Consulting Report

Operating Requirements For Practical Portable Mold Detectors

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Table of Contents

Summary

Purpose

This report is designed to help researchers and instrument manufacturers understand the physical environment for hidden mold detection and to understand the perspectives of potential users of portable mold detectors. Our ultimate goal is to speed the adoption of any mold detection technology which could benefit the public.

Process, sources & support

Research summarized here was carried out by Mason-Grant Consulting, working in collaboration with the technical staffs of the Georgia Tech Research Institute and Munters Moisture Control Services.

The work consisted principally of visits to sites with mold and moisture problems, interviews in person and on the telephone with industry experts and potential users, together with supplemental research on-line.

This project was funded by grants from the Office of Healthy Homes and Lead Hazard Control of the U.S. Department of Housing and Urban Development, the Air Conditioning and Refrigeration Institute, and Munters Moisture Control Services.

The substance and findings of the work are dedicated to the public. The author and publishers are solely responsible for the accuracy of the statements and interpretations contained in this publication. Such interpretations do not necessarily reflect the views of the Government or our other sponsors.

Conclusions

1. Any practical detector must be able to locate mold growing (prolifically) on the far side of gypsum wall board and on the far side of oriented strand board located near the center of a wall assembly or under a finished floor.
2. A mold detector would still be practical even if it could not detect low levels of contamination (e.g.: settled spores), and even if it could not establish the species, amount or age of hidden mold. Nor is it essential to detect mold growing in carpets. The most common need of the stakeholders is simply to have some tool which can detect the edges of prolific growth, so those areas can be marked for more detailed investigation.
3. "Edge detection" of areas of prolific mold growth, in real time, is the minimum level of performance for a practical portable mold detector.
4. "Z-location"—depth location of the growth layer inside a wall assembly—would be the next most useful level of performance.
5. 3-D imaging of prolific mold growth areas, in real time, would be the ultimate level of performance.
6. Detection results must be repeatable between operators with different skill levels, and must avoid false positives from normal components of walls and ceilings.
7. Rapid, nondestructive *moisture mapping* of exterior walls in three dimensions—from a position at ground level outside the building—would be at least as useful to the public as mold detection.

Submitted by:

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April 28th, 2004

Introduction

This report is part of a research project at the Georgia Tech Research Institute to develop the technical foundation for hidden mold detection. Our overall goal is to help bring mold detection technology into the service of the public. This report is an effort to assist those who plan to use the technology in useful products.

To describe what we believe to be the more important needs in the field, the report is divided into two principal sections:

- Section I - Locations and causes of hidden mold
- Section II - Resolving mold problems

In the first section, we enumerate and explain the nature and causes of the more common hidden mold problems. With this information, the prospective manufacturer of mold detectors can understand the physical realities of looking for mold.

In the second section, we explain the process of resolving mold problems. We also describe the stakeholders in that process, along with their "operational and cultural" imperatives. By understanding these, the prospective manufacturer can begin to consider who, exactly, would be interested in using mold detectors, and which levels of performance might be of value to each group.

Our basic approach

Currently, the subject of indoor mold has generated an unholy tangle of costly litigation, confusion, conflicting science, questionable medicine, gaps and overlaps in professional responsibilities along with some very real human misery. It is not a situation which lends itself to clear, analytical thought. Further, the detection technology we are trying to define in market terms does not yet exist—it's a figment of our intention.

Therefore, gathering valid quantitative information about the operating requirements for mold detectors would have been very difficult. So we chose the more qualitative approach of site visits, combined with wide-ranging interviews with experts who are currently wrestling with various aspects of the mold problem.

In effect, we asked the experts to imagine first that an effective mold detection technology would exist someday. Then we asked them what they would expect such a device to be able to do.

Subjects and field visits

Over the course of the research, we contacted more than 50 professionals who are currently working in the fields of forensic analysis, mold remediation, water damage restoration, building managment, environmental health, insurance underwriting and loss prevention.

In addition, we visited seven water-damaged buildings where mold detection had been an issue, and attended national technical conferences of five organizations which are focused on mold problems.

Interviews

Interviews asked this question: "What are the operating requirements for a practical portable mold detector?"

The wording of this question was carefully considered. We wanted the subjects to imagine a device for field use rather than laboratory use. Also, one which would provide results in real-time and which would be carried by hand. The word "practical" was used to imply the device would be both durable and affordable. But to guide the conversations still further, we explained exactly what we meant by a practical device.

Our definition of a practical portable mold detector

> "A device which is likely to reduce the owner's cost of insuring the building."

This definition was useful in both expanding and focusing the subject's imagination, because it allows for:

- An expensive device, provided it reduces net costs.
- A complicated or clumsy device, provided it reduces costs and remains portable.

At the same time, this definition sets a very high and difficult standard of performance because it insists that:

- The building owner benefits financially, not just through peace of mind or through improved perceptions of comfort or health.
- The device is so effective, repeatable and affordable that insurance companies would use it to help measure risk and therefore to establish rates.

This definition helped keep the interviews on track by reflecting on the probable judgement of the insurance market. If, in that context, a given feature would be "nice to have" but would not actually reduce owners' costs, then that feature or that level of detection could be set aside. Further, the criterion of cost reduction forced the subject to look forward, making his or her most educated estimate as to what features or performance would *really* reduce risk, and therefore ultimately reduce costs.

Field input - Definition of a mold problem

Another thorny issue for mold detection is to define what level of performance would be useful. Often a subject's first question to us would be: "How much mold will the detector locate, and how deep into the wall can it see mold?"

Since portable detectors don't yet exist, our response was: "What level of detection do *you* usually need?" Their responses were usually something like: "I guess I would just need it to help find the real problem areas... not every last mold spore."

There is currently no established definition, nor even a generally-accepted consensus, on what constitutes a "real problem area." Rather than imposing a definition, we listened to what the subjects seemed to consider a real problem. Based on those conversations and our on-site observations, we evolved a working definition of a mold problem:

> "Enough hidden mold growth to interfere with the use of a building by those who are sensitive to mold."

In turn this definition helped us evolve some idea of what levels of detection would be useful in a mold detector.

Field input - Required levels of detection

Based on the definition above, we could then ask the subjects: "How much growth do you usually find when there's enough to cause a problem for sensitive people?" In most cases, the answer was "When people are having problems, there's usually ***lots*** of hidden mold growth... enough to be quite obvious to the naked eye, after we finally get into the area where it's been growing."

Based on that input, we've concluded that a mold detector would be useful even if it can only locate the areas of very heavy mold growth—because those are the circumstances most likely to generate a large enough problem to involve third parties.

No doubt there are many problems caused by hidden mold growth at low levels, many of which are never understood to be mold problems by either the occupants or owners. No doubt also that if a portable detector could locate such low levels of growth, it would be an even more useful device. But at present, even a device that only detects prolific mold growth (visible growth) in hidden locations would be useful.

In support of this conclusion, an anecdotal report from Elisa Larkin, the founder of Mold Relief, illustrates the current state of the art. During a recent address to the members of the American Association of Restoration Contractors at their national convention, Ms. Larkin asked what percent of mold removal projects usually need change orders—expansions of the original scope of work as defined by a Certified Industrial Hygienist, Engineer or other professional who generates remediation protocols. The group responded that between 95 and 100% of their projects required change orders—the renovator nearly always discovers much more hidden mold than defined by the inspector.

Said another way, existing techniques for defining areas of hidden mold growth may only be effective in fewer than 5% of projects. Given that discouraging situation, it appears that *any* level of hidden detection is likely to be an improvement over the current state of the art.

SECTION I

Locations and Causes of Common Hidden Mold Problems

From the interviews and site visits, it became apparent that mold grows on an immense variety of substrates, in highly variable locations, caused by dozens of different wetting mechanisms. Every person contacted had fascinating examples of mold found growing in unexpected locations. On the other hand, when asked to say "Where and how do 80% of the problems occur?" some distinct patterns emerged. These are reported here.

First we remind the reader that our research is aimed at hidden mold detection—not mold growth which is apparent to the unaided eye on exposed surfaces, such as mold growing on bathroom shower curtains, or in carpets, or on upholstered furniture in damp basements. Those problems may also be important, but they are obvious and can be solved at much lower cost than mold problems inside wall cavities.

How mold grows

To understand why mold grows in hidden spaces, it helps to understand its basic 4-stage growth cycle:

Stage 1 - Create nutrient broth

First, a spore lands on a food source. That spore remains dormant until the food source absorbs enough moisture at its surface to dissolve the hygroscopic enzymes that cover the surface of the spore. In this first stage of growth, moisture from the food dissolves the enzymes, which then act as corrosive catalysts, dissolving the food. Then the liquid nutrient broth under the spore is pulled back into the spore through a difference in osmotic pressure. The liquid nutrient outside the spore is less concentrated than the dry matter inside the spore. So liquid nutrient diffuses through the spore's exterior wall to equalize concentrations on both sides of that spore wall.

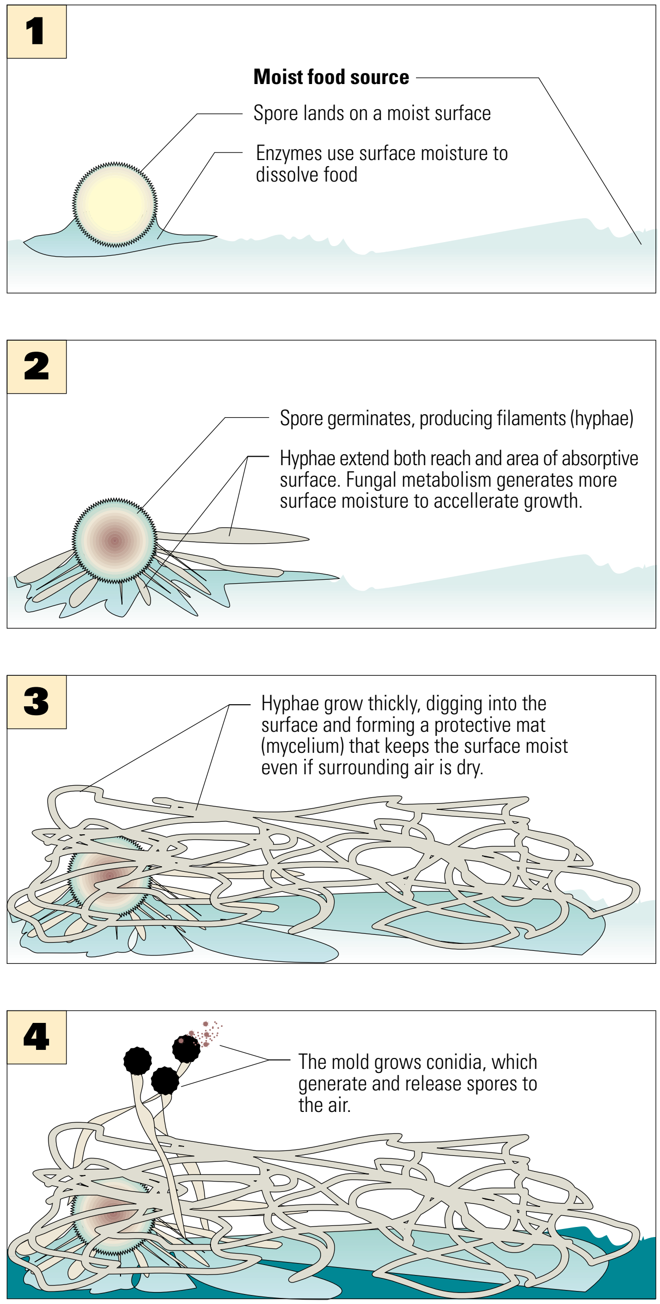


Figure 1. Mold growth cycle.

At this first stage of growth, the fungus is most easily controlled. As long as the food source lacks sufficient moisture, the enzymes do not dissolve, so nutrients are not available to feed fungal growth. Or if the food source dries out—as often happens in buildings with minor leaks or only periodic wetting—some mold may grow, but not enough to cause any real problem. It's only when the material stays wet for extended periods that mold will flourish.

Stage 2 - Generate more absorptive surface

When sufficient moisture is available at the surface of the food, growth proceeds to the second stage. The fungus begins to extend its reach for nutrients by growing filaments called hyphae. As more nutrient solution is drawn into the hyphae, more filaments are grown, eventually forming a dense mat called the mycelium. Towards the end of this stage, the organism may become visible to the unaided human eye. Then, as the mycelium thickens it behaves as a vapor retarder, preventing the food surface from drying out, which would slow or halt growth.

Stage 3 - Generate metabolic water

After the mycelium thickens, the fungus may generate and retain enough moisture through its normal metabolism to maintain growth. As food is metabolized, moisture is produced. This water combines with more enzymes to dissolve additional food. At this third stage, lack of moisture from the air will not limit growth. Fungus will grow until it consumes the food, or until the temperature changes, or until it is killed by some other means such as ultraviolet light, a toxin or one of its many biological competitors. Unfortunately, at this stage the hyphae extend *below* the surface into the bulk of the food. So even if fungal bodies on the surface are killed, the organism can regenerate from its components buried deep inside the food. This explains why remediation is so difficult after mold growth is firmly established. Surfaces that appear clean can re-grow mold when moisture returns to the food source.

Stage 4 - Reproduce

After the third stage of vigorous growth, the fungus has the resources necessary to reproduce. It forms fruiting bodies which generate spores by the millions. These are released to the air, often accompanied by perceptible vapors—the "musty odors" so common to HVAC systems in humid climates. Spores drift through the air to other food surfaces. The cycle repeats when the new food source has sufficient moisture to dissolve the spores' external enzymes.

Where hidden mold growth occurs

The fungal growth cycle explains which parts of the building will be at greatest risk. Mold grows in places where wetting exceeds drying, so that local mold food stays moist.

But that general principle does not define the operating environment for portable mold detectors. To guide potential instrument manufacturers to the specific locations most likely to need hidden mold detection, we divided the reported problems into three categories, according to how the material gets wet. It appears that building assemblies become vulnerable under three types of wetting: catastrophic, episodic and chronic.

1. Catastrophic weather

Floods, hurricanes, tornados, and blizzards can all tear apart even the most water-tolerant buildings, making them vulnerable to the wetting that leads to mold growth.

But increasingly, the public fear of mold has made it obvious to those with professional responsibility that when a building gets really wet, it must be dried quickly.

Over the last few years—and especially after the lawsuits that resulted from inadequate drying after the Houston floods of 2001—there is less mold damage after catastrophic events. Earlier, buildings were more frequently allowed to stay wet for days or weeks while insurance coverage was debated, or dried only enough to create the perception of dryness rather than

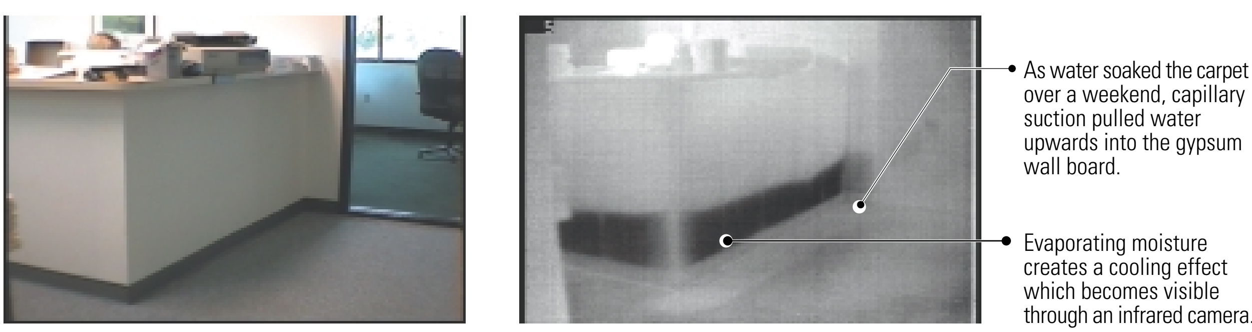


Figure 2. Thermal imaging for moisture detection.

the reality. These days, more people understand the need to start drying within the first 24 hours of a major wetting event.

Further, a new technology—thermal imaging—is being rapidly adopted by the water damage industry to help locate moist materials before that moisture can lead to mold growth. This technology makes the moisture more obvious to remediators and owners, so there is less delay in removing it, and therefore less risk of hidden mold growth.

This is not to suggest that there is no use for portable mold detectors in catastrophic wetting situations. There will always be buildings where the occupants, owners or managers do not understand the importance of immediate, aggressive drying, or simply cannot afford it. Some proportion of these buildings will need mold detection tools when they develop problems after the damage. But increasingly, the areas affected in catastrophic situations are becoming similar to those affected by episodic or chronic wetting, which we will now describe.

2. Episodic wetting

Wetting at regular but widely-spaced intervals, or wetting which happens only once or twice in the life of a building has been named "episodic" for the purposes of this report.

In some respects, these wetting events are more likely to produce a mold problem than catastrophic wetting, because the occupant, owner or manager may not understand the importance of drying. Or, the wetting may not be obvious enough to trigger involvement of the professionals who are familiar with the consequences of failing to dry out moist materials.

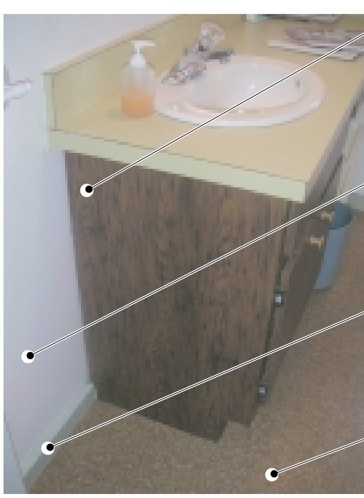


Figure 3. Examples of potential locations of hidden mold.

Dan Bernazzani, who investigates potential mold problems for insurance companies, related a typical example. Upon entering a residence in Vermont with the insurance adjustor and also the homeowner, odors made it obvious that extensive mold growth was present. When asked about possible water damage, both the homeowner and adjustor assured him there had been "Nope, no water damage at all... apart from the basement flooding a few months ago, which has long-since been taken care of." The interesting point is that, since odors developed much later than the flooding, not even the insurance adjustor—who had attended technical training on loss prevention and mold avoidance through drying—made the connection between the flood and the moldy odors produced months later. The homeowner, a very intelligent university professor, had no understanding of the cause and effect between moisture and mold.

This suggests that a portable mold detector would be very useful in episodic wetting situations. It could provide a means of establishing if the odors that homeowners *do* perceive as a problem are being produced by hidden mold rather than by some other source.

On the other hand, not all episodic wetting leads to mold. An interval of wetting is usually followed by much longer periods of drying, so the mold does not have enough time to produce enough growth to create a problem. An example is the familiar "musty odor" that is apparent when a summer home in a northern climate is opened up after the winter. The high relative humidity in an unheated building during cold winter and humid spring leads to moisture absorption by organic materials, and subsequent mold growth. But the growth is seldom extensive enough to see with the naked eye, and is soon halted as warm summer air dries out the minor amount of moisture in the mold's food source.

At least four types of episodic wetting usually produce mold problems:

- Frozen pipes
- Construction moisture
- Seasonal drainage problems
- Seasonal shut-down of the building

Frozen water pipes

The classic cold climate problem of "frozen pipes" can produce a one-time wetting event on any scale, but the basic mechanism is the same, as explained by research performed by Professor Bill Rose of the Building Research Council at the University of Illinois, Urbana-Champaign.

Dr. Rose showed that pipes do not break where the ice is located, as most have historically assumed. In fact, the ice first blocks the pipe. Then, any further freezing generates immense hydrostatic pressure *in the water* trapped between the freezing ice and the next valve. With high pressure (often over 50,00 psi) between the ice plug and the nearest valve or fixture, the pipes will rupture at their weakest point in that section, usually at a soldered connection at a pipe bend.

Pipe breaks usually occur inside such exterior walls, which consist of many layers. The resulting mold growth can be located on several layers, each of which would be targets for a hidden mold detector. After pipe breaks, mold can grow on:

a) Hidden faces of gypsum wall board inside the wall. Linerboard (the light cardboard backing of gypsum board) provides the mold food.

b) Interior faces of the exterior sheathing, usually oriented strand board (OSB). The wood chips that make up the board provide the mold food.

c) Indoor faces of gypsum wall board, behind the molding at the bottom of the wall. The paper facing of the gypsum board provides the mold food.

d) Indoor faces of gypsum wall board, behind cabinets which are mounted on the wall surface. The paper facing of the gypsum board provides the mold food. If wetting is persistent, mold can also grow on the back side of cabinets made of of wood, OSB or fiberboard with a protective "medium density overlay." (That composite product is known as MDO board, or simply "MDO").

e) Upper sides of subflooring near the base of the wall, under carpets, vinyl tile or continuous flooring. The surface of the plywood or OSB subflooring provides the mold food.

Figure 4. Drying during construction.

Wetting during construction or renovation

Extra water is a normal and necessary part of the construction process. For example, every cubic yard of poured concrete contains enough water for concrete hydration ("curing") but also an extra 45 gallons to make the mixture thin enough to flow smoothly into the forms. Most of the extra water dries after the building gets a roof, and before exterior walls are closed-in. But with fast-track construction, rain can keep the concrete saturated. The rainwater, combined with the excess water needed for the pour, becomes trapped inside the building, providing a steady release of water vapor. This can be absorbed by materials which provide mold food, such as paper-faced gypsum board and ceiling tile.

Even more common are problems with concrete block construction, which is often used in schools, hotels and similar low-rise commercial construction. First, the foundation is poured and cured. Then concrete block walls are built while the whole assembly remains open to the weather. Any rain keeps the concrete wet, and also saturates the hollow block walls. If the roof goes on after a rainy period, it can trap residual moisture in the masonry. As that moisture evaporates indoors, it can fuel mold growth in gypsum board and ceiling tile.

The saturated block problem occurs frequently in Florida and the Gulf Coast, where frequent heavy rain is the norm. But interestingly, the problem also occurs in northern climates, where the school construction season is short. In cold climates, the building must be closed in soon after spring rains, to ensure that construction is complete by mid-summer. Otherwise, administrators could not make the building operational in time for the opening of school at the end of August.

Figure 5. In high-rise construction, water from upper stories can wet lower finished floors.

In high-rise construction, finished lower floors can become wetted by water from either rain or normal construction operations on the higher floors, which are not yet weather-tight. The probability of a problem increases with the number of stories in the building—every open floor represents a risk to all the finished floors below. All it takes is one water hose left running to let water drip down through floor penetrations into finished apartments or offices below.

In most cases, construction moisture does not cause mold problems. The wetting events described above usually just dry out before the sensitive materials are in place, or most of the water dries out so there's not enough to support prolific hidden mold growth. Where mold does grow during or after construction, it's often caused by high humidity inside hidden cavities, and therefore is diffused across broad surfaces, rather than being concentrated by gravity in one location, as happens with gross liquid water intrusion. But both mechanisms can occur. For example, with construction-related moisture, mold can grow on the:

a) Hidden face of gypsum wall board inside the wall. Linerboard (the light cardboard back side of gypsum board) provides the mold food.

b) Indoor face of gypsum wall board, behind the molding at the bottom of the wall. The molding prevents the humidity from diffusing out of the wall, and the paper facing of the gypsum board provides the food.

c) Indoor face of gypsum wall board, behind vinyl wall covering which prevents the damp wall cavity from drying out. The paper facing of the gypsum board provides the mold food.

d) Indoor face of gypsum wall board, behind cabinets which are mounted on the wall surface. The paper facing of the gypsum board provides the mold food. With sufficient wetting, mold can also grow on the back side of cabinets made of wood, OSB or MDO.

e) Underside of finished flooring such as carpets, vinyl tile or continuous flooring. Water-based leveling compound, or the adhesive provides food.

f) Hidden face of acoustic ceiling tile, facing high humidity areas above the hung ceiling. Cellulose in the ceiling tile itself provides the mold food.

Seasonal drainage problems

Another set of episodic wetting events can occur annually, but perhaps for only a short time, and during only one season each year. For example, Southern California is basically a dry climate, with very little annual rainfall. But Pete Fowler, a mold investigation expert and construction cost estimator in San Clemente points out that there can be short periods of very high rain intensity. During those downpours, so much water can cascade off of roofs, parking lots and streets that it overwhelms the design details intended to keep water out of buildings and away from foundations.

In the close-packed cluster-built neighborhoods common in Southern California, much of the land is covered, with only narrow strips separating buildings. Unless these "micro-yards" are very carefully graded and drained, rainwater will be a problem, because they must accept and get rid of all the water draining off the roofs. Mr. Fowler notes that because the climate is so dry most of the time, builders don't always attach much importance to flashing around windows, or to grading the lots so that water running off roofs and driveways does not run up against or into the buildings.

In most cases, short periods of intense wetting still will not result in prolific mold growth, because the surrounding climate dries out the structure before any significant problem

Figure 6. When houses are close together, rainwater from roofs can collect between them, leading to drainage problems and water near the foundations.

occurs. But in a few cases, a combination of factors can prevent that normal drying and result in mold growth:

a) On the hidden side of wood or MDO trim around exterior doors when water periodically collects against the base of the door. The paint on the exposed side of the trim keeps the moist interior from drying out. The cellulose in the wood provides the mold food.

b) Water penetration into roofs from ice dams. The combination of warm roofs, snow and cold weather results in ice dams as water running off the edge of the roof freezes as it hits the cold roof edge. The resulting ice traps a small pond of meltwater on top of the shingles. Water eventually seeps back upwards under the overlapping shingles and then through cracks and into the roof sheathing and into the ceiling underneath the roof. Linerboard on the back of gypsum wall board provides the mold food.

c) Foundation ponding caused by finish grading that carries rainwater towards the building, rather than away from it. Water seeps into the building at the foundation, or into the basement. The paper facing of gypsum wall board, or the chips of wood in OSB sheathing provide the mold food.

Seasonal building shut-down

The musty odors of the recently-opened summer camp do not usually indicate a significant mold problem. But other seasonal occupancies create episodic wetting with widespread and notorious consequences.

a) Moldy schools after summer vacation. Schools are only partly occupied, if at all, during humid summer months. Since typical buildings allow significant infiltration of outdoor air, humidity drifts into a school during the vacation. The AC system, which could otherwise remove the excess moisture, is reset to a higher temperature setting to save energy. So it does not run long enough during each on-cycle to dehumidify the air. Moisture is absorbed into mold food like ceiling tiles, books and carpets, and when the school reopens in late summer, mold growth is widespread. In many cases, there is hidden mold in addition to the obvious growth on exposed surfaces in classrooms and libraries.

b) Empty vacation homes and winter-occupied condominiums located in hot, humid climates. Their problems are similar to those described for schools. Condos on the Gulf Coast, unoccupied for most of the summer, collect and trap humid infiltration air, which is not dried by the AC system because it's been shut off or re-set to save operating expense. The indoor environment is very humid, so if there are any small rain leaks in the

Figure 7. Shutting down AC systems in schools during summer months can lead to mold in hidden spaces as well as in libraries.

exterior wall, there is no dry air to remove the excess moisture from walls. Small water leaks can generate large hidden mold problems which would not occur if the air inside the building were kept dry.

3. Chronic wetting

The most common mold problems and the most difficult to resolve are those resulting from chronic wetting rather than from catastrophic or episodic events.

One could make an analogy to the heath care industry. It's very well-equipped to deal with trauma or acute infectious diseases. But chronic diseases like asthma, arthritis, allergies, dermatitis and obesity have such complex causes, and have their roots in such long-term phenomena that medical science is not very successful in eliminating them.

Similarly, the mold remediation industry is well-equipped to deal with major, sudden problems like catastrophic wetting. But it lacks the tools and techniques needed to locate low-volume wetting that grows mold over months or years.

Chronic wetting creates the problems that will probably be the largest and most widely-distributed target for portable mold detectors. These problems often have more than one source of moisture, but one can group them into two categories:

- Indoor moisture sources
- Outdoor moisture sources

Chronic wetting from indoor moisture

Larger mold problems come from larger amounts of water. In general, that means rainwater—directly or indirectly—is the source of most major problems. But there are several circumstances where internal moisture is responsible for problems that would be the target of a hidden mold detector.

Leaking appliances

"Leaky plumbing" is often reported as the cause of moisture and mold problems. But our interviews and other research indicates that more precisely, the problem is likely to be leaking connections to appliances.

Washing machines, in particular, are the most common cause of water damage claims to the insurance industry. To be accurate, it's not the machine itself, but rather the connecting hoses that leak or burst, allowing water to flow into the building structure. The appliances themselves are designed to last between 10 and 15 years. The hoses are not.—so they don't. Water from leaking hoses slowly accumulates below the laundry machines and spreads out from that point. In most cases, this simply means the carpets or flooring will have to be dried, or replaced. But in some cases, a slow leak will allow water to seep more directly into walls or under flooring. There, the paper face of gypsum board, or the wood chips that make up the commonly-used OSB subflooring provide the mold food.

Dishwashers are another common source of water leaks, and again, the hoses connecting to the appliance are usually the problem. Leaks occur between screw thread connections, and occasionally at the connections between the hose and the inlet valve, or between the hose and the screw connector. Problems sometimes occur on outside walls in cold climates. Wind-driven cold air infiltration freezes part of the water in the line, compressing the remaining water to pressures far higher than what the hose is designed to contain, so it develops a slow leak. Mold grows inside the enclosing cabinet, or on nearby gypsum board walls, or in subflooring near the dishwasher.

Icemakers inside refrigerators are a well-known source of moisture among mold investigators. They generate mold problems in and below kitchen areas. Again, the problem is the copper or polyethylene water supply line to the appliance. That thin, initially flexible tube is pushed around during installation, or may become kinked or work loose if the refrigerator is moved for cleaning. Over time, or even during initial installation, the tube sometimes become brittle, or works loose at one end, providing a slow leak of water which flows downward into the flooring, or into the structure beneath the kitchen.

Figure 8.
Water lines to ice makers in refrigerators sometimes leak, leading to moisture problems in hidden spaces.

As in other cases, the gypsum wall board and the OSB subflooring are the first materials to develop mold.

Letters

Keep Bath Vents Away From Soffits

To the Editor:

I am currently involved with a whole-house rehab on a ten-year-old ranch house. The bathroom vent fan exhausted to the outside near the soffit vent strip. Inside the attic, the roof sheathing was nearly completely black with mold from the soffit (in the truss bay directly above the exhaust) all the way to the ridge vent, with the mold fanning out in a V pattern about 6 to 8 feet wide at the top.

While I did not find it necessary to "fit my cap with a chin strap" while working near the soffit vent, as Arne Waldstein wondered (*Letters*, 2/04), it might have been helpful to keep my jaw from dropping so far when I reviewed the proposed remediation cost of $6,488. (The attic did have some other minor areas of mold, as well.)

It may not be common sense, but I'll be locating vents away from soffits!

Jim Conneman
Conneman & Associates, Inc.
Barre, Vt.

Figure 9.
Humid toilet exhaust vented through soffits can return to the attic to grow mold.

Shower riser joints

In most code jurisdictions, plumbing is tested for leaks. But one area which can escape that test is the joint between a tub spigot and the pipe that carries the water upwards to the showerhead in a combination tub-shower. Water only flows up through the riser when the person lifts the small diverter valve in the tub spigot. If the joint leaks at the connection to the riser, it will only leak when somebody is taking a shower—not during the pressure test. This intermittent, but chronic source of water has led to many mold problems behind bathroom walls and around tubs. With good building practices, these areas will be lined with moisture resistant material such as cement board. But if the leaks continue over extended periods, or if the leak is a large one, water can eventually find its way down into the structure beneath the cement board and into a mold food source.

Trapped vapor during the winter

When buildings in cold climates are not adequately ventilated, humidity can rise indoors, to the point where it can condense on cold surfaces and lead to mold problems. The problem occurs more often in residential than commercial construction. This may happen because the enclosed area is smaller, while the internal moisture generation—while small—can accumulate if the home is occupied 24/7. Problems include:

a) Condensation inside walls in tight homes which are not ventilated, and which do not have effective vapor barriers at the indoor face of their walls. Mold food is available in the form of the paper or linerboard backing of gypsum wall board, or the wood chips which make up the OSB sheathing.

b) Condensation on underside of cold roofs. The stack effect lifts warm, humid air upwards through the home to the attic, where moisture can condense on the underside of a cold roof. The problem occurs in tight buildings without enough ventilation. It can also happen in well-ventilated homes which happen to have a moisture load from damp basements or crawl spaces.

c) Condensation in the attic, caused by bathroom exhaust fans which are vented through soffits. In newer homes, attics are often ventilated through a combination of soffit vents as air inlets in the eaves, combined with ridge vents as the air outlet at the peak of the roof. For aesthetic reasons, the exhaust ducts from bathroom exhaust fans are sometimes brought through the attic, so they can discharge humid air downwards and out though the soffit, avoiding a penetration of the exterior wall. But with this design, the warm, humid air from the exhaust accumulates under the eaves, where it is pulled back into the attic through other parts of the soffit vent. When the attic surfaces turn cool at night, the moisture that has collected in the attic condenses on sources of mold food, such as OSB sheathing and the paper faces of gypsum wall board.

These examples have explained how mold sometimes originates from moisture generated indoors. However, the most frequent mold problems are those caused by outdoor moisture which gets indoors.

Chronic wetting from outdoor moisture

There's a great deal of water that falls onto a building over its useful life. If that were not enough of a challenge, the ground around the building retains water, keeping moisture in constant contact with foundations. All buildings also leak a great deal of air—typically between 0.2 and 2.0 complete air changes every hour. During much of the year, that infiltrating air is humid. Finally, irrigation systems can add water to the building's moisture load. All of this water must either be kept out of the building, or must be dried out after it gets in—for the entire life of the building.

Usually, these challenges are met successfully, and no mold problem occurs. But since the national building stock consists of more than a hundred million units, occasionally some combination of small but chronic moisture problems will result, over time, in mold growth. Understanding the common moisture intrusion paths and mechanisms will help the reader understand the working environment for portable mold detectors.

Water through the foundation

According to Sears, 80% of the residential dehumidifiers sold in the US are used in damp basements. Hundreds of thousands of homes have chronic moisture intrusion at the foundation.

If a basement is both finished and moist, mold can grow over time in the finished walls and flooring. Typical mold food sources are the paper faces of gypsum wall board, or the backside layer of decorative plywood or hardboard paneling, or the wood chips in the OSB flooring underlayment. Less commonly, mold can grow on the binders or in the dirt trapped by fiberglass batt insulation, or on the paper face of the batt.

Water can also enter the building at the foundation even when it consists of a slab-on-grade instead of a basement. In those cases, mold can feed on the underlayment of the finished floor, consuming either the water-based leveling compound, or the adhesive which attaches the finished floor.

Typical defenses against foundation moisture include a drainage layer of crushed stone underneath and around the foundation, combined with a perimeter drain underneath the crushed stone to carry water away, plus a water-impermeable membrane on the outside of the foundation between the concrete and the drainage layer. When water loads are within expected limits, these measures are usually successful in keeping water out. But the sales of basement dehumidifiers certainly indicate that some problems do occur. These are usually because of poor drainage, or because of an overload from one of three moisture sources:

a) Roof rainwater. Water running off the roof is a focused stream, concentrating the water that falls over the entire roof area into a much smaller and concentrated flow. This flow must be carried away from the foundation. If it is not, it can saturate the ground and even fill up the drainage layer at the base of the building. Then it can enter the building through the normal small cracks and imperfections in any construction.

b) Landscaping drainage water. Multi-unit residential construction often covers a large percent of the buildable lot, leaving little space for drainage. If the landscaping includes decorative berms, or if the lot slopes generally upwards from the foundations, as when the building is located on the side of a hill, water can run down the lot until it hits the foundation.

c) Irrigation water. Automatic sprinklers are a popular and common feature of commercial and upscale residential construction. If the sprinkler heads are misaligned, or if the wrong ones are used near the edge of the building, or if the water piping develops leaks, water can accumulate at the foundation.

Rainwater through joints in EIFS walls

EIFS (Externally-Insulated Finish Systems) are very nearly—but not entirely—impermeable to moisture. EIFS becomes vulnerable to water intrusion at its joints—around and under windows and doors, or joints where the EIFS connects to other building elements like decks or balconies, exterior cladding like brick, masonry block and wooden siding, or

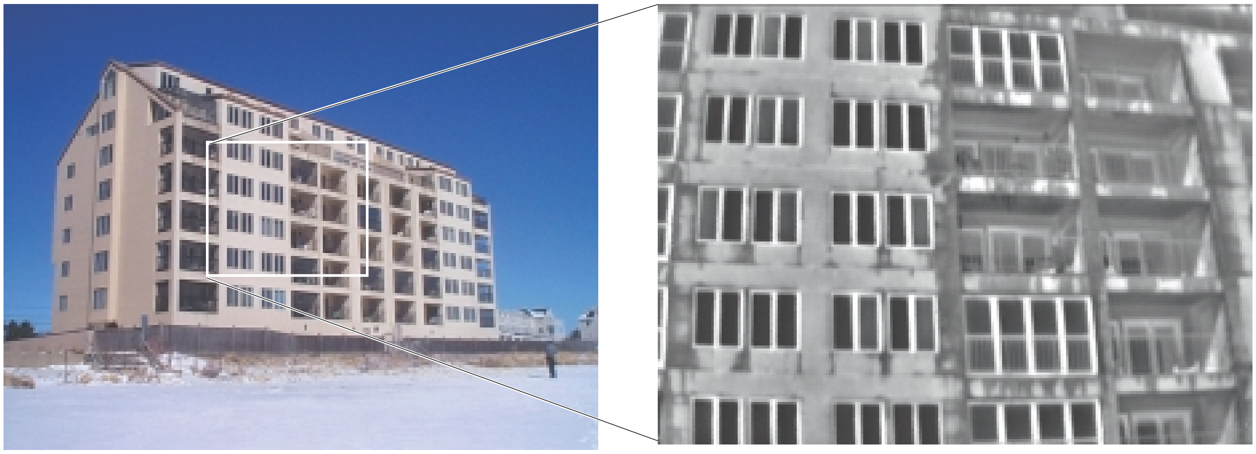


Figure 10. Rainwater entering through cracks in EIFS can lead to mold growth. IR images show moisture accumulation here.

where a vertical EIFS surface joins a sloping roof. In short, like any other building system, EIFS can leak anywhere it connects to anything else, including itself.

To avoid problems, modern EIFS is installed with a drainage layer—effectively a short air gap—between the insulation and the sheathing, so that any water can drain downwards and eventually be forced back out of the wall by flashing. That way, moisture cannot accumulate in the sheathing, nor find its way into the rest of the building. But in earlier systems, this was not common, and even today, flashing and drainage layers are not always installed correctly.

When moisture enters through EIFS, the usual mold growth locations include the outer face of the sheathing—usually OSB—and the linerboard backing of gypsum wall board.

Rainwater and irrigation overspray through cement stucco

Cement stucco is very water-tolerant. It can collect a great deal of water without danger of growing mold directly, because there is essentially no mold food in the cement mixture. However, when stucco stays wet, it acts as a large reservoir, evaporating moisture. Water vapor evaporating from the stucco diffuses into the rest of the building wall. Eventually, the vapor comes to a cool interior surface and condenses. If the cool surface is organic, as in the case of the paper facing or linerboard backing of gypsum wall board, mold can grow.

Peter Sierck, an indoor air quality inspector in Carlsbad, CA, reports that this phenomenon can occur when an irrigation system (automatic sprinkling system) soaks the stucco at the base of a building once or twice each day. Plants near the base of the building (the reason for the irrigation) prevent the air movement that would dry the wall. Then the sun or hot air heats the saturated stucco, creating a "boiler" which drives water vapor into the building. The vapor diffuses into the exterior wall, and encounters a cold surface in the form of the back of gypsum wall board at the base of the interior wall (the cooled indoor air settles near the floor). Where diffusion is blocked by base molding at the bottom of the wall, mold can grow in the face of the gypsum board.

The challenge for a portable mold detector in this situation is to be able to locate mold growing *inside* the wall cavity, *behind* the base molding at the bottom of the wall. In commercial buildings, that molding is likely to be a vinyl extrusion. In residential construction, the molding is more likely to be varnished hardwood or painted softwood, or a painted composite material such as MDO. In kitchens and bathrooms, the base molding may be ceramic tile.

Rainwater through unsheltered brick or masonry walls

Brick and concrete block are also excellent water-tolerant, exterior cladding materials. But just like stucco, masonry walls can retain water from rain and irrigation, and then release it into the building, driven by outdoor heat and radiation from the sun.

To prevent this moisture migration, best design practices call for a vented drainage cavity behind brick veneer, with a moisture-impermeable membrane lining the inboard surface of that cavity. The air space and membrane keep the water vapor from the wet brick from penetrating into the wall.

But brick veneer *without* a drainage cavity is still very common. So mold problems are likely in the future from wetted exterior brick. The growth pattern is usually diffuse, and occurs on the back of interior gypsum wall board.

Evaporation and condensation in crawl spaces

Crawl spaces under the first floor of residential structures are common sources of chronic moisture intrustion into the rest of the building. Dr. Achilles Karagiozis of the Oak Ridge National Laboratory is a leading expert in modeling of moisture transport in building assemblies. He has often remarked that crawl spaces are probably the most complex hygrothermal environment in any building, especially considering the influence of different climates and subsurface geologies.

To greatly oversimplify the problem, it's that moisture inside the crawl space supports mold there, and also supplies moisture upwards into the rest of the building, through rising air currents, or through liquid diffusion through flooring. But like other chronic problems, these mechanisms move moisture slowly, and in relatively small amounts. So mold problems inside the rest of the building are not always obviously associated with moisture from the crawl space.

For example, moisture from crawl spaces is carried up through the house by the stack effect. (Dr. Karagiozis' work suggests that more than 60% of the air in the building is likely to have entered through the crawl space.) Moisture can accumulate inside cold walls during the winter to fuel mold growth. And of course mold will grow on the underside of wood or OSB subflooring that forms both the ceiling of the crawl space and the foundation for the first floor.

Crawl spaces are quite problematic in all climates, including the "dry" climate of Denver, Colorado. As explained by Carl Grimes, an indoor air quality investigator in that city, a common feature of recently-built houses is a "structural crawl space." The soil under much of the Denver area is largely clay. This expands when it gets wet, which leads to heaving and broken basement floor slabs.

One recent solution has been to dig the basement much deeper than usual. Then, instead of pouring a concrete slab for the basement floor, builders place horizontal structural members across the basement, at about 24 inches above the soil. Then they lay a floor of OSB on that structure. In other words, there's a full-depth basement with a floor of OSB, built on top of a 2 ft high, sealed crawl space.

Figure 11. Investigations of crawl spaces would be easier with a portable mold detector which could locate mold from the occupied side of the 1st floor rather than from below.

This construction has proven to produce mold on the underside of the OSB basement floor. Moisture from the soil, damp only occasionally, evaporates and creates high humidity in the crawl space, which is usually entirely sealed and entirely inacessible. The moisture supports mold growth on the "ceiling" of the crawl space, which is made of OSB.

For chronic crawl space problems, a practical portable detector must be able to locate mold through the floor of the first story of the building. It first grows on the ceiling of the crawl space.

Condensation in finished basements in cold climates

The problem of episodic water penetration into finished basements was addressed in the earlier section. But there is also a chronic problem common in cold climates.

In much of the country, the ground temperature stays between 45 and 60°F year-round. Most basements are not insulated, so that means the basement walls stay at the same temperature as the surrounding earth. This is not a problem during the winter, because usual infiltration air from outdoors is dry. But when spring and summer arrive, the outdoor dew point rises, and can stay much higher than the ground temperature for many weeks or months. Then any infiltrating air carries enough moisture to condense on the cool foundation walls. When the basement space is finished, moisture condensed on

Figure 12. Leaking HVAC duct work pulls humid air into a building to support mold growth.

the foundation wall can help grow mold on the back of the finished wall and the underside of the finished floor.

Jeff May, an indoor air quality inspector in Boston, explains that in this situation, the most prolific growth is likely to be in the corners of the finished basement. That's because the corners stay colder than the rest of the walls. In corners, there is more radiational cooling and warm air does not flow freely into corners. So the colder corners allow more moisture absorption from the condensed water on the foundation, and therefore mold grows first and most prolifically behind those corners.

Jeff May points out that in this case, the challenge for a practical portable detector is relatively simple. In fact, the inspector who smells odors in a finished basement knows perfectly well that in nearly all cases, there is enough mold to warrant complete removal of all of the finish materials including the walls. But it's difficult to make that fact apparent to the owner without destructive testing. So if a detector could simply signal the edges of the growth area on the hidden face of gypsum wall board and hardboard decorative paneling, it would be a very useful device.

Humid air infiltration via HVAC suction

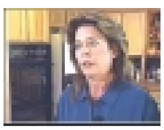
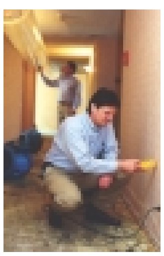
Usually, mold problems are caused by gross water intrusion, not high humidity. But there are many examples of chronic problems generated when large amounts of humid air flow through air conditioned buildings. The combination of chilled surfaces and humid air leads to moisture absorption in organic material, which then grows mold. Sometimes this combination occurs behind walls, providing a need for a hidden mold detector.

Hotels, manufactured housing and portable classrooms provide notorious and widespread examples of this chronic problem. When ducts leak on the return-air side of the system (the suction side), they pull air into the ducts and out of the hidden areas they pass through. That slight suction is enough to pull air into the building from outdoors. The outdoor air is often humid, so it can add moisture to the linerboard backing of gypsum wall board, and its paper face.

Mold problems also come from this mechanism in manufactured housing, as reported by both Neil Moyer of the Florida Solar Energy Center, and Mike Lubliner of Washington State University. Leaking return air ducts or leaking return plenums pull humid outdoor air into the structure, which is often equipped with larger cooling equipment than is necessary. Then, overcooled surfaces create condensation and mold growth.

The mold usually grows inside walls, on the back of the gypsum wall board. It can also grow underneath vinyl wall covering on the front side of the wall. If a portable mold detector could locate the edges of such growth, or at least locate the general areas of greatest growth, it would be a helpful device.

Figure 13. Resolving mold problems - Stakeholders and their principal needs

Groups			Numbers	Principal Needs
Owners		1. Owners	10,000,000+	Mold edge detection
		2. Building managers	1,000,000+	Mold edge detection
		3. Occupants	10,000,000+	Mold edge detection
Finders and Fixers		4. Home Inspectors	10,000+	Mold edge detection
		5. Mold remediators	10,000+	Mold mapping Moisture mapping
		6. Water damage	10,000+	Mold edge detection Moisture mapping
		7. IAQ Investigators	10,000+	Mold edge detection
		8. Forensic investigators	1,000+	Moisture mapping Mold mapping
		9. Public adjustors	10,000+	Moisture mapping Mold mapping
Payers		10. Self-insured owners	100,000+	Mold edge detection
		11. Company adjustors	10,000+	Mold edge detection
		12. Underwriters	10,000+	Moisture mapping
Litigators		13. Defense attorneys	10,000+	Moisture mapping Mold mapping
		13. Plaintiff attorneys	10,000+	Moisture mapping Mold mapping

SECTION II

Resolving Mold Problems

After one has a basic understanding of how and where mold problems develop, it becomes helpful to understand how such problems are typically resolved. Who owns the problem, who fixes it, who pays for it, and what are the principal detection performance requirements of each of these groups?

As mentioned in the introduction, the answers to these questions are currently rather fluid, but some patterns are emerging. The diagram in figure 13 outlines the major groups of stakeholders, their numbers and our estimate of their principal performance requirements for portable mold detectors.

The process and the stakeholders

After an owner, manager or occupant of a building notices a mold problem or suspects there may be one, they may fix the problem themselves if they perceive it to be minor.

If they don't fix it themselves, or if their efforts are not successful, an increasingly common course of action is to call a cleaning company or a mold remediation firm. If the problem appears minor to those professionals, they will fix it themselves. But if it appears to be a more significant problem—one which might involve high cost or risk of litigation, or which appears to be having negative health effects, the cleaning firm or mold remediator will usually recommend that the owner engage the services of an environmental consulting firm.

Then the environmental consultant surveys the facility and establishes a remediation protocol. This defines the extent of the problem and how the mold should be removed and also defines the "clearance criteria" - the tests which will establish whether or not the mold has been removed.

In the current litigious climate, the mold remediation firm then follows that protocol very carefully with very little deviation, even when the protocol may have obvious shortcomings. This "I know nothing... nothing", hands-off approach is perceived to help reduce the liability exposure of the remediator.

During all stages of this process, there may be insurance adjustors involved. The company adjustor, who works on behalf of the insurance company, works to minimize the cost of the loss. Then a public adjustor may be hired by the insured, if he or she believes that the company adjustor is not being fair in the reimbursement of the cost of the loss, or in deciding the extent of coverage.

When the parties disagree, attorneys are sometimes brought into the dispute. The plaintiff's attorney seeks to gain maximum benefit for the owner or occupant—those who own and live with the problem. Defense attorneys seek to minimize the liability of their clients, which can include insurance companies, remediation firms, or the environmental assessment firm.

Each of these groups have different perspectives on what level of performance is necessary, and what level is desirable for hidden mold detection. The diagram in figure 13 summarizes our estimate of these needs, and the following text provides more details.

Owners and owner-occupants

The variation in the backgrounds, opinions and needs of owners is as wide as the number of people in the general population. But in general, for those who are confronting a possible hidden mold problem, the first questions are: "Is there toxic mold in the building, and if so, where?"

It's unlikely that the first generation of mold detectors will be able to determine if the mold is toxic, since there is no agreement on what the term "toxic" really means. But after that, the need is to find out if hidden mold is present.

So we believe that a "mold edge detector", one which functions roughly like a studfinder, would be a useful device for building owners, and one which some number of them would actually purchase and use if it were low-enough in cost—probably less than $100.

For most building owners' purposes, the accuracy and repeatability would not have to be high enough for research or legal purposes. A useful device would simply help the owner decide whether to call a mold professional.

Home inspectors

Similar levels of performance will probably be adequate for home inspectors. The acceptable cost of home inspection is very low, so it would not support the time and cost of a mold detector which would be more accurate or more comprehensive than the device envisioned for use by owners.

In support of this assessment, the fact is that many home inspectors do not even find it necessary to invest in either hygrometers or moisture content probes, which are the most basic level of instrumentation needed to identify a possible moisture problem. The cost of such instruments is less than $300, but some inspectors don't believe these instruments are useful enough to justify that relatively low cost. Moving up the scale of instrument cost and effectiveness, virtually no home inspector has invested in an infrared camera, which can be used to locate moisture problems more quickly and reliably, but which costs at least $9,000.

It is certainly possible that some home inspectors will find a more expensive and more capable mold detector cost-effective and at some point essential, especially those who also work on commercial properties, multi-unit residential buildings or high-cost homes. But these are very few compared to the number of home inspectors who do everyday inspections in connection with residential real estate transactions. Based on input from such inspectors, and from observers of the home inspection profession, we estimate that most inspectors will be content with the "edge detector" capability envisioned for use by interested property owners.

Mold remediators

At present, nearly any person or any firm which decides to call itself a mold remediation company can be one. There are dozens of "certification" courses and examinations, all of which result in impressive honorific initials and certificates of approval. Many of these are rigorous processes which demand both scientific and practical understanding of mold problems and provide useful results to building owners. But others are less useful and some are questionable both technically and ethically.

Consequently, there is a broad variation in the acceptable performance and acceptable costs for a hidden mold detector among this group. At the base, a simple, low-cost edge detector is the only requirement. But as the quality and liability assumptions of the firm increase, the desired feature list expands and the acceptable cost increases.

There is a dynamic tension between mold remediation contractors and the environmental investigators who are supposed to define the nature and extent of a mold problem. The remediators expect the investigators to "get it right" and to accept liability if they get it wrong. However, remediators live with the fact that the investigators *very seldom* "get it right", and usually cannot accurately define the location or extent of mold growth until things are torn apart.

This situation makes clients very angry with the remediators' bills. The clients didn't want the mold problem in the first place—much less to find out halfway through the project that it will cost twice or three times the original estimate.

So the larger or more careful mold remediation firms would welcome a mold detection tool that would let them map the extent of the mold. That way, even if the investigator chosen by the client did not do an effective job of defining the problem area, the remediator would be able to provide a better estimate to the client up front. Remediators have been using thermal cameras to map moisture visually, and would like to have a similar capability to map the extent of mold growth.

The need to clearly map the mold is very strong in buildings with multiple ownership or multiple tenancy, and buildings with multiple insurance coverage, such as condominiums, apartments, and high-rise office buildings. Consider the example of a mixed-use high-rise urban building with residential condos on upper stories, leased offices below and leased retail spaces at street level. Imagine a condo owner installs a jacuzzi on the 32nd floor, and that the cold water connection develops a slow leak while the owner is living in Florida for the winter. Water moves slowly down behind the walls, eventually reaching street level, after having passed though other condos and offices (some of which already had mold problems because of leaking windows) and eventually down into the retail space, where it drips onto ceiling tile and mold growth becomes apparent. The retail tenant calls the building management firm and demands a solution, since stains and odors are a problem. The management firm calls a mold remediator, because visible mold growth is apparent, and because they don't want to fix the problem themselves and accept liability for the solution.

Now the mold remediator is asked to provide a firm quote to the management company to remove the mold. It seems to affect three different types of occupancies, each with condo and leaseholder improvements, covered by 25 different insurance companies, and the first $30,000 of the project cost will be covered by the building owner's self-insurance.

Where is all the mold? Who will be paying for its removal? What the building owner needs is a good overall map. So a device which investigators could use to map the mold throughout such a building quickly and reliably would be a useful tool, and one which could be quite expensive and still be cost-effective for a large-scale mold remediation company to own. The circumstances do not have to be so complex as in this example. Nearly every mold remediation job in condominiums or apartments has the same problem on a smaller scale—mold which physically spans many areas covered by different insurance carriers and different ownership.

IAQ investigators

IAQ investigators tend to be engineers or other professionals with two or four-year degrees in environmental, biological or chemical science, or degrees in public health. Mold and moisture investigations have never been part of their academic training. They have been forced to develop those skills and techniques because of the science underlying the problem, and because of the public's concern. As with the mold remediation industry, results from IAQ investigations centering on mold have been mixed, from the client's perspective.

As some have said, "When your favorite tool is a hammer, all your problems look like nails." Until recently, IAQ firms have been more concerned with quantifying the mold spores in the air and mold fragments in settled dust than in actually locating the mold and the moisture which caused it. There are comforting quantitative tests to measure and characterize particulates. These appeal to an IAQ investigator and they provide a false sense of success in defining the problem. But thousands of dollars later, the investigator may still have no idea where the mold is located, nor where the moisture is coming from.

If better tools were available for locating mold and moisture, the IAQ investigation community would use them. The fact that IAQ investigators are beginning to invest in infrared cameras supports this conclusion.

The performance requirements for a mold detection or mold-mapping device used by environmental investigators are much more demanding than for tools used by remediators or by building owners.

The investigator is professionally liable for the results he reports, and often, an investigator becomes involved because the matter is expected to end up in court. Investigators with technical degrees are meticulous and cautious by their nature and by their training, and become even more so when what they report has major financial and legal consequences.

A mold detector or mold mapping system for use by such investigators could be allowed to be complex and costly (a budget of $10,000 appears to be acceptable, based on the fact that these firms are now buying infrared cameras which can cost even more). However, its results would have to be ***highly repeatable***. And as the cost of the device goes higher, it would have to be effective—at that high level of repeatability—in many types of construction and at nearly any depth.

Water damage restoration firms

The needs of water damage restoration firms are similar to those of the mold remediation industry, and many firms perform both functions.

At the most basic level, a water damage firm needs to be reasonably sure that its workers will not spread mold spores when they dry the building, or when they pull out the materials which are too damaged to be restored through drying. For this need, the simple mold edge detector is probably sufficient.

For firms which also remediate mold during water damage restoration, the needs are more similar to those of the IAQ investigator—mold mapping, highly repeatable results, and higher acceptable costs for the device.

Insurance underwriting

Until recently, mold insurance for chronic problems has not been available. Or if available, the coverage has been so limited as to be essentially risk-free to the insurance industry.

Of course, there is currently a great deal of litigation against insurance companies regarding mold—the amounts under dispute are measured in the tens of billions of dollars. However, those are issues on the adjustment and loss-management side of the business. On the underwriting side—where new risks are quantified, priced and accepted—there has been no rush to sell mold insurance. But this is currently changing, which provides an interest in portable mold detection.

Interestingly, the industry appears to more eager for moisture mapping than for mold detection. John Fajin is a senior technical executive with AIG Insurance, the largest property and casualty insurance provider in the U.S. He neatly summarized similar inputs from others in the insurance industry by telling us: "If you can find moisture, you've given me an opportunity—but if you've found mold, you've given me a claim."

In other words, locating moisture at the underwriting stage allows the owner to find and fix a small problem before it becomes a very large one (and before any risk is accepted).

Mr. Fajin remarked that the best of all possible tools (for underwriting) would be some form of high-speed, drive-by CAT-scan, generating a 3-D moisture map of all exterior walls with no need to enter the building. Such a tool could be useful to the industry even if were very expensive to buy, and could even be quite complicated to use—as long as it provided quick, comprehensive and repeatable results between different structures and different operators.

Insurance adjusting - Company adjustors

On the adjusting side of insurance companies, moisture mapping is again much more desirable than mold detection. The company's adjustor is not interested in locating mold under any circumstances, no matter what its origin. And he's certainly not willing to pay for finding it. Pat Harmon, the Education Director of the Property Loss Research Bureau, summarized the attitude of the industry when he explained that; "There's an old saying in the insurance industry—'It's not our job to present the claim."

As on the underwriting side, company adjustors are beginning to have an interest in better moisture mapping, because when all the moisture is located and dried, it keeps the cost of the claim at more reasonable levels compared to when moisture is allowed to generate mold.

To illustrate the value of moisture detection in loss management, Mr. Fajin provides these numbers: "Every dollar's worth of moisture damage becomes:

- $10 if it stays wet and becomes a small mold claim
- $100 when it becomes a large mold claim
- $1,000 when a mold claim is accompanied by a claim for bodily injury"

For adjustors as well as for underwriters, moisture mapping is the real need.

Public adjustors

For every action, there is an equal and opposite reaction. That rule of nature also applies to insurance adjusting.

When a client believes a loss is not fairly compensated by his insurance carrier, he can hire an independent, "public" adjustor to represent his interests when dealing with the insurance company. Public adjustors have a much greater interest in mold detection than company adjustors.

Like owners, remediators and water damage restoration firms, the most basic need of the public adjustor is for an edge detector for areas of prolific mold growth. This would allow them to argue to the insurance carrier that there is a problem, before that problem is physically exposed and also becomes an annoyance to the owner.

Defense attorneys

When a mold event enters the legal system, it becomes very expensive, and the attorneys begin to take an interest in detection technology. There are two perspectives. The defense attorney—the one defending the insurance company or defending the building owner from the occupant—is interested in showing that there is no problem with mold. These attorneys are less likely to be interested in mold detection, except to:

- Prove that its results are bogus and unreliable, or
- Use it to demonstrate conclusively that there is no mold problem in the building in question.

Given that it is unlikely for any technology to be able to rule out the presence of mold entirely, it seems equally unlikely that defense attorneys will be interested in using or encouraging the use of mold detectors. In this regard, they are similar to adjustors who work for insurance companies—they'd rather not know about the presence of mold, and are certainly not willing to pay for the information.

Plaintiff attorneys

On the other side of legal disputes, the plaintiff's attorneys are quite interested in establishing the presence of mold. But the detection performance requirements for legal disputes are the most stringent and difficult of all.

The attorney bringing a mold case needs results which are highly repeatable, and which have a low probability of false positives, and which can generate compelling visual displays for non-technical jurors. If these characteristics can be met, the detection technology can be quite expensive and still be cost-effective for legal disputes.

Again, the emerging use of thermal cameras to document areas of excess moisture provides support for this conclusion. But the current status of thermal moisture detection also provides a caution. While the images produced are compelling, false positives are very easy to create, which makes both professionals and juries skeptical of the results of costly new technologies.

Conclusions

Based on our research, we believe that at the most basic level, any practical portable hidden mold detector must be able to locate the edge of an area of prolific mold growth. By prolific, we mean that if the mold were exposed, it would be visually apparent. Further, any practical detector must be able to locate the edge of growth when mold is on the :

- Near side of gypsum wall board, behind a layer of vinyl wall covering or behind vinyl base molding
- The far side of gypsum wall board under the same conditions
- The near side of OSB, when under a layer of carpet or vinyl flooring, or under fiberglass or polystyrene board exterior insulation (under EIFS)
- The far side of OSB, under the same conditions.

If such a detector existed, we believe it would be used by tens of thousands of professionals, even if it cost as much as a thermal infrared camera (between $10,000 and $15,000). Then, if the detector were cheap enough to appeal to building owners (under $100), its use would reach into the tens of millions.

If a hidden mold detector could *not* meet these basic requirements, it might still be quite useful and even popular. But would not be ‘‘practical’’ as we have defined it—it would not be likely to reduce the cost of insuring the building.

Finally, we also conclude that, to the insurance industry, reliable mapping of hidden moisture may be even more important than hidden mold detection. A fast and reliable moisture map of exterior walls would almost certainly reduce the cost of insuring a building against the risk of mold.

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Stoneham, MA

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U. S. General Services Aministration
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Chris Yost
Yost Construction Consulting, LLC
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Travis West
Air Quality Sciences
Houston, TX

Teresa Weston
E.I. DuPont
Wilmington, DE

Field visits

Denver, CO (Residence)
Carlsbad, CA (Various)
San Clemente, CA (Various)
Cambridge, MA (Various)
Fauquier County, VA (High school)
Frederickburg, VA (Middle school)
Honolulu, HI (Federal building)
North Reading, MA (Residence)
Washington, DC (DC Appeals Court)
Windsor, VT (Various)

Conferences

Water Loss Institute (WLI)
Scottsdale, AZ

Association of Specialists in Cleaning & Restoration (ASCR)
Colorado Springs, CA

American Society of Air Conditioning, Heating & Refrigerating Engineers (ASHRAE)
Anaheim, CA