged hot weather is also conducive to mold growth. This is especially true, when combined with humidity from sources inside the building.

But mold is not the only problematic pollutant, found too often in the airstreams we inhabit.

Levels of Indoor Air Pollution

The primary cause of indoor air quality problems, are sources that tend to release particles or gasses, into the airstream. The secondary cause, resulting in high levels of such pollution, is inadequate ventilation. Not enough outside fresh air is being brought into the building, to significantly dilute pollutants in the airstream. While not enough polluted air is being removed, to affect the balance. With either issue, levels of pollutants tend to slowly rise, with concentrations often increasing during hot, humid weather.

Pollutant Sources

Sources contributing to pollution of air inside our buildings, are many and diverse. Building materials like; insulation containing asbestos, wet carpet, furniture, and cabinetry made of pressed wood, can release particulate into the air. Cleaning products, personal care products, and product sprays for hobbies, all contribute aerosolized particles. Combustion equipment, like wood burning stoves, fireplaces, furnaces, and even cigarettes, release fumes and particles into the airstream. Central HVAC systems, humidification devices, and associated ductwork can harbor bacteria and moisture, and add it to the air they deliver. Radon, pesticides, and other sources of outdoor pollution are happy to enter, whenever an open door or window presents an opportunity.

How much importance should be placed on any contamination source, depends on the level of pollutants it contributes, and how dangerous those emissions are to human health. Some sources, like an old gas stove that has not been properly maintained, will emit far more pollutants than a newer version. The danger of such sources, can largely be mitigated with replacement or much needed maintenance.

Also, important in considering pollution sources, is whether they contribute to the airstream continuously, intermittently, or on rare occasion. Automatic air fresheners, decaying or damaged building materials and furnishings, and some household products release contaminants on a continual basis. Smoking, using unvented heating equipment on demand, using solvents for cleanup of sporadic activities, using pesticides, and cleaning products used in the home, all release sporadically into the air we breathe. Some sources, like chemicals used to strip furniture, or pine trees drying out during holidays, are rarely problems. But if there is inadequate ventilation, with multiple sources contributing, concentrations can rapidly build up in indoor environments.

We will later touch lightly on other sources of air contamination. But first, since it is the focus of this work, we look at indoor pollution related to mold growth.

Identifying Air Quality Issues

Observable changes in health, especially some noted earlier, can be very good indicators of problematic indoor air pollution. This is especially true, if they manifest immediately after environmental changes. These might include moving to another home or work location, treatment of the home or building with pesticides, or remodeling or refinishing projects. If you suspect that new health issues might be related to an environmental change, your doctor or a local health board might be able to help determine, whether you truly do have air quality issues.

Another way to ascertain whether recent changes are creating health issues, is to try to identify possible sources of air pollution in the new environment. Whether they are contributors or not, just awareness that they are potential sources, is a big step toward improving the quality of air being breathed.

An examination of lifestyle and activities is another way to decide, whether a home or work environment has indoor air issues. It is entirely possible, that the source of pollution is the user. Human activities have an inevitable impact on surrounding environments, indoors and out.

One last potential suspect that can quickly be ascertained, is whether sufficient ventilation is coming in and out of the air space. Moisture condensing on walls, smelly or stuffy air, stored books, shoes, and paper items becoming moldy, and HVAC equipment becoming dirty, are all indicators of inadequate ventilation. We become accustomed very quickly, to what our senses detect. To better determine if your environment stinks, step outside long enough to clear the nostrils, then take a deep breath upon reentering the air space.

Concerns about Air Quality

Risks to our health are inherent in day-to-day activities, in which we all engage. The degree of risk varies, based on what we know about hazards we encounter, how prepared we are to lessen the danger involved, and to what extent, our safety depends upon our own actions and decisions. Flying in planes? That we have little control over, other than the decision as whether to participate. But deciding to engage in various recreational activities, how we drive our cars, the environmental hazards to which we willingly subject our bodies? Those are levels of risk we choose. Some we would avoid, if we could so choose, especially if we were well informed about possible consequences of our choices.

Indoor air pollution fits well within that last description. Research in recent years has documented, that in many cases, the air we breathe inside where we live and work, is significantly more contaminated than air outdoors. Even in some of our largest cities, known for their poor air quality. This is because pollutants are far more concentrated indoors, than in the vast quantities of available air outside. Since we spend most of our time inside, health risks due to poor air quality, are much greater than most people would imagine.

The problem with contaminated airstreams inside buildings, is exacerbated by the fact that those most at risk from indoor air pollutants, are people who are often inside for the longest periods of time. These groups include small children, the elderly, the bed-ridden, and the chronically ill, sometimes from respiratory ailments.

Health Issues Related to Indoor Air Quality

There are immediate reactions, as well as long-term effects of breathing polluted indoor air. Some symptoms do not manifest for years.

Some effects show up after just one exposure. Often short-term and easily treated, they can include dizziness, fatigue, shortness of breath, headaches, and irritation of the eyes, nose, and throat. If the source can be identified, the most effective solution is to remove the person from the source of the pollutant. But since that is usually where they work, live, or attend school, physical separation is not often practical.

Symptoms of some diseases, already experienced by suffering building users, are exacerbated by exposure to indoor pollutants. Diseases in this class include asthma and hypersensitivity pneumonitis.

Whether there is an immediate reaction to indoor pollutants, will depend on factors peculiar to individuals. Sensitivities to certain chemicals and toxins vary widely between individuals. Age and pre-existing medical condition, play a large part in how a body reacts to stress put on its respiratory system. Some sensitivities to certain biological pollutants are learned reactions, based on repeated exposure. The same thing appears to be true, for some chemical irritants.

Since some symptoms mirror those of cold and flu viruses, it may be difficult to tell at first, whether indoor pollution is really causing health problems. An accurate record of when, and how symptoms appeared, tied to external sources and events that may have contributed pollutants to the airstream, is an invaluable diagnostic tool for health professionals. When symptoms abate upon leaving a certain place, and resume upon the person's return, that's a pretty solid indication of air quality issues. Pollution sources should be sought. If there are sources of high humidity in the building, or there is little ventilation, those are two problems that may quickly be addressed to seek relief.

Other health problems may manifest, only after long periods of time have passed, or with repeated exposure to a polluted airstream. Some maladies, like COPD, heart attacks, or cancer are quite deadly or debilitating.

There is no consensus though, on what periods of exposure are safe, for which known sources of air quality contaminants. Further research is both necessary and ongoing. One thing is certain. If it is possible to improve the quality of air where we live, work, or breathe, failing to do so seems to be a foolish choice.

Health Concerns with Dampness

We may not know for sure, how much of certain pollutants it takes to have adverse effects in certain people, but some things we do know are health concerns. Many symptoms are caused or exacerbated by mold and damp.

The most common problem associated with mold, is allergic responses. Inhaling or touching spores can provoke a health response in someone who previously exhibited no sensitivity at all to mold. Symptoms tend to include sneezing, stuffiness, a runny nose, red, itchy, or watery eyes, and irritation of the ears, nose, and throat. But in people with known allergies, exposure to mold can also provoke wheezing, coughing, and shortness of breath. Studies have already linked long-term exposure to the worsening of pre-existing asthma symptoms. New studies indicate prolonged exposure to mold, can also cause asthma.

When lung inflammation occurs in people, whose immune systems become sensitized to organic dust, it is termed hypersensitivity pneumonitis (HP). It can be mistaken for pneumonia, except it does not respond to treatment with antibiotics. Signs appear within hours after exposure to mold and can last for 1-3 days. Symptoms can include; cough, muscle aches, chills, fever, sweating, excessive fatigue, weight loss, and shortness of breath. If the problem is work-related, that may only become apparent if symptoms wane and resume during holidays, and upon leaving and returning to work. With continued exposure and lung inflammation, scarring and other permanent damage to the lungs may result. HP is not contagious but is due to a person's immune system reaction to inhaled organisms, whether dead or alive. It has; however, been documented in multiple workers in buildings, that have mold and bacteria contaminated air conditioners. It has also been linked to those working in water damaged buildings, with recurrent leaks and high levels of indoor humidity.

With the asthma form of lung disease, airways become inflamed and spasm in response to a sensitivity, or irritating exposure. Episodes of shortness of breath, coughing, tightness of chest, and wheezing can ensure. If panic sets in, because of the struggle to breathe, it further dangerously restricts the bronchial tubes. This occurs, whether exposure is to a generally irritating substance, or one to which the asthma sufferer is already allergic.

In a fair number of cases, the sickness may have been caused or worsened by their workplace environment. Some organic substances, like wood from the western red cedar, are known risks for the development of asthma. Damp buildings have been shown to worsen the conditions of those already with asthma, and new research indicates they may trigger its onset.

Early diagnosis, and removal from environmental factors triggering asthma attacks, can significantly improve symptoms. Barring this as a possibility, identifying and eliminating the source of irritants is a good second option, if possible. The third level of defense, is to seek optimal medical treatment to keep the asthma under control.

Changes in Indoor Air Quality Attributable to Mold

One known irritant, to those already suffering from allergic or breathing disorders, is an excessive presence of mold. The chain of events leading to health problems, is the production of dangerous mycotoxins, from mold spores, which are produced by mold in the process of propagating itself. Symptoms experienced by people, who react to mold and its byproducts can include; fever, lung infections, irritation of the eyes, stuffiness, wheezing, and skin irritation.

As mentioned earlier, many types of mold are found everywhere in the natural environment. They do not pose a health problem, till they appear in our environments in dangerous quantities. Since such excessive growth is almost always fueled by excess moisture, the obvious best way to control mold, is to control moisture feeding it. But after the water issue has been resolved, the mold now present, will still need to be addressed and removed.

When symptoms begin to manifest in inhabitants, users can respond with technology to improve indoor air quality. Extra ventilation can be introduced. Better filters can be used in the airstream being delivered. Air filtration devices, like those utilizing activated carbon or HEPA filters, can be added to existing HVAC systems. Mold and asbestos abatement programs can be launched, involving significant renovations and alterations to buildings.

All these remedies have varying levels of success in improving indoor air quality. None will do so for long, if a source of moisture that is feeding mold growth, is not found and remedied.

Air Quality in Schools

The quality of air, found inside of our schools, is of special concern. This might be because their inhabitants are young and vulnerable, stuck inside for long periods of time, a somewhat captive population, and one that emits large quantities of humidity, simply by existing.

There are many reasons for moisture accumulations in schools. Temporary structures are often used for educational purposes, one example being temporary classrooms. Such utilitarian structures rarely have enough ventilation provided, to properly exhaust the amount of humidity generated inside them. Precipitation making its way into the building, resulting from delayed or insufficient school facility maintenance, is a long-standing byproduct of community budgetary woes. Some moisture problems are simply the result of updated building practices, creating tighter building envelopes, that seal moisture inside, much more efficiently than previous, more drafty versions.

Because of, and usually in a combination of these typical issues, mold growth in school facilities tends to be an ongoing battle. Some simple remedies have been historically used, that go a long way toward resolving that problem.

One simple approach is to eliminate humidity sources usually found in schools, when that possibility exists. For example, showers and other areas that generate steam can be vented directly to the exterior, with exhaust fans. Dehumidifiers can be added to HVAC equipment to keep humidity levels down in the 30-60% range. Exhaust fans can be placed over dishwashers, ranges, and cleaning sinks in food service areas. Air conditioners can be installed, to additional perform as dehumidifiers, especially in areas like gymnasiums, where additional body heat is being expelled along with humid breath.

School buildings need to also be inspected periodically, for telltale signs of moisture, so leaks and spills can quickly be addressed. The smell of mold can usually be traced to a source. Discoloration on ceiling tiles, floors, walls, and window sills, usually has a water leak nearby. Water should not be allowed to stand in AC drip pans, simply because a float switch is jammed or has failed. Bathrooms can regularly be inspected for standing water and mold, indicative of plumbing leaks.

Moisture condensation, once spotted, can be addressed. Insulation or additional layers can be added over windows, around piping, on exterior walls, or in floors of unheated spaces.

When leaks occur, or signs of mold are spotted, a quick response will minimize additional damage. The leak should, of course, immediately be repaired. If leaks and spills are properly cleaned and dried within 24-48 hours, chances are good that mold growth can be prevented. Absorbent materials will still need to be quickly replaced, so it is best to keep extra replacements for these in stock, for quick access. Hard surfaces can easily be cleaned and disinfected, to become inhospitable to microbes. Mechanical rooms are a good place to check for such leaks.

Floors and carpets should be cleaned immediately, should there be evidence of moisture problems. If carpet is in a location where it becomes necessary to dry it on more than one occasion, get rid of the carpet and replace it with hard water-resistant flooring. Spots and stains should be removed immediately, in accordance with cleaning procedures, recommended by the material manufacturer.

They won't eliminate ongoing damage to school facilities from moisture accumulation, but such maintenance procedures, once implemented, will surely slow it down.

WHAT TO DO BEFORE MOLD OCCURS

Given what is certainly known about the health effects of mold, its occurrence on stored materials, or on building components, mold is a definite public health hazard. When discovered, it is subject to enforcement action or removal by any local Board of Health. Before forced involvement with regulatory agencies occurs, or expensive renovations become required, it is far better to take steps to insure mold does not gain a foothold. Prevention is far less painful than the cure.

There are a few specific areas, that when regularly inspected and maintained, can eliminate most of the known causes of mold growth and other moisture damage.

Below Grade Space

Spaces that exist below grade, especially in buildings used by the public, should periodically be inspected to insure water is not penetrating through foundations to damage interior materials. This inspection is especially important, following heavy rains. If any evidence of water penetration is discovered, that space should not be finished or converted to use. If already in use, below grade spaces should be closed off to the public, till the source of the leak can be found and eliminated. Such a remedy may not even be possible. Even if no leak has not yet manifested, as a precaution, only non-porous finish materials should be specified and used in spaces found below grade.

Water penetrating through foundation walls

General Building Condition

All elements of a building, which might affect the water tightness of the structure, should be thoroughly inspected. Foundation, floors, walls, doors, windows, caulking, roof, staircases, porches, chimneys, water removal elements, flashings, and columns that support the structure, fit this category. All these elements, and any others that if damaged or weakened, could result in unplanned gaps in the envelope, should be periodically examined. Holes, cracks, and loose places, even in the interior finishes, should all be immediately repaired upon discovery.

Doors and Windows

Windows should be maintained as follows, to maintain their intended resistance to moisture penetration. They should all open and close without difficulty, with all panes of glass intact and thoroughly caulked. Gaps between window frames and exterior walls should be caulked. If possible, there should be either a storm window, with caulking between it and the primary window, weather-stripping to fill any spaces between the primary window and the sashes, or the window be so well fitted, that no gaps greater than 1/32” exist between the primary window frame and operable sashes.

Exterior doors should be maintained as follows, to fulfill their intended resistance to moisture penetration. All doors should open and close without excessive effort, and all glass in them be unbroken and properly caulked. Cracks between the exterior walls and door frames should all be caulked. If possible, there should be either a storm door attached to the outer frame, with joints between its frame and the primary frame caulked, weather-stripping to close any gaps between doors and their frames, or so well fitted, that the largest gap between door and frame is less than 1/16” on the sides and 1/8” on the top and bottom.

Maintaining HVAC Systems

Plumbing, waste disposal, and heating and cooling systems need to be inspected and maintained, before small damage to them, grows to become significant. Frequent inspections should be conducted to find, and repair leaks, before they foster mold growth in nearby building components.

In buildings of all sorts, there is an array of equipment designed to exhaust moisture from various spaces and equipment in that building. Examples include; shower exhaust fans, those for restrooms, locker room vents, kitchen vents, and exhaust systems for indoor pools. Such exhaust systems need to vent directly to the exterior and be programmed to operate continuously, so long as water vapor exists in the area being vented. They should most definitely not vent into concealed attic or interstitial wall spaces, either intentionally or accidently, because joints in their ducts have separated. And it is not hard to imagine how fast mold growth will occur, if a ventilation system serving one of these wet areas, is damaged and remains in a state of disrepair, while the space continues to be used.

DEALING WITH MOLD IN THE AIR STREAM

But suppose, despite the best prevention programs, despite periodic inspections, excess humidity finds its way in, and is followed rapidly by excessive mold growth? It is in the air stream, and indoor pollution has now become a problem for the building inhabitants.

Reiteration of Basic Facts

Mold is found almost everywhere. It can grow on almost any organic substance it can consume, and many building materials fit that description. It only needs food, moisture and oxygen to multiply. Mold spores migrate to damp surfaces indoors, where they attach and begin new colonies. In locations where excessive moisture accumulates on organic surfaces, mold will grow and increase, so long as it remains undiscovered and untreated. The most effective way to control and inhibit mold growth, is to minimize or eliminate the source of the moisture on which it thrives. Left alone, mold will eventually consume whatever it is growing on. Even when mold remains unseen, its presence is usually announced by its characteristic odor, a musty, earthy smell. If occupants of a building are experiencing health issues that surface when they are in one location, and abate when they leave it, or if they detect mold by sight or by smell, they should alert health officials or building owners, and request remediation take place.

The general approach for dealing with excessive mold, is as follows. Mold can grow anywhere on almost any building material. There is no practical way to eliminate all mold. It must just be cleaned up, then ways found to control its growth by eliminating excess moisture. If there is a leak, plug it or fix it. Clean and dry wet materials within 24-48 hours. Clean mold off hard surfaces. Replace wet materials that cannot be quickly dried. Install insulation around pipes or add insulation to reduce condensation. Replace absorbent materials like carpet with hard surfaces, in areas prone to spills or drips. Then work to eliminate other sources of excess moisture. Control indoor humidity by venting bathrooms and other wet areas to the outside. Use air conditioners and dehumidifiers and increase the amount of ventilation. Use exhaust fans when doing household tasks involving water.

More specific approaches to controlling the growth of mold, once excess amounts are present, are as follows.

Controlling the Growth of Mold

The moisture source driving the mold growth needs to be identified. It is very likely to fall into one of these categories.

- Moisture was trapped in the building when wet materials were used during construction
- Moisture was trapped when methods used in installing materials included excessive moisture that had no opportunity to properly dry, before it became encapsulated.
- Defective materials, defective installation of materials, corrosion, or lack of adhesion between incompatible materials, caused gaps to open in the envelope.

- An unplanned event, like a plumbing leak or natural flood, occurred and subjected the building to excessive moisture.
- Lastly, some activity of the building user is introducing excess water into the building envelope.

General Prevention Strategy

When the presence of mold is confirmed, remediation measures should include the following steps at a minimum. These may need to be tweaked somewhat, based on specific conditions on site. If there are questions on procedures, those should be addressed to experts.

- Make sure site drainage systems are functioning and the ground is sloped away from foundations.
- Regularly inspect the building and HVAC systems, and make repairs immediately if the problems found compromise, or will compromise, the integrity of the envelope.
- Put equipment in place to maintain indoor humidity between 30-50%, and definitely below 60%.
- Verify that condensation and drip pans are functioning and properly draining.
- Make sure equipment that generates moisture, and building spaces that generate moisture, are vented directly to the outside, and duct connections are all secure.
- When water does inevitably finds its way inside, take immediate action to get the leak stopped.
- Clean up damaged areas and if possible, get them dried in the first 24 hours, and certainly in the first 48 hours. Damaged porous materials will probably need to be replaced anyway, and immediately discarding them, will open walls and ceiling spaces and allow air circulation to assist in the drying.
- Make long term repairs to eradicate whatever problem led to water, suddenly becoming available to foster mold growth. Given its pervasive nature, it is logistically impossible to completely eradicate all traces of it. But it will be difficult to win the war against excessive mold, if moisture continues to be available, with which surviving spores can thrive.
- If an active leak cannot be located, verify no existing sources of condensation are feeding the problem. Correct those, if found.
- If the moisture source is condensation, that is caused when moisture laden air meets a surface that is cooler than the dew point. Raise the temperature with insulation, or by increasing air circulation, or reduce humidity levels by eliminating leak sources, or installing air conditioning. Easy entry of humid outside air, can be prevented by installing airlocks and closing windows.

Procedures – Problem Found in First 48 Hours Following a Leak

- As mentioned repeatedly, if it can be done quickly, using logic and the physical location of the water at the time, find and stop the source of the leak.
- If moisture can be removed from the damaged area within the first 48 hours, and this includes removing wet building materials and furnishings, further abatement of mold is rarely necessary.
- Clean up the area and add fans and ventilation, to increase circulation
- Observe the area to make sure no signs of mold appear.
- If there are no visible signs, but an odor becomes apparent, request testing be conducted by an expert.
- If there are no further problems, reoccupy the space.

Procedures – Problem Discovered After 48 Hours Have Passed

- Mold growth is likely to have begun, and abatement procedures will probably be required
- Inhabitants of the space should find another space to use temporarily.
- The source of water infiltration will still need to be identified and corrected.

- Damages materials will need to be cleaned, removed, and/or replaced in accordance with the decision matrixes given earlier. At this point, the solution will be a renovation project.
- Finish cleaning up the area and add fans and ventilation, to increase circulation
- Observe the area to make sure no signs of mold appear or reappear.
- If there are no visible signs, but an odor becomes apparent, request testing be conducted by an expert.
- If there are no further problems, reoccupy the space.

Minimizing further damage during restoration

Cleaning Up Mold

If mold is present, who should be involved in abatement, will depend somewhat on how much mold is there.

If the area involved is less than ten square feet, one individual can probably handle it. The Environmental Protection Agency has guidelines available for how to properly do so. Their recommendations can be summarized as follows. Items from additional sources have been included.

- Avoid exposing yourself or others to mold. Use of an N-95 respirator, available at many hardware stores, is recommended. Wear long gloves that extend to the middle of the forearm, so you don't touch mold with your bare hands. Wear goggles without ventilation holes, so mold spores do not get in your eyes.
- Note that if you are already sensitive to mold, have known allergies, or already suffer from respiratory ailments like asthma, you don't want to be the one cleaning up mold. It would be a good time to hire a professional.
- Fix the leak and dry all items thoroughly.
- Scrub mold off all hard surfaces and completely dry them.
- Throw away porous materials, like carpet or ceiling tile, that have become moldy.
- Clean areas that were covered, with a disinfecting cleaner containing bleach.
- Increase ventilation in the area, to thoroughly dry it out.
- Take care not to paint, or caulk over surfaces that are moldy. What is being applied will not properly adhere.
- If unsure how to clean any area or item, consult a specialist.

Use of an N-95 respirator

Use of additional personal protection equipment

If the water damage was extensive, and mold growth covers more than ten square feet, it is probably best to get expert help in handling remediation. The EPA also provides guidelines for procedures in this case, that can be summarized as follows. Items from additional sources have been included.

- Assess the size of the problem.
- Assign a manager to handle the problem, evaluate the situation, and develop a plan for remediation
- If the likely source of the water is contaminated, like sewage, it is best to verify that any professionals hired to assist in cleanup, have had experience in dealing with damage from contaminated water.
- Note that if someone is already sensitive to mold, has known allergies, or already suffers from respiratory ailments like asthma, that’s not the right person for the job.
- It will most likely be necessary to relocate users out of the area, until remediation procedures are complete. This is because of the scope of work involved, the potential health effects on occupants, contacting and breathing spores loosened by work, and the difficulty of completing normal activities during the ensuing disruption.
- Fix the water or moisture problem. Stop the leak. Eliminate the source of condensation. Kill the problem.
- Make sure everyone dealing with the damage restoration, is wearing protective clothing and gear as described above.
- Clean with detergent, disinfect with bleach, and completely dry, moldy materials that are not porous.
- Discard materials that cannot be cleaned.
- Ventilate and air dry the space, and all affected materials.
- Check for any return of moisture, or of mold.
- If additional or hidden mold is discovered, reevaluate and begin again.
- Even though eliminated, mold may have cause permanent staining or discoloration. It may not be possible to restore damaged surfaces to their previous appearance. If that is the goal, it will be necessary to replace those materials, even if they are free of mold.

Permanent water stains on wood

There are some other key points to consider during the restoration process. If a contractor or remediation service is hired to perform the cleanup, make sure they have previous experience, dealing with mold. Ask for references. If there is any question as to whether the HVAC system has been infected with mold, do not turn it back on till it, and its ductwork system, have been inspected and passed by experts. Otherwise, spores can be distributed throughout the area served by the infected system, and health problems can certainly be expected to follow.

DEALING WITH OTHER POLLUTANTS IN THE AIR STREAM

Dealing with Pollution at the Source

Sources of emissions that decrease indoor air quality, are best handled by eliminating problems at their sources. Some, like materials containing asbestos, can be removed or encapsulated, so no more particulate from them can enter the airstream. Appliances like gas stoves or wood burning stoves, can be adjusted or repaired, to reduce the amount of gasses they emit to the atmosphere. If repair is not possible, replacement is always an option. Increased ventilation will always help, but source control is usually a cheaper solution. That is because fresh air brought into a home, will also need to be conditioned, and there is an ongoing price tag to do that.

Cleaning Up Air in General

When air quality concerns weigh on our minds, technology exists at several levels to clean it up. They range from simple table-top models, that scrub the air in small areas, to whole-house systems. Some air cleaners, those using far more sophisticated filters, are effective at removing particles from the air. Smaller, less expensive models will not do that. Simple air cleaners are not designed to remove pollutants that are gasses.

There are two components controlling the effectiveness of an air cleaner. One is how well a cleaning system collects, and removes pollutants from the inside air, expressed as a percentage efficiency rate. The second is how much air it draws through its filtering elements, expressed in cubic feet per minute. A cleaner that has a very high percentage efficiency rate but draws very few cubic feet per minute through its filters, is not an efficient cleaner. Likewise, a cleaner that has a low efficiency rate, but cycles a lot of cubic feet per minute through, is not efficient. And in either case, the continued performance of any cleaner will depend on maintaining it, according to the instructions of its manufacturer.

The strength of the source of the pollutant, will also impact the efficiency of an air cleaner. Table-top cleaners are not very effective at dealing with nearby sources that are strong. They do not remove the necessity of also ridding the building, or home, of the source of the pollutant. Those who purchase such models, hoping to eliminate the harmful effects of their smoking on others, while continuing to smoke near the cleaner, are generally disappointed by the results.

Houseplants have been touted as a natural way to improve indoor air quality and help remove pollutants. Although they clearly increase oxygen levels, there is no credible evidence that plants significantly reduce pollutant levels in any way. Moreover; the necessity of keeping plants watered, increases humidity levels in homes, increasing exposure to the risk of excessive mold growth.

Currently, reliance on air cleaner systems is not recommended by the EPA, to reduce radon levels. While air cleaners partially mitigate the effects of radon decay products, they make little difference in the amount of radon entering the home. Research is still underway, to determine if air cleaner systems can be altered, or improved, to more effectively treat problems with radon.

Measuring Levels of Radon

How can we know if radon is even of concern? Radon is colorless, odorless, radioactive and unfortunately, sometimes present in our homes and businesses. That is why testing is recommended, in situations conducive to its formation. Without testing, it is impossible to verify radon's presence, other than by the emergence of the health problems it can cause. Devices that measure radon are available and inexpensive. The EPA has published guidelines covering risks associated with various radon levels, and what corrective steps should be taken to mitigate it. Certain steps have proven to be effective in reducing radon, and some of these are automatically being included in construction of new homes.

Testing for other sources of indoor pollution can be expensive, so building owners tend to put that off. But these other sources of airstream contamination should be tested for, when health symptoms begin to manifest, specific sources or pollutants have been identified as potentially being present, or problems with ventilation become evident.

Dealing with Radon

It was mentioned that radon is radioactive, which means it will influence cell growth. This radioactivity occurs because radon is emitted by uranium, found in the ground on which buildings are built. Radon gas, odorless and invisible, is naturally released as uranium breaks down. The gas seeps up through the soil, up through concrete slabs and wood floors, through drains and sumps, and enters the living space. In some cases, it enters by infusing well water. Some building materials themselves emit radon, though they rarely cause problems, in and of themselves.

Any home, new or old, can develop a problem with radon. Well-sealed homes are even more problematic than older, more drafty structures. This is because newer, more energy tight structures, do a better job of trapping the rising gasses. Older buildings have more natural ventilation, to carry radon away and/or dilute the concentrations of it.

When it becomes trapped in the home's atmosphere, and concentrations of constantly produced radon slowly increase in the atmosphere in which we are also trapped, problems occur. We don't coexist well with invisible, radioactive gas.

Health Effects of Radon

Lung cancer (uncontrolled cell growth) seems to be the primary risk associated with radon. This is likely because lungs are the first tissue to contact the radioactive gas, when we breathe it in. Health organizations concur that thousands of preventable lung cancer deaths are caused each year by exposure to high levels of radon. Smokers, who also live in homes with high radon levels, are especially vulnerable. Swallowing water, contaminated with radon, may also pose risks, but not nearly as severe as those connected with lung cancer.

Reducing Home Exposure to Radon

Take the minimal time, and minimal expense, to measure levels of radon in your home. Measure it with one of the many inexpensive kits that have been approved by the EPA. If you want to know how much is present, but do not wish to purchase a kit, there are qualified contractors who offer the service. Instructions come with the kits, but there are also guidelines available from the EPA on how to interpret test results.

If testing reveals unacceptable levels of radon, one immediate step to be taken, if possible, is to stop anyone smoking in the home. Tobacco smoke, combined with radon, poses a serious health risk. If radon is found in well water, that problem should also be immediately addressed. Guidelines for doing so, can be found at state offices that deal with radon.

If tests indicate radon levels of concern, other steps can be taken to lower concentrations. Lowering such levels requires technical expertise. Trained radon contractors are available who can study the problem, test for air flow currents to establish convection routes, pinpoint areas of weakness where the gas is finding entry and suggest proper treatment methods. Most states have offices that will provide names of such qualified contractors, in specific locales.

Most types of radon reduction systems involve some loss of heated or conditioned air. It makes sense that one way to get rid of contaminated air, is to dump it outside. How much this will increase utility bills, will depend on your climate and the construction of your home. Systems that use fans, to remove rising radon from spaces below the home, are more effective in reducing radon levels and will only slightly increase electric bills. The difference lies in whether the radon is removed, before or after it enters living space.

Radon reduction systems are usually grouped by the type of foundation used in the home. They will differ, based on whether your home is slab-on-grade, on a crawl space, or built over a basement.

In homes built on a slab-on-grade, or over a basement, radon is usually removed by one of four types of soil suction. Active subslab suction is the most reliable, using suction pipes inserted through the slab, into the crushed rock or soil below the slab. These are then vented by a radon vent fan, directly to the outdoors. This powered venting, also creates a vacuum below the slab, further pulling contaminated air, in and away. Passive subslab suction uses the same types of suction pipes but relies on natural convection to draw contaminated air up and out, and foregoes the use of an exhaust fan. The perforated drain tiles used in some homes will help do this naturally. Another variation is called sump-hole suction. In this, when the home is already using a sump pump in a pit, the pit is capped, continues to drain water, but also serves as a location for the radon suction pipe outlet and radon fan. Block-wall suction is used in conjunction with hollow block foundation walls. This removes radon while depressurizing the walls, working somewhat like subslab suction.

Radon is dealt with somewhat differently in homes with crawlspaces. The most effective way involves installing vent pipes in the soil, along with a vent fan to push air outside. Then the floor of the crawl space is covered with high-density plastic sheeting with the joints sealed. This type of treatment is called submembrane suction. A less favorable option, is to use a fan to exhaust air from the crawlspace to the exterior, but that will also require bringing in outside air to replace it. That air will need to be treated for humidity, temperature, etc. Passive ventilation is accomplished by crawl space vents, already required in most crawl spaces by building codes. Note to the wise. If cold air is being introduced into the crawl space to mitigate radon levels, make sure any pipes in the crawl space are well insulated. If ducts distribute through a cold or hot crawl space, delivery of heated or cooled air will also be affected.

Properly protected crawl space

Built-in Radon Resistance

Some approaches to radon reduction are common sense. Sealing cracks in foundations and sealing openings between the foundation and living portions of a home, goes a long way in reducing exposure to radon in the living area. Pressurizing the living space, or the basement space above the slab, will create air pressure to resist the entry of radon gas. Reliance on such pressurization; however, precludes leaving doors or windows open, so it is not terribly practical in a residence. A heat recovery ventilator (HRV), brings in outside air, while using inside air being exhausted to pretreat that incoming air. These are effective in reducing levels of radon, by simply exhausting part of it and diluting what remains with fresh air. Natural ventilation, letting the wind blow through a building to carry away any contaminated air, is of course, the oldest air quality technology that can be implemented.

SUMMARY

There was serious concern over the quality of the air, that athletes from all over the world would be breathing during the Olympics at Beijing. Given known results of air quality testing in that city, knowing the pollution I would pull into my lungs while competing outside, were I an athlete, I too would have been concerned. But most competitors made the choice to take the risk and endure that exposure.

Few of us choose to breathe contaminated air in our homes, schools, and workplaces. More and more, we are learning the health risks and complications associated with poor air quality. Known risks range from high concentrations of radon, other gasses, particles in the air stream, and organic compounds like spores from mold. We don't want to breathe those in. We often don't know we are doing so. But when we do find we are at risk, few are willing to leave their homes, quit their jobs, or drop out of school. That leaves us with the option to live with risks or take steps to lower those risks.

Knowing now, that many severe problems will arise from leaks and other sources of excess moisture in our buildings, we take steps to prevent the same. We can design in barriers, maintain existing systems, and move swiftly to minimize long term effects, when failures occur. And they will. Because all buildings leak in some way, at some point in their life span

Nature itself assures that we will always fight airstream issues in our enclosed environments. Humidity laden air will always flow from warmer areas of high pressure, to cooler areas of lower pressure. Radon will always rise through the soil, as deterioration occurs in the uranium beneath. Thousands of strains of mold exist, just seeking organic food like materials found in our buildings, and a moisture supply to proliferate. All organic materials are designed to decay in some way, adding particulate to the airstream.

The goal is to eliminate the potential harm, to reduce the risk posed by these processes, to users of the buildings we design, build, and maintain. Hopefully, basic knowledge of these natural processes, along with known ways to mitigate risks, has provided useful tools to lessen those health hazards.

In the context of the subject matter we explored, it is impossible that leaks will never occur at some point in the life of a building. It is impossible, that the quality of air being breathed by building inhabitants, will never be compromised. Whether that happens with mold, or because of other indoor air contaminates. Just by existing, by expanding and contracting under seasonal and climatic influences, buildings will develop flaws through which water and other pollutants will enter. But if we are qualified, and armed with knowledge to design, or build, in such a way as to delay such an occurrence. Or if we are hired to conduct maintenance to forestall such an event, what a shame if it happens on our watch.