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## MOISTURE AND MOLD IN THE BUILDING ENVELOPE

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# MOISTURE AND MOLD IN THE BUILDING ENVELOPE

Claims resulting from moisture related building envelope failures and mold growth have continued to escalate in an exponential manner. Most of the damage in these cases are caused by wood rot and related building material deterioration as a consequence of water infiltration or moisture entrapment. As water problems often lead to mould growth within the building envelope, there is an increasing specter of claims for personal injuries due to environmental health concerns.

The problem is often characterized as one of water "infiltration", yet the exact cause is much in dispute. Whether it is the infiltration of water through a defective envelope, a defective HVAC system, or entrapment of moisture from within a structure, the dynamics are complex and quantitatively different to assess.

As to liability, case histories have pointed to a broad range of potential causes of the building envelope failures including design, construction, field service, regulatory agencies, and building products. It is possible that a "typical" leaky condo could reveal evidence implicating several causes. In addition to design and construction errors, the use of new or innovative building products have been suggested as likely contributory causes.

## ENVELOPE COMPONENTS

Components of the building envelope can be grouped according to function and location. Roof, walls and floors each perform a unique job in resisting elements and require different inspection strategies. Specialized components -- doors, windows, and louvers -- allow people, materials, light and air to pass through the envelope. These operable components pose added maintenance challenges because their moving parts take user abuse. All systems must resist thermal flow and prevent moisture penetration.

**Roofs.** The roof is the source of most building problems. Materials and characteristics of roof systems vary dramatically, as do each system's ability to resist damage. The roof is the first line of defense against the elements, and it must resist the full force of the sun, rain, snow and sleet. It is under constant attack from ultraviolet light, atmospheric pollution, birds and HVAC repair men. Leaks usually develop at seams, joints and flashings.

Ensuring proper roof drainage is essential to envelope integrity. Plugged drains can cause water to enter through flashings and mechanical equipment, as well as impose dangerous roof loads. Often, leaks are first discovered on the interior; it can be difficult to locate the source because water can easily travel horizontally within the roof system. Secondary water barriers are a must in most systems.

**Walls.** Materials and construction vary from masonry to steel and EIFS. Walls are the most visible components of the envelope.

Besides creating first impressions, they also resist wind forces and damage from careless or over-enthusiastic users. Secondary barriers are a must as well as relief of entrapped water.

**Doors and windows** are operable portions of the envelope, and they are sources of water infiltration.

**Floors and foundations.** Problems from subsoil movement can cause foundations, walls and floors to settle or allow water to enter. Solutions to below-grade water problems vary greatly in cost and effectiveness. Often, below-grade water problems can be traced to improper roof and site drainage around the building.

## FORCES ATTACKING THE ENVELOPE

**Thermal movement**. Constant thermal contraction and expansion of building components put stress on the envelope. While most building components and systems are designed to accommodate movement, design limits can be exceeded when excessive forces are generated by rapid and extreme temperature cycling or unexpected solar exposure. Sealants have limited life, and inappropriate installation can further limit effectiveness.

**Freeze/thaw**. Water penetrating cracks and joints in the envelope can add enormous stresses when it freezes and expands. This action can turn hairline cracks into major envelope problems, especially in joints between hard materials, such as masonry and stone.
**Decay.** Changes in material properties can be caused by chemical changes induced by exposure to ultraviolet light, pollutants, repeated wetting and drying cycles, attack from insects and microorganisms, or offgassing of essential compounds as the products age.

**Use**. Building envelopes suffer accidental damage from users, as well as deliberate damage from vandals. Vibrations from operating equipment can loosen flashings, fittings and sealants, and operation of doors and windows contribute to wear.

**Plants and animals.** Plants and animals can cause envelope damage. Plants contribute organic matter, such as leaves and branches that can interfere with drainage and form favorable environments for the growth of other plants. Roots can penetrate roof membranes, as well as concrete foundation walls and floors, and vines can grow inside wall assemblies.

**Water intrusion.** In liquid form, water intrusion can cause permanent damage to steel, wood, insulation, interior finishes and, eventually, interior equipment and resources. As water vapor, moisture can condense within wall and roof systems, causing a decrease in insulation values and contributing to permanent decomposition.

## MOLD/FUNGI - THE UNWANTED FREE LOADER

Ever notice the pink or yellow spots on the vinyl wall covering on the interior face of the wall? Pulll back the vinyl and you will find black mold and mushy drywall. The pink spots are literally mold vomit. Feeding mold exudes digestive enzymes that react with the plasticizers.

The composite materials we use today have adhesives that can be digested by fungi we call molds. Mold will also digest sugars and starches in wood fiber, if the cell walls have been crushed or broken. Solid lumber has intact cell walls that cannot be penetrated by molds. Molds will grow on the surface, but the wood will retain its structural strength. Particle board,

oriented-strand board (OSB), a.k.a. waferboard, medium density fiberboard and paper-covered gypsum board, are full of adhesives, which make them good “mold chow”.

Adhesives are used throughout these materials to give them form and to hold together the crushed, pulverized or torn wood particles that make up the board. Mold digests the adhesives and mold hyphae penetrate the resulting cracks and holes between the wood particles. Structural integrity is eaten away and so is the building envelope.

Aeroallergenic fungi such as Cladosporium. Penicillium, Aspergillus, Epicoccum, Chaetomium, Fusarium, Stachybotrys and Sterile Fungi, as well as bacterial agents such as bacillus are routinely isolated in minor quantities from Florida inside air samples. Cladosporium has a low potential for causing health problems. Penicillium have been reported to be responsible for hypersensitivity pneumonitis. Aspergillus has been associated with three distinct illnesses. These include allergic broncho-pulmonary asporgillosis, pulmonary aspergilloma and invasive aspergillosis. Epicoccum is a common allergen and normally considered a contaminant. Chaetomium is occasionally implicated in cutaneous phaeohyphomycosis, but commonly considered a contaminant. Fusarium is a known agent of mycotic eye infections and occasionally involved in skin and nail infections. Stachybotrys atra may produce toxins which are present in the spores. Individuals with chronic exposure to the toxins reported flu and cold symptoms, sore throats, diarrhea, headaches, fatigue. dermatitis, intermittent local hair loss and general malaise. Toxins produced by this fungus will suppress the immune system affecting the lymphoid tissue and the bone marrow. Stachybotrys spores are in a gelatinous mass end unless disturbed are difficult to find in indoor air samples.

High levels of yeast, Gram positive bacilli and other bacteria could represent potential agents of disease, or manifestations associated with constant exposure to such agents in high quantities.

According to OSHA (OSHA Technical Manual, Chapter 6, Indoor Air Quality Investigation. Part D,3,1,5; CD-ROM. A94-1), contamination indicators for airborne microorganisms are:

. 1000 viable colony forming units in a cubic meter of air

. 1,000,000 fungi per gram of dust or material

. 10,000 bacteria or fungi per milliliter of stagnant water or slime

The Bioaerosols Committee of the American Conference of Governmental industrial Hygienists state that – “During the growing season, outdoor fungus spore levels routinely range from 1000-100,000/m3 of air. Indoor levels should be less than one- third of outdoor levels where outdoor air is the only source and should be qualitatively similar" (Burge, H; Chatigny, M.; Morey. P.; Otten, J.; et al; Guidelines for the Assessment and Sampling of Saprophytic Bioaerosols in the Indoor Environment, Applied Industrial Hygiene 5(2):R10. 1987).

## REMEDIATION METHODS

1. Remediation is done by property trained personnel equipped with respiratory protection (e.g. N95 disposable respirator), in accordance with the OSHA respiratory protection standard (29 CFR 1910.134). Gloves and eye protection are worn. A negative pressure containment area is commonly constructed for all removal areas to reduce airborne concentrations during removal and prevent contamination of adjacent areas. All occupants are kept out of the work area, and the people with health problems are moved to a different section of the building during the removal procedure.

2. The work area and areas directly adjacent are commonly covered with a plastic sheet(s) and taped before remediation, to contain dust and debris. The use of a negative air machine with a HEPA filter to generate negative pressurization is used within the containment area.

3. Ventilation ducts/grills in the work area and areas directly adjacent are sealed with plastic sheeting.

4. Rooms not involved in the remediation are commonly sealed off with plastic sheeting. All items and furnishings not able to be moved from the containment area may be covered with plastic to prevent dust and debris from contaminating clean Items.

5. Dust suppression methods, such as misting (not soaking) mold contaminated surfaces prior to remediation, are recommended. (10% Clorox solution may be used as a high level disinfectant).

6. Contaminated materials that cannot be cleaned are commonly removed from the building in sealed plastic bags. There are no special requirements for the disposal of moldy materials.

7. Upon completion of the drywall removal, the work area and surrounding areas are HEPA vacuumed and cleaned with a cloth and/or mop with a 10 % Clorox solution.

8. All areas are left dry and visibly free from contamination and debris.

9. Follow-up bioaerosol testing before replacement of new drywall is performed to determine if the space meets acceptable indoor air quality criteria.

## CLEANING METHODS FOR FUNGAL DECONTAMINATION

1. Non-porous (e.g. metals, glass and hard plastics) and semi-porous (e.g., wood and concrete) materials that are structurally sound and are visibly moldy can be cleaned and reused. Cleaning can be done using a 10% Clorox solution if material is not susceptible to bleach damage.

2. Porous materials such as ceiling tiles and Insulation, and wallboards with more than a small area of contamination are removed and discarded if possible. Porous materials

(e.g., wallboard and fabrics) that can be cleaned, can be reused if properly cleaned and disinfected

## KEEP THE RAIN AND GROUND WATER OUT

Controlling rain and ground water are the most important factors in the design and construction of durable buildings and for the control of mold. Air conditioning and dehumidification systems cannot be used to control rain and ground water problems and fix the rain and ground water problems with drainage. The fundamental principle of rain and ground-water control is to shed water by layering materials in such a way that water is directed downward and out of building or away from the building.

## DRAIN EVERYTHING

The most elegant expression of this concept is a flashing. Flashings are the most underrated building-enclosure component and arguably the most important. Drainage also applies to materials. Water that is absorbed in a material cannot be drained away. We paint and stain wood siding so that water is not absorbed by it and can be drained from the siding surfaces. We dampproof concrete foundations for the same reason.

Drainage applies to assemblies such as walls, roofs, and foundations, as well as to the components that can be found in walls, roofs, and foundations, such as windows, doors, and skylights. It also applies to the openings for the windows, doors, and skylights and to the assemblies that connect to walls, roofs, and foundations, such as balconies, decks, railings, and dormers. Finally, it also applies to the building as a whole. Overhangs can be used to drain water away from walls. Canopies can be used to drain water away from windows, and site grading can be used to drain water away from foundation perimeters.

Drainage is the key to rain and ground- water control:

- Drain the site.
- Drain the building.
- Drain the assembly.
- Drain the opening.
- Drain the component.

In other words, drain everything.

## WINDOWS

Window and door openings cry out “ pan flashings”. Windows and doors leak frequently enough that you need to treat them as if the are going to leak. An under-window pan flashing (or "gutter") is essential to redirect this leaking water to the exterior.

## WALLS

Wall assemblies should have secondary drainage planes: a membrane covering the wall behind the exterior cladding. This is real important with brick veneers and stucco, especially synthetic stucco. There are only two kinds: stucco that has cracked and stucco that will crack. There are now some magnificent synthetic stucco systems with available: "Drainable EIFS" (external insulation and finish systems). These work because they drain. Watch out for the non-drainable systems especially when they are used with windows. Mold heaven is when you combine a non-drainable stucco with a leaking window.

It's not uncommon to find wall sandwiches made from OSB or paper covered gypsum, steel studs, cellulose or fiberglass in the cavity (to keep water from draining away), paper-covered gypsum, and vinyl-covered wall paper to keep the wall structure from drying. Does vinyl repel mold? Not at all, mold will digest vinyl paper adhesive and grow into the paper as well.

## LET IT DRY

Controlling water problems in buildings should be easy, keep the rain and ground water out. Design and construct the building enclosure to be able to dry when it gets wet and make no mistake, it will get wet. Control the airflow across the building enclosure because air carries water, so build the building enclosure without holes, at least without big ones. Remember that as part of this air-control system, you have to control the air pressure across the building enclosure. Should buildings be pressurized or depressurized or should you attempt the impossible to maintain a neutral pressure? I think you should pressurize building enclosures in Southern environments and depressurize building in Northern environments.