The Complete Guide to

# WATER DAMAGE RESTORATION

## IICRC Approved WRT
## **Course Manual** 2023



Presented by
DELOATCH TRAINING & CONSULTING

# Water Damage Restoration

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V. 2022.5

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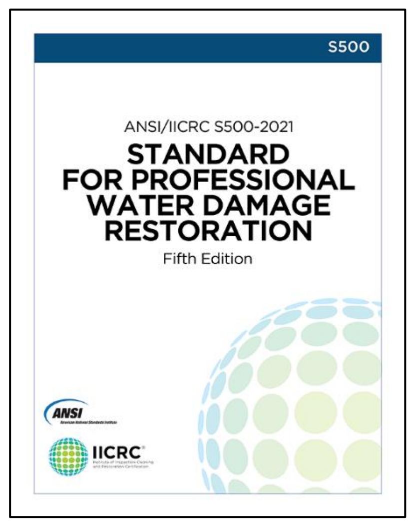
## Introduction — Section 1

Water is considered the earth's most precious resource. It accounts for approximately 70% of the earth's surface, has strong bonding properties and the ability to dissolve materials. Water is essential for life. Water is unique in that it is the only natural substance that is found in three states — liquid, solid (ice) and gas (vapor) — at temperatures normally found on earth. At the same time, water is the single leading carrier of pathogens in the world today. This potential for serious adverse health effects should never be underestimated. In Mexico, one person out of every 60 dies of waterborne disease (cholera). In Africa, a person dies each minute from such disease.

Water is also the cause of damage in some of the worst natural catastrophes North America encounters on a regular basis: hurricanes, which account for eight of the 10 most costly catastrophes ever recorded in North America.

As destructive as hurricanes are, they are not the leading cause of water intrusion and water damage in structures today. Excessive moisture also occurs in buildings because of construction defects, plumbing failures, damage from freezing and even improper maintenance.




Clearly, excessive water has the potential to cause many problems in the built environment. The elements necessary to support microbial growth are always present; all that is required to initiate a destructive chain reaction of microbial growth is the addition of excess moisture. Where abnormal moisture is present, microorganisms will rapidly multiply and cause structural deterioration, create odors, and potentially create serious health issues for building occupants. When a water loss occurs, the single most critical factor in defining the amount of potential damage is the amount of time the structure remains abnormally wet. It is for this reason that, initially, the most critical course of action in restorative drying is to respond quickly and begin mitigation as soon as possible. All other lessons covered within this manual pivot upon this very important principle.

The restorative drying process — assessment, documentation, controlled drying and selective replacement — is used to recover from many forms of water intrusion. Much of what the restorer encounters during a drying project is influenced by a large number of variables. Due to the number of variables, the restorer must frequently revisit the tools, systems and science throughout the drying process. All restorers should follow the standard of care for the water restoration profession developed by the restoration industry entitled the IICRC S500 *Standard and Reference Guide for Professional Water Damage Restoration.*

The goal of the restoration process is to transform an abnormally wet, potentially damaged structure into an environment of equal or better appearance and cleanliness than before the intrusion occurred, and to do so in the most economical and efficient means possible.

The restorer begins this process by identifying all affected materials. Water must be tracked from its source and followed in every direction to establish an accurate perimeter of the flooded area. Next, the restorer documents what types of materials have been affected (e.g., type of subflooring, type of carpet and underlay, type of wall construction, type of insulation). Affected materials are then evaluated against three criteria to determine if they should be restored or replaced. The three criteria are:

- Degree of contamination
- Damage to the item
- Replacement cost versus restoration cost

Only after identifying the material and considering these three factors does the restorer decide which materials should be dried and which should be replaced. In addition, the restorer will also decide which materials should be dried aggressively and which should be dried through more disruptive means.

High value structural materials and contents that have slight reversible damage are dried aggressively. This procedure is referred to as drying in place. Drying in place means that the wet surfaces are dried with little or no manipulation.


Damaged materials that cannot be decontaminated or are of relatively low value should be removed or manipulated to facilitate restoration. This process is referred to as disruptive, and may include perforating materials, removal of surface or finish materials (e.g., vinyl sheet goods, wallpaper, wallboard, etc.) and the use of inter-air drying systems.

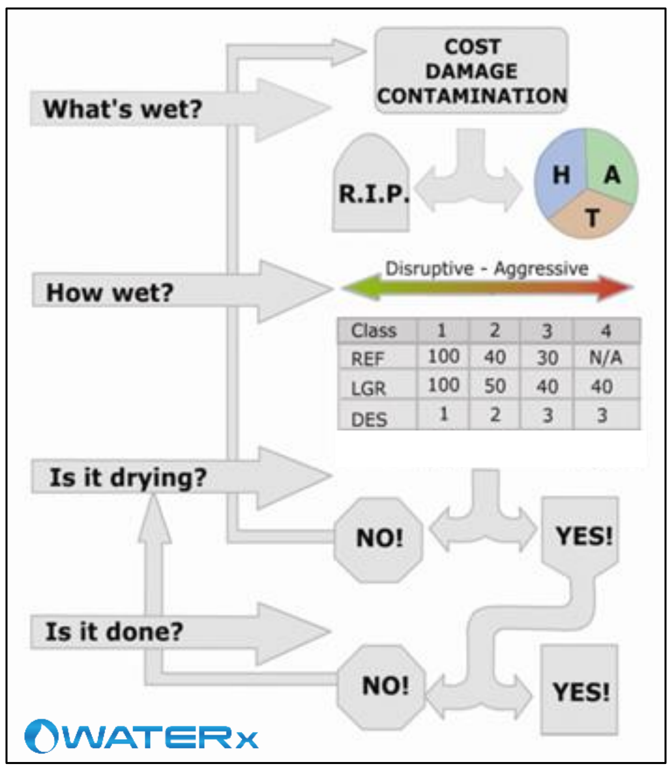
All materials that are determined restorable are inspected further, and the amount of moisture absorbed by the material is measured and documented. Answering “How wet is it?” is critical to the drying process for two reasons. This information influences the amount and type of equipment used. It is also necessary in order to determine if drying progress is being made on subsequent monitoring visits.

Drying progress is noted during daily monitoring visits. The restorer asks “Is it drying?” while comparing the moisture readings taken from two separate monitoring visits. These two sets of data, recorded on a monitoring report, reflect the impact of the drying effort on the affected materials over a 24-hour period.

If materials are making significant progress after the initial 24 hours of drying, then drying continues; no major change is necessary to the process. The restorer continues to observe progress until drying is complete.

If materials are not drying, it is clear that the current approach is not working. The restorer must re-evaluate the equipment, systems and processes and refine his or her approach. The approach can be more aggressive, or more disruptive. The evaluation process is identical to the initial assessment except in one important detail. Now the material has been wet for an additional 24 hours. Damage and contamination are of greater concern.



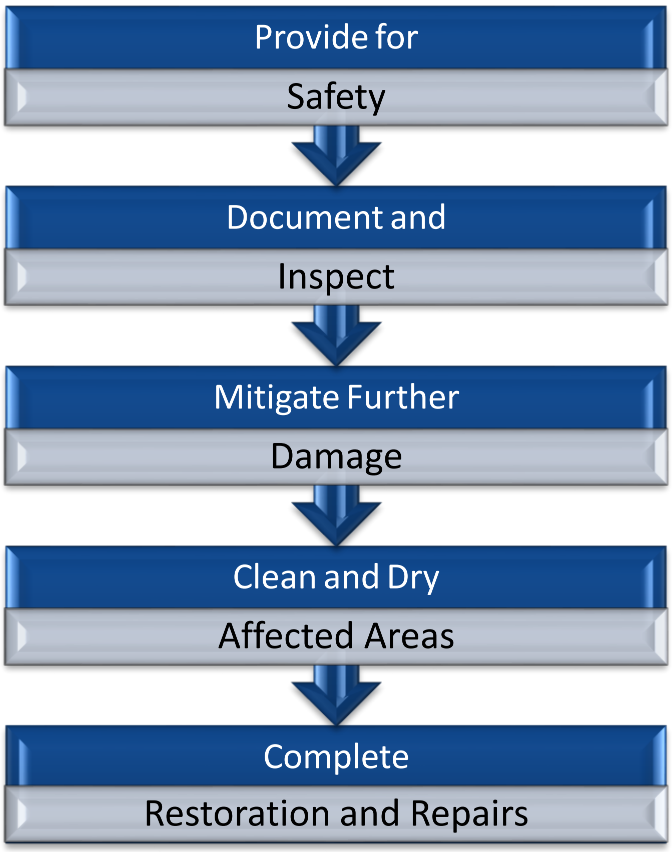

This cycle of evaluation and re-evaluation must continue throughout the restoration project. The critical element to the process is that drying progress must be constant. If the drying process is not working, the restorer must modify the drying environ ment by adding or subtracting equipment or possibly removing wet, non-salvageable materials. The most economical and effective methods are best identified by a consistent focus on contamination, damage and cost.

The restorer must constantly ask “Is it done?” during the monitoring process. This means the restorer must know what “done” is. The materials must be compared against a dry standard or the drying goal. As materials return to their dry standard, equipment is reduced. Only after all drying is complete is equipment removed entirely.

It is important that restoration processes and procedures are carefully evaluated to ensure that they are appropriate. Because every job is unique, the approach should also be unique. Being able to adapt and change to ensure a proper fit between process and structure will translate to significant time and cost savings. The restorative drying process was designed to ensure that each critical and dynamic variable is considered to achieve drying goals based on a dry standard.

## The Principles of Drying

The IICRC S500 Water Damage Restoration Standard and Reference Guide describes the task of water damage restoration through five principles.




### Principle 1 — Provide for the Safety and Health of Workers and Occupants

The technician's first responsibility when arriving at a water damage site is to identify and eliminate safety hazards. The restoration contractor is responsible to provide for the health and safety of workers and occupants during restoration procedures.

### Principle 2 — Document and Inspect the Project

The restorer must evaluate the extent of water migration and be able to measure the amount of moisture absorbed by materials in order to properly scope the work to be done. As drying is attempted, the restorer must verify that anticipated progress is actually being achieved. Due to the number of variables present that affect the drying of materials, progress cannot be assumed. Frequent inspection and monitoring is therefore essential.

Restorative drying is a dynamic process in which a number of variables are constantly influencing the restorer's intended result: returning the structure to a clean, dry and safe living environment. The nature of these variables demands the restorer conduct several inspections of the drying environment:

- Initial Inspection — to identify items that will influence the restorer's end goal.
- Ongoing Inspection(s) — to ensure that expected progress is being made.
- Final Inspection (Completion) — to ensure materials have dried to the pre-determined goals.

### Principle 3 — Mitigate Further Damage

Drying decisions are made based upon critical information the restorer obtains during the initial assessment. The inspection not only checks the extent of moisture intrusion, but also considers the potential for additional water damages.

#### *Control the Spread of Contaminants*

One form of secondary damage — microbial growth — can cause structural components to lose their integrity, can potentially impact indoor air quality, and may ultimately result in compromised occupant health. The restorer identifies any health concerns arising from pre-existing conditions or from the water intrusion. Care is taken to contain contaminants and not spread them to unaffected areas of the structure.

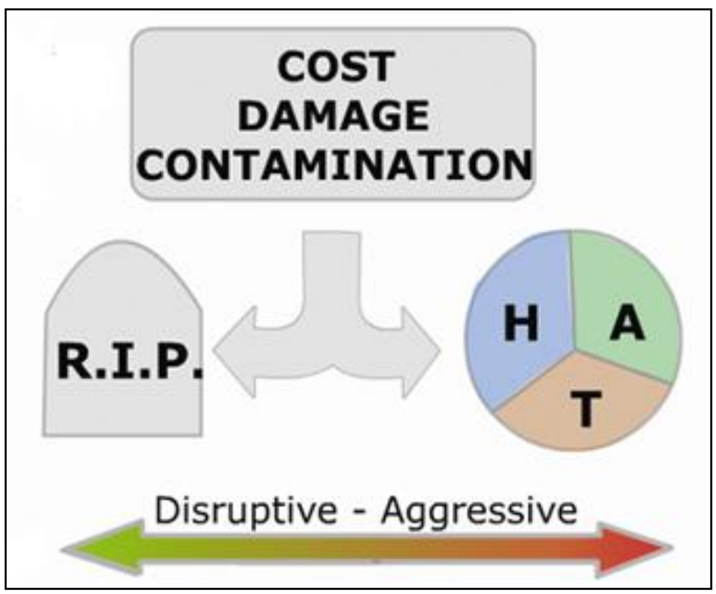
#### *Control Moisture Intrusion*

The source of water intrusion must be stopped and any further moisture intrusion controlled in order for the restorative drying effort to return the structure and contents to an acceptable condition. The technician will determine whether any building materials in the affected areas could suffer potential secondary damage.

### Principle 4 — Clean and Dry Affected Areas

#### *Cleaning*

Cleaning procedures are used whenever soils and debris must be removed to expedite the drying process. Contaminated materials that can be ultimately restored require cleaning either before or after the drying process. Any highly porous items affected, such as valuable contents, require intensive cleaning.




#### *Drying*

Restorative drying contractors manipulate and control as many factors as possible in their drying system to produce the most efficient drying. Once as much water as possible has been extracted, evaporation of remaining moisture is enhanced by:

- Lowering humidity in the affected air.
- Increasing airflow across wet surfaces.
- Controlling temperature of air and surfaces.
- Using outside air when possible.
- Creating a drying chamber.

Evaporated moisture must be removed from the affected areas by dehumidification or ventilation. Additionally, knowledgeable restoration contractors recognize that each loss site is different, and they adjust methods based on each situation, including:

- Adjusting or removing equipment when necessary.
- Removing items that should not be dried.
- Saving items that can be dried in place.
- Using specialized tools to dry difficult areas.

**Principle 5 — Complete the Restoration and Repairs**

The water restoration technician's job is not done when the materials are dry. As the drying proceeds, restorers have to re-evaluate the condition of structural items or contents and consider whether they will require refinishing or repair to return them to a pre-loss condition. Any building materials that were removed or disrupted will need reconstruction. The job is not complete until all affected materials are clean, dry, and equal or better in appearance and function than they were before the loss occurred.

## Hazard Awareness and Risk Assessments

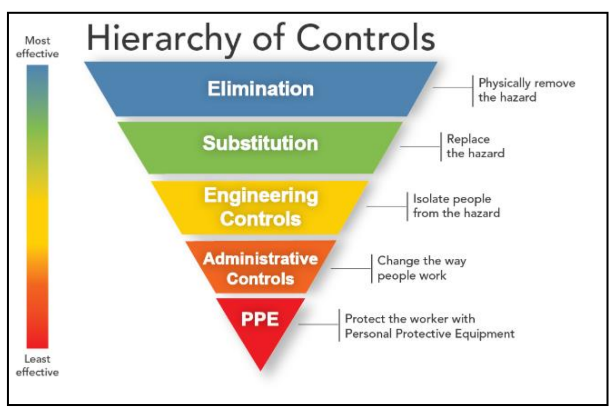
The first line of defense against safety hazards is awareness. A hazard inspection checks for any work-site situation that potentially poses danger to life or property. Restorers must then perform a risk assessment on all potential hazards found on the work site. The assessment evaluates the risk or likelihood a particular hazard will cause harm. Due to the unsafe nature of most water damaged structures, hazard inspections and risk assessments are essential for protecting workers.


The initial hazard inspection and risk assessment of a water damaged facility would involve three important aspects. The first step is to identify hazards that could give reason not to enter the building, such as wet electrical panels and collapsing ceilings. The second step is to identify the presence of regulated building materials such as asbestos, lead, or PCBs (polychlorinated biphenyls). Government-regulated substances may require testing or inspection services from specialized, third-party experts to assess health and safety issues. Finally, a competent technician conducts a risk assessment and installs or implements the necessary hazard controls for any identified hazards.

## Hierarchy of Controls

Hazard controls are implemented to protect against injury or other safety incident. Controls are categorized in a hierarchy. Those considered more effective at protecting workers and occupants are categorized higher in the list. For example, the most effective controls either eliminate the hazard or substitute a safer situation for the hazard. Where hazards cannot be eliminated or replaced, safety programs implement controls lower in the hierarchy:

1. Engineering Controls
2. Administrative Controls
3. Personal Protective Equipment




*Centers of Disease Control and Prevention*

Engineering controls are designed to deal with hazards before workers come in contact with the hazard. These controls isolate workers from a hazard.

Administrative controls are lower in the hierarchy. These controls occur between the source of the hazard and the worker. They include safe work practices which protect workers by changing the way people work.

Personal protective equipment (PPE) consists of controls placed on the worker. PPE is the lowest form of hazard control because protective equipment devices do nothing to eliminate the hazards themselves.

### Personal Protective Equipment (PPE)

Restorers cannot always eliminate all health and safety concerns in water damaged structures, so PPE is often a part of the safety program. Selecting a proper level of protection is important when considering PPE. One step of the initial risk assessment is to closely evaluate the potential risks and determine which type of PPE would be most appropriate.

To help protect technicians from the many hazards associated with contaminated water losses, restorers need to have ready access to several items. These items protect for all potential exposures to the body and include:

- Chemical-resistant gloves
- Splash goggles
- Appropriate respirator
- Hard hat
- Rubber boots with hardened shank
- Protective clothing

#### Respirators

Respirators protect workers against harmful particulates, vapors and gases. These hazards can cause cancer, lung impairment, other diseases or even death.

Utilization of respiratory equipment must conform to OSHA (Occupational Safety and Health Administration) regulations. These regulations require employers to provide a safe environment for all employees who are exposed to potentially hazardous situations. OSHA regulations state that the employer must provide medical evaluations, fit testing (ensuring respirator fits properly) and training.

Respirator types vary, but include the following major classes:

### *Class 1: Air Purifying Device*

This class of respirator is equipped with an air-purifying filter, cartridge or canister that removes specific air contaminants by passing ambient air through an air-purifying element. The air-purifying device (the most common type of respirator used in the restoration industry today) cleanses the contaminated atmosphere. This type of respirator is limited in its use to those environments where the air contaminant level is within the specified concentration limitation of the device. Also, the area must contain sufficient oxygen since the respirator does not supply oxygen. There are various types of air-purifying device technology, including:

- Mechanical-filter cartridge
- Chemical cartridge
- Combination mechanical-filter/chemical cartridge
- Gas masks
- Powered air-purifying respirators

### *Class 2: Atmosphere-Supplying Respirator or Supplied-Air Respirator (SAR)*

This class of respirator supplies the user with air from a source other than the ambient atmosphere and includes supplied-air respirators (SARs) and self-contained breathing apparatus (SCBA) units. With SARs, air is provided through a supply hose connected to the wearer's face piece or enclosure. Three basic classes of air-line respirators exist: continuous flow, demand-flow and pressure-demand flow.

### *Class 3: Combination Air-Purifying and Atmosphere Supplying Device*

This class of respirator combines an air-line respirator with an auxiliary air-purifying attachment, which provides protection in the event the air supply fails. The filtering mode is typically used for escape purposes only. Because they work on positive pressure and have escape provisions, these respirators are highly recommended for use in asbestos type work.

### *Respirator Cartridges*

In addition to the varying types of self-contained respirator units, a number of cartridges are available for respirators that do not supply their own air. The supplied air respirator mentioned earlier simply filters the air using one or more cartridge types. In other words, the work area must contain sufficient oxygen for workers to use the SARs with cartridges. Cartridge types are color coded to indicate what contaminate they will remove from air. Color coding is as listed below:

| | |
|---|---|
| Magenta | P-100 (HEPA) for particulate |
| Black | organic vapor |
| Yellow | organic vapor/acid gas |
| White | organic vapor/acid gasses/formaldehyde |
| Green | ammonia |

(Color coding may vary from country to country)

The respirator cartridges most typically used in a restorative drying environment are those for particulate (magenta) and for organic vapor (black). Stacked or combination cartridges are also available.

## Immunizations

Common restoration environments involve direct contact with a range of infectious organisms. As a minimum medical requirement, technicians performing water damage restoration services need medical consultation with a primary health care physician (PHCP) for appropriate immunizations. Immunizations required vary depending upon the scope of work, previous immunization history, previous exposure and current availability of treatments.

## Safety Standards and Organizations

Business leaders must be familiar with applicable safety standards and laws that affect their businesses. The list below contains some of the relevant organizations and standards restorers need to be familiar with:

- OSHA — Occupational Safety and Health Administration
  - 29 CFR 1910
  - 29 CFR 1926
- ANSI — American National Standards Institute
  - ANSI Z117.1–1989
- EPA — Environmental Protection Agency
  - FIFRA — Federal Insecticide, Fungicide and Rodenticide Act
- The IICRC — Institute of Inspection, Cleaning and Restoration Certification
  - S500 — Standard and Reference Guide for Professional Water Damage Restoration
  - S520 — Standard and Reference Guide for Professional Mold Remediation

This list should be evaluated for its application through varying state, provincial and other government laws and regulations. It is also necessary to check with each of these sources frequently in order to stay current with changes to standards, codes and regulation.

## Code of Federal Regulation (CFR)

Two codes are particularly relative to the work done by restoration contractors. These documents can be accessed on-line. In order to ensure compliance, contractors must thoroughly read and understand these two CFRs:

- 29 CFR 1910 — General Industry Standards
- 29 CFR 1926 — Construction Industry Standards

Significant items covered by these two groups of codes include:

- OSHA General Duty Clause
- Emergency Action and Fire Prevention Plans
- Personal Protective Equipment
- Respiratory Protection Plans
- Asbestos and Lead
- Heat Disorders and Health Effects
- Confined Spaces
- Hazard Communication Plans
- Lock Out/Tag Out procedures
- Fall Protection
- Noise Exposure Limits

The OSHA General Duty Clause (Sec. 5) states that:

> *(a) Each employer: (1) shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees; (2) shall comply with occupational safety and health standards promulgated under this Act.*
>
> *(b) Each employee shall comply with occupational safety and health standards and all rules, regulations, and orders issued pursuant to this Act which are applicable to his own actions and conduct.*

Preparing a company Safety Plan that addresses each of the items listed above will assist in minimizing potential injury while performing restoration services. Documenting this plan and frequent employee training will also assist in complying with federal regulations.

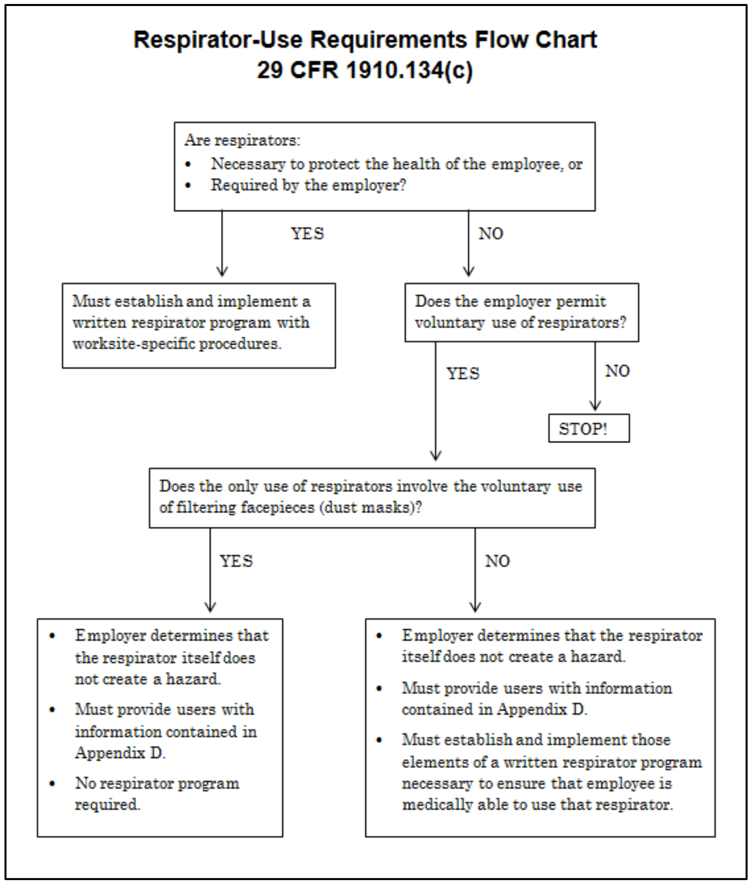
## Documentation

Several areas of health and safety protection require proper documentation. This section will discuss some of the key documentation necessary in the restorative drying business as it pertains to health and safety.

## Respiratory Protection Plans

Employers who assign employees to use respiratory protection are required to have a written respiratory protection plan. OSHA 29 CFR 1910.134 outlines respiratory protection codes as follows:

> *Respirators shall be provided by the employer when such equipment is necessary to protect the health of the employee. The employer shall provide the respirators which are applicable and suitable for the purpose intended. The employer shall be responsible for the establishment and maintenance of a respiratory protection program which shall include the requirements outlined in paragraph (c) of this section.*




OSHA provides all of the information necessary in order to develop and maintain a written respirator protection plan in 29 CFR 1910.134, with sections including:

- 1910.134 — Respiratory Protection Standard
- 1910.134 — App. A - Fit Testing Procedures (Mandatory)
- 1910.134 — App. B-1 - User Seal Check Procedures (Mandatory)
- 1910.134 — App. B-2 - Respirator Cleaning Procedures (Mandatory)
- 1910.134 — App. C - OSHA Respirator Medical Evaluation Questionnaire (Mandatory)
- 1910.134 — App. D - Info for Employees Using Respirators When Not Required Under the Standard (Mandatory)
- Interpretations for 1910.134
- Respiratory Protection - Safety and Health Topics

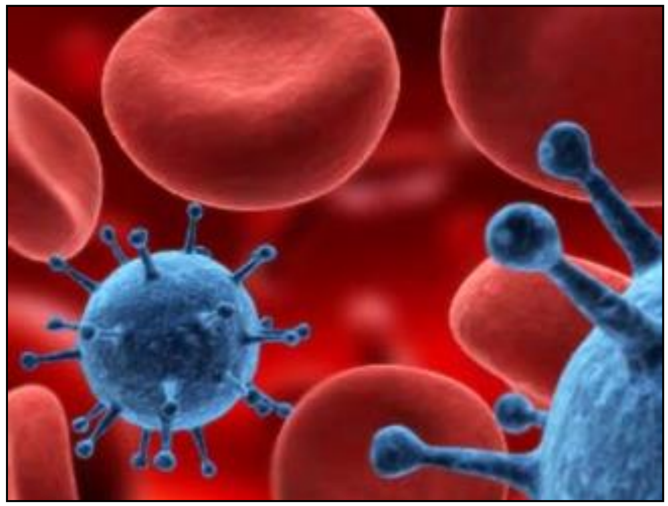
## Hazard Communication (HAZCOM)

Whenever hazardous chemicals are present in the work environment, employers must document their company's HAZCOM program. HAZCOM programs cover the use of training, labeling systems and forms of warning. The OSHA 20 CFR 1910.1200 addresses the creation of such programs.

OSHA's introduction of 29 CFR 1910.1200 reads:

> The purpose of this section is to ensure that the hazards of all chemicals produced or imported are evaluated, and that information concerning the classified hazards is transmitted to employers and employees. … The transmittal of information is to be accomplished by means of comprehensive hazard communication programs, which are to include container labeling and other forms of warning, safety data sheets and employee training.

### Bloodborne Pathogens Plan



Workers in many different occupations are at risk of exposure to bloodborne pathogens such as Hepatitis B, Hepatitis C and HIV/AIDS. First aid team members, housekeeping personnel in some settings, water damage restoration technicians and nurses are examples of workers who are at risk of exposure. In 1991, OSHA issued the Bloodborne Pathogens Standard to protect workers from this risk.

Bloodborne pathogens are microorganisms present in the blood which can cause disease in humans. These pathogens include the Hepatitis B virus (HBV) and the Human Immunodeficiency Virus (HIV). Restorers could possibly come into contact with bloodborne pathogens during day-to-day restoration activities, primarily through the remediation of sewer backups.

Restorers need to understand the seriousness of these pathogens, know what PPE to employ, and what procedures and standards must be followed. When documented, this information becomes the employer's bloodborne pathogens plan for their business. Just as important as developing the plan is implementing the plan, which includes training for workers on the protocols and procedures to be used.

### Emergency Action Plans

Yet another area discussed in multiple OSHA CFR documents is the use and management of emergency action plans. Organizations with greater than 10 employees must have written plans, while organizations with fewer than 10 employees may orally communicate plans to staff.

Emergency action plans must include procedures for: fire reporting, emergency evacuation, operation of critical equipment during evacuation, how to account for staff, rescue operations, and contact information for those who can provide additional information.


An excerpt from 29 CFR 1910 outlines the required scope for an Emergency Action Plan:

1910.38(b) Written and oral emergency action plans. An emergency action plan must be in writing, kept in the workplace, and available to employees for review. However, an employer with 10 or fewer employees may communicate the plan orally to employees.

An emergency action plan must include at a minimum:

1910.38(c)(1) Procedures for reporting a fire or other emergency;

1910.38(c)(2) Procedures for emergency evacuation, including type of evacuation and exit route assignments;

1910.38(c)(3) Procedures to be followed by employees who remain to operate critical plant operations before they evacuate;

1910.38(c)(4) Procedures to account for all employees after evacuation;

1910.38(c)(5) Procedures to be followed by employees performing rescue or medical duties; and

1910.38(c)(6) The name or job title of every employee who may be contacted by employees who need more information about the plan or an explanation of their duties under the plan.

## Initial Phone Call

Prior to the initial job site visit, a skilled company representative acquires information that will better prepare the on-site restorer's response and ensure that a positive first impression is established. Knowing what to ask during the initial client phone call is only half of the challenge. Knowing how to ask takes specialized training and experience. This initial conversation is crucial to obtaining the information required to prepare for the job itself and to establish good rapport with the client.

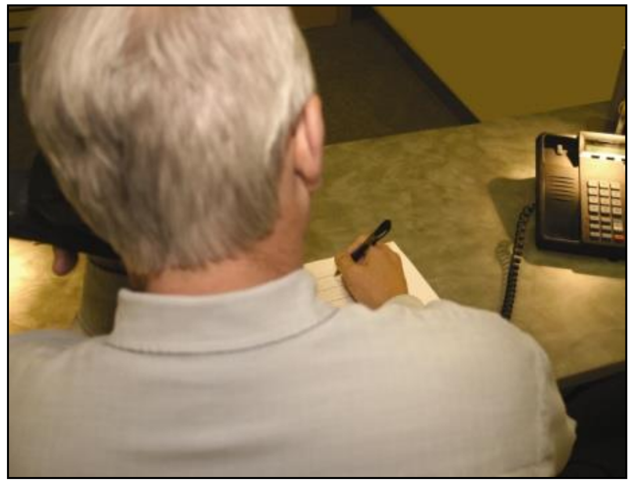
First, the restoration contractor needs to determine the category and classification of loss prior to arrival. An educated and trained representative will know what questions to ask in order to gather this information. For example:

Instead of: *"What category of water is in your home, ma'am?"*

> A skilled contractor asks specific questions such as: *"What is the origin of the water? Where did it come from?" "How long has the structure been wet?" "Where is it wet within the structure? (Where might water have traveled?)"*

Additionally, the company representative must be able to address the client's misfortune in a sympathetic way over the phone, assuring them that the most important step in returning their home to its original condition has already been accomplished: calling their restoration company.



The company representative should collect several pieces of important information during this initial phone call. A call report form should include the types of questions the representative needs to ask. Learn the general nature of the damage before making commitments to clients regarding loss mitigation and restoration capabilities. The *S500 Water Damage Restoration Standard and Reference Guide* offers a series of guidelines for information gathering during the initial phone call. Information gathered during this initial contact includes:

- What is the source and condition of the water?
- When did the damage occur?
- Do you own or lease the property (insurance information)?
- What steps have been taken to repair or eliminate the source?
- Which areas are affected (number of rooms, size)?
- How much furniture is present in the affected areas (possible staining, personnel requirements)?
- Have you experienced a previous water damage (source and remediation)?
- Is electricity and water available (lighting, equipment operation, chemical mixing)?

The initial phone call presents an opportunity to offer guidance to the client on some "do's" and "don'ts". The "Do's" are actions you can encourage the client to do with their personal contents in order to mitigate the potential for additional damage.

The "Don'ts" are suggestions as to what the client is not to do. These activities are just as important as the "Do's" and would include:

- Activities that put the building owner and/or occupants at risk of electrical shock.
- Activities that would create exposure to toxins or any other physical hazard.
- Activities that may create secondary damage from moisture.

These lists will vary depending upon the type of water affecting a structure and the degree of intrusion. Always focus on the health and safety of the client and on mitigating any further loss to the contents and structure.

## DO Ask Clients To:

- Eliminate the source of water if possible.
- Turn off circuit breakers if safe to do so.
- Remove and secure small furniture if possible.
- Protect carpet from staining using foil (plastic furniture tabs, plastic wrap) beneath furniture legs.
- Hang draperies and pin up furniture skirts.
- Remove books, shoes, paper goods, fabrics, potted plants and other items that may stain carpet (or be damaged by water).
- Remove and secure breakables.
- Contact a doctor if you have any health concerns.
- Be cautious of slip hazards.

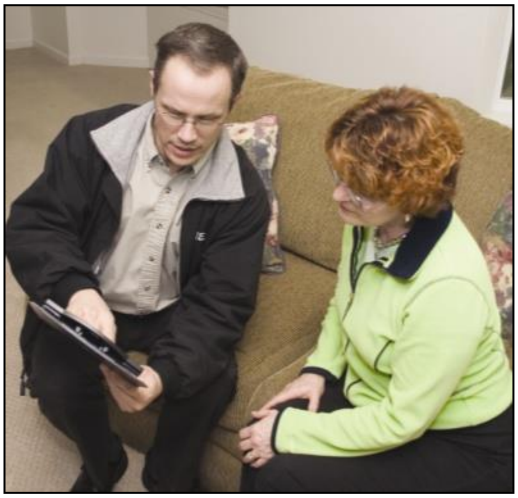
## Ensure That the Client DOES NOT:

- Use vacuum equipment to remove water.
- Use newspaper on wet surfaces.
- Walk across wet surfaces any more than necessary.
- Activate the building HVAC system.
- Adjust indoor temperatures.
- Enter an area with standing water.
- Consume any food in the loss area, especially if water was from an unsanitary source.
- Use personal hygiene items left in the affected area, especially if water was from an unsanitary source.
- Use home fans to dry wet surfaces.

### First Impressions

Establishing a positive image is the first step in ensuring that the client will have faith in the restoration efforts that follow. For this reason, a convincing level of professionalism in appearance should be visible to all materially interested parties.



Items that influence a property owner's first impression include:

- Attitude
- Driving habits
- Appearance of technicians
- Technician's greeting to client
- Certification of company and of technicians
- Communication skills

### Documentation Required

Documentation begins with the initial telephone call. When the technician arrives on the work site, documentation continues with the completion of a contract for the services to be provided. The contract (often called a Work Authorization form) clearly states the agreement between the building owner and the restoration contractor. The form specifies who is responsible for payment and the terms of payment. These agreements are discussed verbally and the restorer makes written notes as each significant item is covered, to ensure that the materially interested parties fully understand the documents they are signing. The contract should be signed before work begins.

Then, using a Customer Briefing checklist as a guide, the restorer briefs clients on the course of action. Remain patient through this process, as most building owners and occupants are unaware of the steps necessary to complete the drying and restoration process. Many clients will assume the work can be completed in a short period of time. In many cases, this is not true. Realistic expectations need to be set with the client.

The Customer Briefing checklist aids in explaining the steps necessary to restore the structure to a pre-loss condition. Following the Initial Loss Assessment, daily records of moisture levels in the structure will assist in communicating the importance of each consecutive step in the restorative drying process. This information is recorded in a way that is easily understood — not only by the technician monitoring the job site, but also by all other materially interested parties.

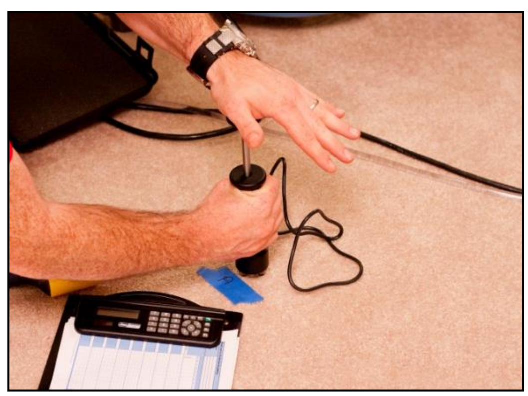
## Loss Assessment Report

Initially, an important piece of documentation that relates to restoration activities is the Initial Inspection and Loss Assessment Report. Information included in an Initial Inspection and Loss Assessment Report includes:

- Identification and evaluation of health concerns and safety hazards
- Determination of the source of water intrusion
- Determination of the need to protect floor coverings and contents
- Determination of the extent of moisture intrusion
- Determination of the job scope
- Evaluation of flooring materials
- Evaluation of inventories and/or content items
- Evaluation of the HVAC system
- Evaluation of basements and crawlspaces
- Assessment of other structural materials (walls, ceilings, etc.)
- Documentation of pre-existing conditions not related to the current loss
- Established drying goals (based on dry standards).

## Record of Moisture Content

Following the Initial Loss Assessment, daily records of moisture levels in the structure will assist in communicating the importance of each consecutive step in the restorative drying process. This information is recorded in a way that is easily understood — not only by the technician monitoring the job site, but also by all other materially interested parties.



Many templates are available today that make it easy to produce complete, professional documentation including key data and graphical illustrations. This type of documentation is essential in ensuring the reader clearly understands that drying progress is being made.

The technician can help manage client expectations by clearly communicating the predetermined drying goals. The daily moisture record helps the client understand when to anticipate completion. Restorers build client confidence by ensuring that the finish line is understood and progress is evident and can be tracked.

Before restoration services are complete, materially interested parties review final documentation and the property owner or authorized agent signs an Acknowledgment of Satisfactory Completion form. Any remaining questions or concerns by any of the materially interested parties are noted and addressed at this time.

Other documentation may be necessary, depending upon the scope of work. This additional documentation may include:

- Contents and personal property inventories
- Schedule of Loss
- Informed Consent of Product Use forms (if biocides are used)
- Client Refusal of Service Waiver
- Change orders
- Estimates, invoices and bills
- Subcontractor contracts
- Permits
- Contact information for other interested parties
- Detailed work activity log
- Equipment logs
- Lien notices and lien releases.

**Drying Standards for Job**

| Material | Meter | Type | Drying Standard |
|---|---|---|---|
| Drywall | GE/MMS2 | Non-Invasive | 120 |
| Wood | GE/MMS2 | Invasive | 11 |

**Visits**

| Visit | Start Date | End Date |
|---|---|---|
| 1 | 12/4/2015 2:23:20 PM | 12/4/2015 2:39:27 PM |
| 2 | 12/5/2015 9:59:49 PM | 12/5/2015 10:49:22 PM |
| 3 | 12/7/2015 2:33:54 PM | 12/7/2015 3:35:32 PM |


Samples of many of the forms discussed in this chapter are available at [www.restorationsciences academy.com](http://www.restorationsciencesacademy.com).

## Safety

The technician's first responsibility when arriving at a water damage site is to identify safety hazards, communicate these hazards and eliminate them as much as possible. Potential safety hazards in water damaged environments include slips and falls, electric shock and falling debris. The restoration contractor is required to provide for the health and safety of workers and occupants during restoration procedures.

### Common Hazards

The most common safety hazards associated with water damaged structures result in slips and falls. Additional hazards that require technicians to use appropriate protective measures include:


- Electrical shock hazards and gas leaks
- Lead and asbestos
- Microbial contamination
- Confined spaces (such as crawlspaces and attics)
- Contaminated water
- Stored chemicals
- Damaged construction components and materials
- Household chemicals
- Commercial or industrial chemical waste
- Excessive heat

Once a hazard has been identified, the first line of defense is to eliminate and communicate:

- Eliminate as many potential hazards as possible.
- Communicate any remaining potential safety concerns to all involved parties.

With each step performed during restoration, additional hazards will arise, particularly during the demolition process. For this reason, the jobsite must be re-evaluated for safety hazards related to the tasks to be performed.

### Lead and Asbestos

Two common hazards that may be present in older water-damaged structures are lead and asbestos containing materials (ACM). Federal regulations apply to the handling of both lead-based paint and asbestos.

### *Asbestos*

According to OSHA, asbestos must be handled and removed only by qualified personnel. Contractors who fail to comply with this regulation can be subject to substantial fines and potential lawsuits. This regulation must be observed when handling asbestos containing materials (ACM) — defined as any material containing more than 1% asbestos by weight.

As stated in the Code of Regulation (29 CFR 1926.1101):

> 1926.1101(e)(6) *Competent Persons.* The employer shall ensure that all asbestos work performed within regulated areas is supervised by a competent person, as defined in paragraph (b) of this section. The duties of the competent person are set out in paragraph (o) of this section.

> 1926.1101(b) *Competent person* means, in addition to the definition in 29 CFR 1926.32 (f), one who is capable of identifying existing asbestos hazards in the workplace and selecting the appropriate control strategy for asbestos exposure, who has the authority to take prompt corrective measures to eliminate them, as specified in 29 CFR 1926.32(f); in addition, for Class I and Class II work who is specially trained in a training course which meets the criteria of EPA's Model Accreditation Plan (40 CFR 763) for supervisor, or its equivalent and, for Class III and Class IV work, who is trained in a manner consistent with EPA requirements for training of local education agency maintenance and custodial staff as set forth at 40 CFR 763.92 (a)(2).

Asbestos is also addressed in 29 CFR 1910.1001 as it pertains to occupational exposure, whereas the CFR 1926.1101 addresses asbestos exposure in construction work.

Restorers learn where asbestos containing materials might be found in the structure and how to recognize that asbestos may be present. For example: 9″× 9″ (23 × 23 cm) flooring tile can be perceived as vinyl composite tile (VCT), but may be vinyl asbestos tile (VAT). Pipe insulation, wall insulation, several glues and adhesives and some ceiling textures are all examples of other potential asbestos containing materials.

### *Lead*

Lead is also addressed in two significant codes of federal regulation. In 29 CFR 1026.62, OSHA addresses lead in the construction work environment. In 29 CFR 1910.1025(a)(1), OSHA addresses lead as it applies to all occupational exposure.

As with asbestos, if lead is identified on the job site, all demolition work must stop. A licensed lead abatement contractor must be contacted if such material is disturbed.

The following are excerpts from 29 CFR 1926.62 - Lead:

> 1926.62(a) *Scope.* This section applies to all construction work where an employee may be occupationally exposed to lead. All construction work excluded from coverage in the general industry standard for lead by 29 CFR 1910.1025(a)(2) is covered by this standard. Construction work is defined as work for construction, alteration and/or repair, including painting and decorating. …
>
> 1926.62(e)(1) *Engineering and work practice controls.* The employer shall implement engineering and work practice controls, including administrative controls, to reduce and maintain employee exposure to lead to or below the permissible exposure limit to the extent that such controls are feasible. Wherever all feasible engineering and work practices controls that can be instituted are not sufficient to reduce employee exposure to or below the permissible exposure limit prescribed in paragraph (c) of this section, the employer shall nonetheless use them to reduce employee exposure to the lowest feasible level and shall supplement them by the use of respiratory protection that complies with the requirements of paragraph (f) of this section.

## Confined Space Entry

A confined or enclosed space is defined as any space that:

- Is configured so that an employee can enter it;
- Has limited means of entry and exit;
- Has the potential for containing atmospheric hazards; and
- Is not designed or intended for continuous occupancy.

Confined spaces that fit the description of "permit required" are those that contain:

- Atmospheric hazards which are or potentially can be asphyxiating, toxic, flammable or explosive;
- Engulfment hazards which exist when someone is trapped or enveloped by a liquid or dry bulk material such as grains, soil or powdered cement;
- Configuration hazards wherein the size or shape of the space can trap a worker or make escape or rescue difficult; or
- Any other recognized serious safety health hazard.

Some environments in a drying project fit the definition of a confined space (i.e., a crawlspace or an attic). Entry into such a space requires specific procedures, training and, in some cases, special permits. Depending upon circumstances, the procedures require the use of:

- Attendant — an individual stationed outside one or more permit spaces who monitors the authorized entrants and who performs all other attendant's duties as assigned in the employer's permit space program.
- Retrieval system — the equipment (including a retrieval line, chest or full-body harness, wristlets, if appropriate, and a lifting device or anchor) used for non-entry rescue of persons from permit spaces.
- Testing — planning and implementing tests in order to identify and evaluate hazards that may confront entrants of a permit space.
- Specialty PPE — the identification and wearing of specialty PPE appropriate for the confined space, which may include supplied oxygen.

OSHA regulations that address confined spaces are found in 29 CFR 1910.146 (for permit required confined spaces) and 29 CFR 1926.21 (safety and health regulations for construction — safety training and education), and further information is available from the American National Standards Institute in ANSI Z117.1-1989, Safety Requirements for Confined Spaces. Before entering any space that is not designed to be an occupied space, technicians need to be aware of the information outlined in the ANSI standard and OSHA CFR.

### Lockout – Tagout

When working in spaces where the unexpected start-up of machines and equipment or the release of stored energy could cause injury or death, restoration employees must use appropriate measures to identify, disable and lock out or tag out the potential hazard. Equipment capable of causing injury in a residential application may include HVAC equipment, electrical systems or equipment containing combustible fuel. When working in an industrial or commercial environment, the list of potential equipment-related hazards varies greatly.

A thorough evaluation of the surroundings and contents, along with a working knowledge of the normal use and application of a particular space or environment, will assist in determining whether such hazards are present. Where these hazards are present, elimination of the source of the hazard can include a lockout-tagout program.

OSHA 29 CFR 1910.147 addresses the procedures and policies necessary to properly disable and prevent unexpected start-up or energy release from these types of hazards. Proper lockout-tagout procedures may include shutting down power to the source of the hazard, labeling the item and using physical locks to ensure that the power is not restored.


## Initial Procedures

Restorative drying is a dynamic process in which a number of variables are constantly influencing the restorer's intended result: returning the structure to a clean, dry and safe living environment. The nature of these variables demands that drying environments be closely monitored to ensure that the intended results are realized. This requires a thorough initial inspection to identify items that will influence the restorer's end goal, followed by frequent monitoring to ensure that expected progress is being made.

## Identify (and Stop) the Water Source

The initial inspection procedure begins with identifying and stopping the source of water intrusion. The sources of water intrusion vary from failures in water fixtures and other plumbing to regional flooding and other weather-related events. The source must be identified and the problem corrected in order to prevent additional water intrusion. In some cases, circumstances will prevent the water source from being stopped. When this happens — if the source of the water can simply not be stopped — restorative drying of the structure is not possible. More drastic actions must be taken to preserve the integrity of the structure and its contents in order to prevent additional damage. These actions include the removal of contents and the removal and disposal of building materials in the affected area that will support mold problems as time elapses.

## Job Scope

During the initial inspection, the restoration contractor needs to gather the information necessary to properly scope the restoration process. This requires knowledge of the building's history and a thorough understanding of:

- the extent of the water intrusion,
- the type of building materials affected,
- the amount of damage that has occurred,
- any pre-existing conditions,
- any complications.

## Water Migration: "What's Wet?"

After safety concerns have been addressed and the initial water source has been stopped, the restorer must complete an evaluation of the water's migration through the structure. During this process, the restorer inspects all potentially affected areas. In many cases, this is done by plotting the water's migration horizontally and vertically across surfaces and through materials in the wet environment. As wet areas are discovered, contents and structure are protected from further damage.

For example, the restoration contractor will:

- Use foam blocks or plastic tabs to prevent contact between wet surfaces that may transfer color.
- Lift clothing and draperies from the wet area.
- Remove metal objects from wet surfaces.
- Protect dry surfaces from the wet environment.

The ultimate goal is to find the "edge" of water migration, which moves in a three-dimensional path throughout the structure. The perimeter is found in carpeted surfaces using a moisture sensor. A non-invasive (non-penetrating) moisture meter tracks the migration of water below hard finish surfaces, such as under vinyl tile or ceramic tile.

The identification of all wet areas related to the water intrusion is critical during the initial inspection process. Wet areas overlooked in the initial inspection will be vulnerable to damage and will delay completion of drying. Additionally, progress cannot be noted unless the wet areas are not only identified initially, but are also properly quantified.

As wet areas are identified, the types of materials affected must be established. This includes types of carpeting and underlay, subflooring, wallboard materials, paints, wall cavity insulation, stud material (wood or metal), hard surface flooring type, etc.

The entire structure is considered in this initial inspection process. This includes substructures, cavities, HVAC systems and any other space or material where moisture may have traveled that could adversely affect the building's appearance, usefulness and cleanliness.

Some building HVAC duct systems are installed beneath flooring materials. When this is present, floor (supply) registers can be removed so that all flooring material layers can be noted and duct lines inspected for standing water. After initial drying of water-damaged structures, HVAC duct work and mechanical components can be evaluated to determine the need for additional services.

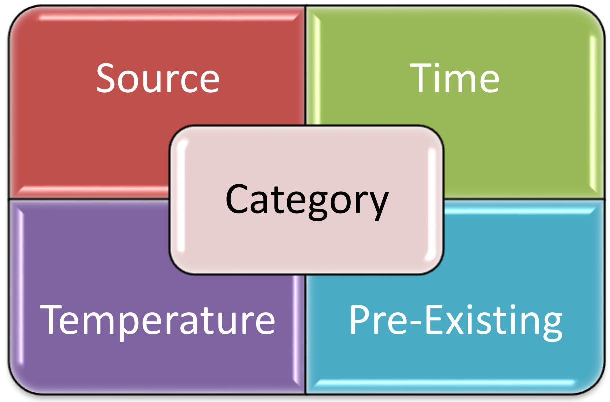
In addition, the type of construction should be evaluated. If the construction assembly poses a complexity which can inhibit the drying process, it should be properly documented. Difficult-to-dry construction can include:

- Steel studs, which can hold water in the bottom "C" channel at the base of walls, and higher up in metal stud ceiling and wall construction.
- Bay windows, greater number of wall studs, laminated beams, etc.,
- Multiple layers of affected material (retaining more moisture),
- Vapor barrier or retardant surfaces/materials.

## Categories of Water and Procedures

Based on the source of the water, the length of time the water has been allowed to dwell in the structure, the temperature, and pre-existing conditions, it is possible to assess the category and employ appropriate means of restoration. Restorers will diligently investigate structures for indications of contamination, assigning a category only after a thorough investigation.




## Category 1

Water from a clean source with no substantial risk of causing sickness or discomfort is said to be Category 1 water, or "clean." In order for a situation to remain a Category 1, water must not have been present for an excessive amount of time, and materials affected must be clean and well maintained. If odors are present in the structure, further investigation is necessary until the source of the odor is found. Odors indicate that the water is not Category 1.

Examples of Category 1 water include broken water supply lines, tub or sink overflows with no contaminants, and appliance malfunctions involving water supply lines.

Once the loss has been established as Category 1, structural drying can proceed. No substantial departure from standard procedures for addressing contamination is needed. It is possible to effectively restore the structure to a pre-loss condition by thoroughly and rapidly drying materials, and by replacing only materials with permanent structural or aesthetic damage.

## Category 2

Water that has a significant degree of chemical, biological and/or physical contamination is said to be Category 2. Water sources that can result in Category 2 damage include aquarium leaks, waterbed leaks, toilet bowl overflows (that contain urine), dishwasher or clothes washer discharges, and water that enters the structure from hydrostatic pressure (from below grade). Category 2 water has the potential to cause sickness or discomfort and should not be allowed to dwell in a structure for an extended period of time.

When structures are affected by Category 2 water, special steps and procedures are necessary in order to return the structure to a pre-loss condition. Cleaning procedures must be employed before the drying process can continue. At a minimum, affected carpet underlay must be removed and disposed of, and carpet must be thoroughly cleaned using a hot water extraction method.

Restorers then employ appropriate antimicrobials to mitigate growth of microorganisms, especially when there are porous materials that are to be cleaned and restored. As with any water intrusion, once the affected materials have been completely cleaned, thorough and rapid drying is necessary to prevent further damage.

### Category 3

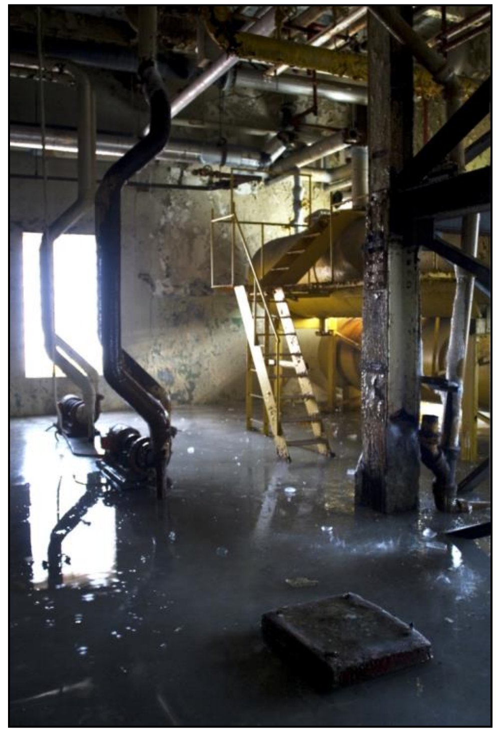
When water intrusion results from a grossly unsanitary source or carries pathogenic (disease causing) agents, it is said to be Category 3. Examples of Category 3 water sources include discharge from toilets that originate from beyond the toilet trap (from the sewer or septic system), and intrusions from the surface of ground water into the structure (flood waters).

Many procedures are necessary to address cleanliness and safety when dealing with Category 3 water intrusions.

- Several forms of PPE are used, including rubber gloves, respiratory protection, body coverings, rubber boots and appropriate eye protection.
- Worker and occupant health and safety are the first priority on every project. Areas affected by the water intrusion are marked and posted as potentially hazardous.
- Individuals with compromised immune systems are evacuated from the structure until it has been judged safe for occupancy, e.g., the very young, the elderly, those who have undergone recent surgery or chemotherapy, and those whose immune systems are suppressed.
- Various cleaning and decontamination procedures must be used, including the removal of all highly porous materials affected by the water intrusion including carpet, underlay, wall board, and insulation.
- Surfaces that are to be restored must be thoroughly cleaned.


Very few exceptions exist to these rules when dealing with Category 3 water. If attempting to restore any highly porous item affected, such as a valuable oriental rug, restorers must thoroughly clean the item, properly apply an antimicrobial, perform intensive cleaning, dry, and employ third party testing. This process is very expensive and will not therefore be a cost-effective approach for most highly porous materials.

Additionally, restorers must apply an appropriate biocide during and after the demolition process to help control microorganisms and increase cleaning effectiveness. They must be familiar with the biocide's product label and local laws and regulations that govern its use.



After an initial assessment and the determination of necessary procedures, it is important to ensure that all materially interested parties — property owner, insurer, etc. — are made aware of the work that will be done. If resistance to following proper procedures is encountered, restorers should ensure that the reasons for the procedures have been communicated and documented.

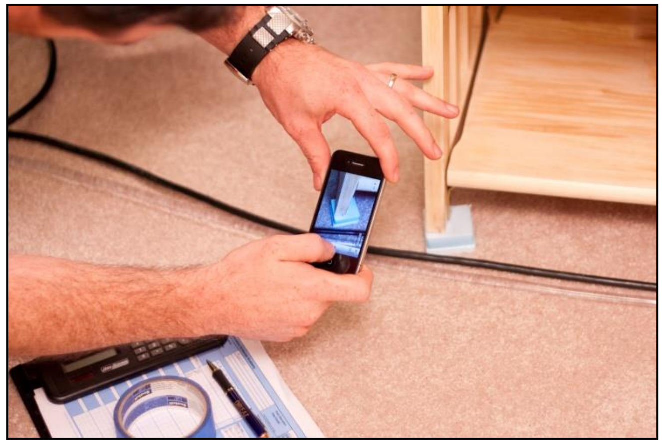
When resistance is still encountered and performing services properly becomes a challenge, restorers stop work immediately to prevent liability. No amount of documentation, waivers or releases will offer complete protection if the work is done in a way that does not diligently provide for occupant safety during and after the restoration process.

### Hazardous Materials or Mold Do Not Change Category

Losses where regulated or hazardous materials or mold have contaminated the structure are situations requiring specialized expertise. Restorers must have specialized training to address many of these substances, or use specialized, third party experts. Third party experts are commonly referred to as Indoor Environmental Professionals, or IEPs.

The presence of regulated or hazardous substances does not change the category of water loss. A Category 2 loss where growing mold is discovered is still Category 2. However, the mold should be remediated before aggressive drying procedures could spread contamination.


## Identifying Damage



For the purposes of this course, damage refers to a physical change to a material that cannot be reversed by drying alone. It is a permanent condition, requiring physical repair or replacement. There are three types of damage the restorer will need to identify:

- Pre-existing damage,
- Primary damage, and
- Secondary damage.

### Pre-existing Damage

Pre-existing damage is a condition that was present before the water intrusion that may or may not have been caused by moisture. Restorers can be held liable for conditions that are not a result of the restoration process. It is critical, therefore, that pre-existing damage be identified, documented and communicated to all materially interested parties during the initial inspection. Digital photography can be very useful for documentation of these conditions.

Restorers need to look for any condition that affects the materials' or contents' cleanliness, appearance or integrity. Factors to take into account when assessing pre-existing damage include

- Quality of building material installation
- Integrity of building components or contents
- Appearance of building components or contents
- Microbial contamination, including mold

From a restorer's perspective, the most important forms of pre-existing damage to note are microbial growth (mold) and carpet delamination (the separation of primary and secondary carpet backings). Both are commonly associated with water damage and can become the liability of the restoration contractor if not identified and documented prior to restorative drying procedures. Pre-existing carpet delamination is also a significant issue. When carpet delamination has occurred, further damage is very likely. For this reason, when extensive delamination is discovered, technicians must call it to the attention of all materially interested parties and document the condition. Replacement of the carpet should be recommended.

There are a number of causes for carpet delamination — many of them related to improper restoration activities. Typical causes of carpet delamination are:

- Folding or stretching of carpet when wet,
- Overly aggressive extraction,
- Improperly specified carpet underlay,
- Improper installation,
- Improper removal from tack strip,
- Improper floating of carpet,
- Excessive wear,
- Pet damage.

Regardless of the cause of pre-existing damage, it must be identified and documented in the Initial Inspection Report, then clearly communicated to all parties concerned. Although written documentation is generally sufficient, it is useful to include photographs of the condition.

## Primary and Secondary Damage

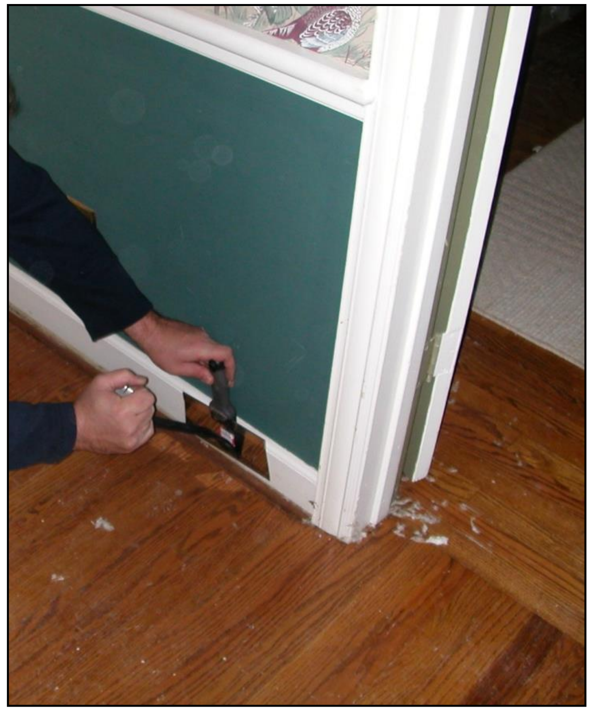
Water intrusion will affect building materials both immediately and over time. Damage that occurs immediately by direct contact with water is referred to as primary damage. Damage that occurs because material remains wet for an extended period of time is referred to as secondary damage.

Water also affects materials indirectly. Excessive moisture leads to elevated humidity. Many building materials will absorb excess water vapor and suffer damage, especially when the air in the structure is allowed to remain above 60% relative humidity. This form of damage from high humidity is also referred to as secondary damage. Secondary damage includes dimensional changes, loss of structural integrity, microbial growth and staining.

Hygroscopic materials absorb moisture easily, whether from direct contact with water or from exposure to high humidity. As a result, hygroscopic materials are very susceptible to secondary damage. Such materials gain and lose moisture continually in an effort to equalize with the water content in the surrounding air. The more hygroscopic the material, the faster it will collect water vapor, and the easier it will suffer secondary damage.

Structure and contents must be evaluated for the presence of primary and secondary water damage. As with preexisting damage, primary and secondary damage need to be properly identified, documented and communicated to the appropriate parties. The scoping process needs to include the necessary work to restore the appearance and performance of all affected material. Removal of permanently damaged materials must occur promptly in the initial stage of restoration. If the material is removed without delay, the moisture contained in the material will also be removed. This will speed the drying of the remaining affected materials that can be saved, reducing the total restoration cost.

Hidden damage can occur that will require a more invasive method of inspection. One of the most common forms of hidden damage occurs with wall insulation. When water intrusion results in standing water deeper than the wall plate (bottom plate), or when water intrusion occurs from above and results in water running through wall cavities, insulation must be closely evaluated. Inspection access holes are used to help determine whether batt or blown-in insulation, particularly cellulosic blown-in, has compacted and lost its R value. If the wall insulation has been damaged, replacement is necessary. In most cases, the wallboard will also need to be removed in order to remove the insulation.



## Choosing a Drying Method

Drying science has advanced to the point where nearly any material item in a structure can be dried. There are many tools and techniques to achieve drying goals, and a true professional will have all of these tools at their disposal. Since everything can be dried, the critical question in restorative drying is: “Should it be dried?”

### Factors That Influence Drying Method

When determining if a wet material or item should be dried, restorers consider three factors:

*Contamination* must always be the first consideration when determining if a material should be dried. Porous items that are affected by Category 3 water, for example, must be removed. Good professional judgment is important when evaluating contaminated environments. The health and safety of the customer and employee are the primary concern. If an item cannot be economically returned to pre-loss cleanliness or better, it is removed and disposed of.

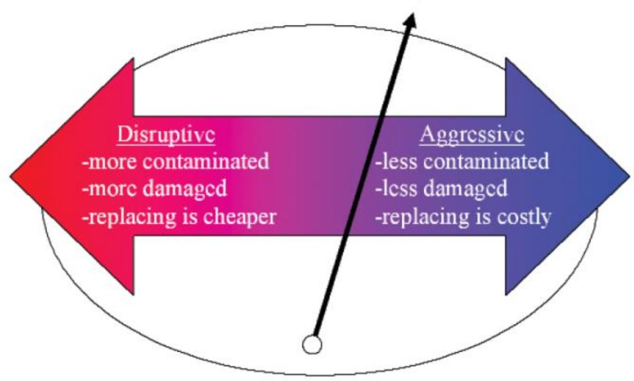
*Damage* is also an important consideration when choosing a drying method. If a material or item is damaged beyond economical repair, it is removed from the structure. For example, fallen ceilings, insulation that is packed down, and particle board furniture that is beyond repair are all discarded. Drying will not return these permanently damaged materials to a pre-loss condition, and additional repairs would be necessary after drying is complete.


*Cost* is the final consideration in choosing a drying method. It must cost less to dry an item than to replace it. For example, a base cabinet installation that is affected by water may cost $1,500 to replace. Therefore, drying the cabinet must cost less than $1,500 in order to be practical. Costs evaluated must include replacement and historical value, additional time and business interruption. Many restorers aim for a drying cost of at least 50% less than replacement. When estimated costs for drying break the 50% threshold, the restorer communicates openly with materially interested parties to ensure that the customer is involved in the decision-making process.

"Should it be dried?" is the primary question. If restoration is not supported after evaluating the level of contamination, damage and costs, then the items are removed. On the other hand, if restoration is supported, the item is dried.

## Two Drying Methods

After making the decision of whether or not to dry a material, restorers begin evaluating how to begin the restoration work. Many methods are available — each applying a different combination of humidity control, temperature, airflow and physical manipulation of the material (e.g., injection of airflow, perforation, removing finish materials).




Restorers use the information obtained during evaluation of materials to help select the best drying method for the job. Generally, there are two primary methods to promote drying of affected structures: 1) disruptive methods and 2) aggressive methods.

### *Disruptive Drying Methods*

Disruptive drying methods involve removing wet items, injecting air to speed drying, or perforating surfaces to allow water to evaporate. The term *disruptive* is used because repairs will have to be done after the structure has been dried. Use disruptive methods when contamination, damage, cost or customer concerns require removal or manipulation of the affected material.

### *Aggressive Drying Methods*

Aggressive or “in place” drying methods involve leaving wet items in the structure and drying them in place using warm, dry direct airflow. Aggressive methods are used when contamination and damage are not concerns, and when it is cost effective to dry an item instead of replacing it.

*Aggressive or "in place" drying methods involve leaving wet items in the structure and drying them in place using warm, dry direct airflow.*

Restorers use aggressive drying methods when all of the following are true:

- The water intrusion came from a sanitary source (Category 1).
- Drying carpet and underlay (pad, cushion) in place will not cause structural damage to subfloor (especially hardwood).
- Adequate dehumidification is available and usable on site.
- Deep extraction tools are available.

The success of each decision made during the restorative drying process depends on the information upon which the decision was based. A skilled technician with quality meters will make the proper decisions at each phase of the project. This produces value for the customer and profit for the business owner.

## Performing a Complete Triage during Emergency Response

During the passing minutes of an emergency response to a water loss, damage could be occurring rapidly. Restorers must consider where to focus their time, energy and resources. They should also consider where their customer would want to focus the restoration effort. Answering three questions will indicate what needs attention first.

- Is damage present, and is it permanent?
- What is the level of risk for secondary damages, and what might be the consequences of delayed action?
- What value does an affected item possess?

Prioritizing efforts properly will ensure the best allocation of resources.

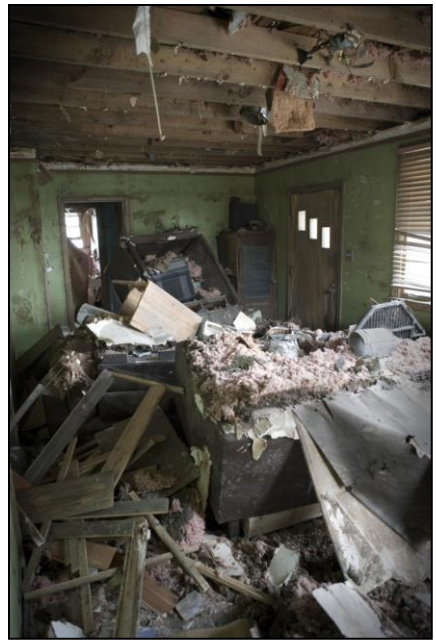
### Triage Helps Soothe Emotions

Assessing damage during the initial response to a restoration situation can be difficult. The property damage suffered is not always evident, and the customer’s emotions are running high. The restorer’s assessment must account for both emotional value and monetary value. Furthermore, time will show no mercy. A restorer’s decision needs to be made immediately regardless of any hurdles encountered in the loss. Despite these challenges, a triage assessment performed professionally can soothe the emotions.

### Begin Triage Assessment

The triage assessment can begin before arrival at the job site. Information gathered about the loss can help establish a proper response for different material types even before a physical inspection. An example is a Category 3 sewage backup where most damaged materials will be replaced, simplifying the triage task.



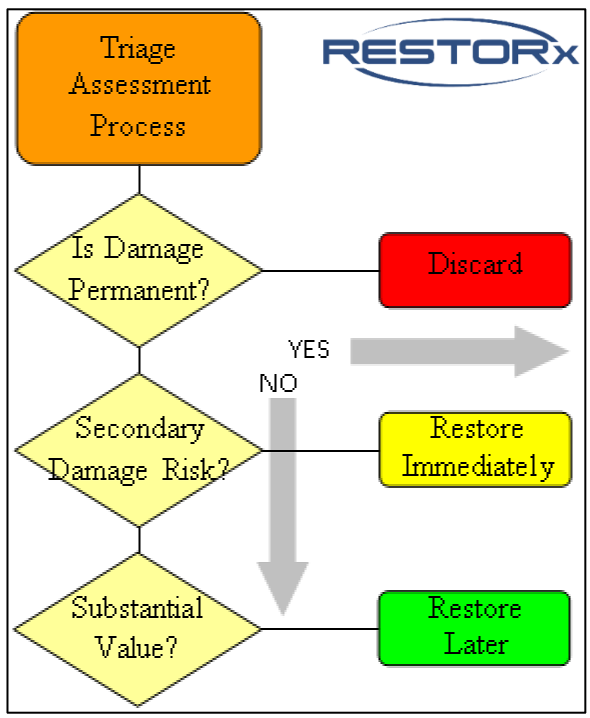
After arriving to inspect the site, triage decisions may be dictated by the severity of the damage. The decision process is much more objective for more severe losses. Where the damage is dramatic and obvious, triage decisions will be just as obvious.

Decisions are more difficult to make where the damage is not as obvious. Especially challenging is the loss area showing only a small amount of primary damage or contamination. Assessment here will be more a process of eliminating or minimizing secondary damages.

### Prioritize the Response

Applying the three questions mentioned earlier, prioritize affected items and structure into three types of actions:

- Discard
- Restore immediately
- Restore later




Whether evaluating structure or contents, this triage process guides decision-making in the first moments inspecting the loss. Affected items are categorized into the three potential actions, and each action has its own set of potential deviations and considerations.

#### *Discard*

Restoration of an item to preloss condition may not be possible when it has suffered irreparable damage due to contact with moisture, contamination, or physical damage. During the initial inspection, most items fitting this description should be listed on a schedule of loss, set aside for review by an adjuster, and, if approved, discarded and replaced.

This action necessitates discussions with all materially interested parties. Exceptions can occur where, due to the emotional or monetary value of an item, the customer decides to overlook the irreparable damage and accept the item in a less than preloss condition. Obtain written authorization and photo documentation for any materials or items that are discarded.

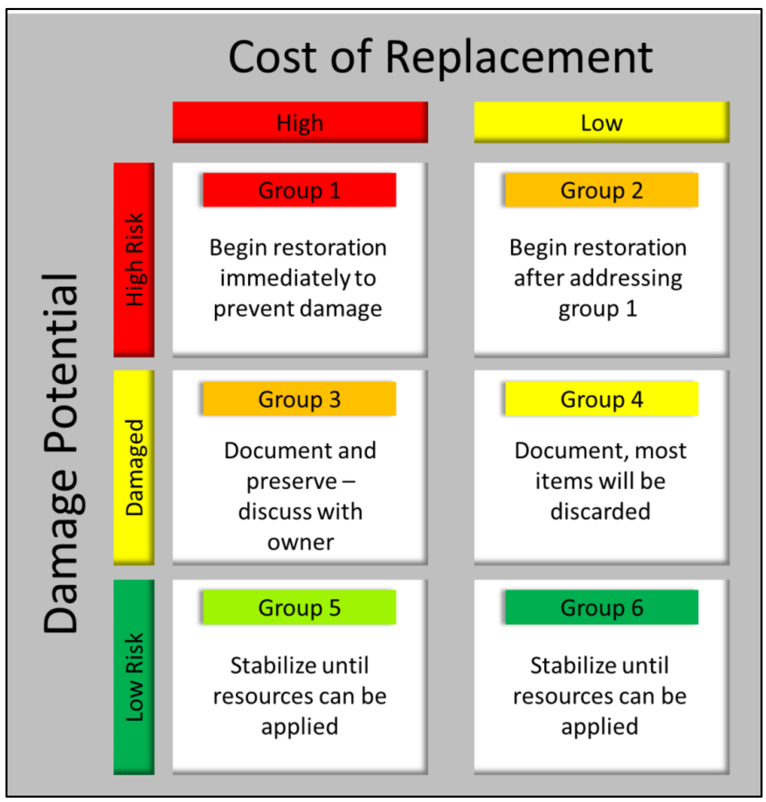
Another exception to consider is containment. Even though removal of a structural component may be necessary due to permanent damage, the actual removal may have to be delayed. Such is the case where removing the material will result in a loss of containment (especially if containment is critical).

Communication and gaining approval may also slow the removal process. Consent from other materially interested parties must always be considered, whether dealing with structure or contents.

***Restore Immediately***

This type of action requires the restorer to make more independent decisions. Communication with involved parties, such as the building owner, insurer or adjuster, is always preferred. Take immediate action when dealing with items highly susceptible to secondary damage.

Documentation again plays an important role. Items needing to be restored immediately play a large role in either increasing or decreasing the overall loss severity. The value of the item significantly influences a decision to restore. Photo documentation can help determine the value of these items.



### *Restore Later*

Materials or structural components that have suffered minor but repairable damage should be low on the priority list. These items face little risk of secondary damage since they typically are not hygroscopic, are not wet, or do not suffer from short-term exposure to water. Examples include concrete, brick, structural lumber, synthetic materials, or any hygroscopic material that has not been exposed to high levels of abnormal moisture.

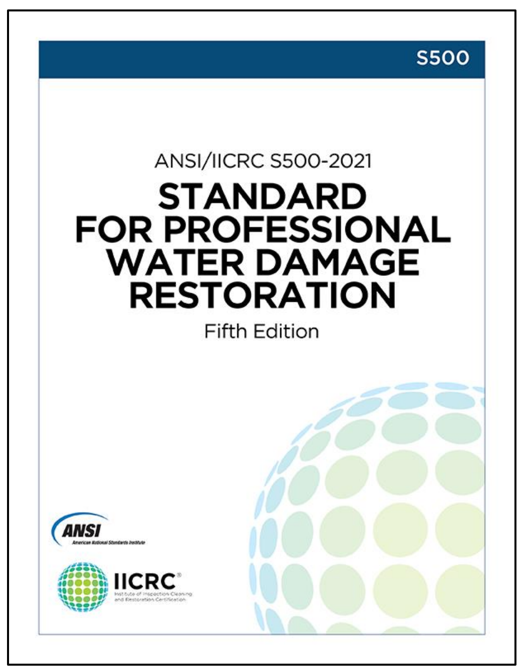
Do not spend time and energy in the first moments of the mitigation response on these items. Any immediate attention to them will not greatly influence the outcome of restoration efforts.

## Triage Benefits for the Restorer

Decisions made during the emergency mitigation process will dramatically affect the success of the overall restoration process. Employing resources based on a triage assessment will reduce the severity of damage. Effective decision-making and communication help ensure the greatest potential impact from mitigation efforts.

## IICRC S500 Standard Language — Levels of Importance

The IICRC S500 assists restorers in decision making by using specific language to indicate a level of importance for practices and procedures. This gives the restorer clear direction what procedures are critical, and which may be left to professional judgment.




Critical procedures are indicated by the words ***shall*** or ***should*** in the procedure description. These procedures are characterized by the IICRC S500 Standard as components of the accepted "standard of care" to be followed.

Less critical procedures are indicated by the words ***recommend*** or ***may*** or ***can*** in the procedure description. These are not characterized as components of the "standard of care."

The IICRC S500 Standard considers the standard of care to be:

> "… practices that are common to reasonably prudent members of the trade who are recognized in the industry as qualified and competent."

The table *Levels of Importance* explains the IICRC S500 language and provides an example of each of the key words.

**Levels of Importance in S500 Standard Language**

| | Word | Definition | Example from the IICRC S500 |
|---|---|---|---|
| **Critical Procedures** | **Shall** | Means that the practice or procedure is mandatory due to natural laws or legal requirements | 12.3.1 Before entering structures that are known or suspected to be contaminated, either for inspections or restoration activities, restorers **shall** be equipped with appropriate personal protective equipment (PPE) for the situation encountered. |
| **Critical Procedures** | **Should** | Means that the practice or procedure is a critical procedure to be followed, but not required by natural law or legal requirements | 12.3.1 Restorers **should** refer occupants with questions regarding health issues to qualified medical professionals for advice. |
| | **Recommended** | Means that the practice or procedure is advised or suggested, while not a part of the standard of care. | 12.3.9 It is **recommended** that when decontamination cannot be practically completed by cleaning alone, that appropriate antimicrobial (biocide) or mechanical means be employed. |
| | **May** | Means that the *S500* expresses permission to perform a practice or procedure | 12.5.1.3 Restorers **may** also consider a continuous use of outdoor air while dehumidification systems are deployed, when conditions are appropriate. |
| | **Can** | Means that the practice or procedure is possible or capable of being performed | 12.5.5 Restorers **can** use the installed HVAC system as a resource; provided contaminants will not be spread or the drying effort will not be negatively impacted. |

## Extraction: Remove the Easy Water First — Section 4

The most effective way to speed the drying process is to remove as much of the water in a liquid state as possible during the extraction phase. Poor extraction will significantly slow the drying process.

Extraction and evaporation are the only ways water can be removed from a wet structure. During the extraction process, liquid water is vacuumed, mopped, squeegeed or otherwise removed from the structure. This takes some energy, but not nearly as much as evaporation.

Abide by local laws and regulations when disposing extracted water. Waste water is best disposed of into a sanitary sewer, however, in some areas it may be necessary to dispose of waste water at an approved municipal waste water disposal site.

The most important factor in extraction is not how much water is removed, but how much water is left behind. It is important to remember that every drop of water left behind will add time to the drying project. The two-step process for carpet and pad extraction:

1. The primary goal of the initial extraction of the affected area is to contain further migration of the water within the structure. This step is accomplished using a light wand attached to either a portable or a truck mounted extraction unit.
2. The deep extraction process is accomplished by using a sealed or weighted extraction tool attached to either a portable or truck mounted extraction unit.

If deep extraction is not available, the carpet cushion must be removed to prevent lengthy drying times. Otherwise, excess water will remain in the carpet underlay. This water must be removed through evaporation, which prolongs the drying process. It also increases the amount of equipment required to meet drying timelines and drastically increases the likelihood of secondary damage to the structure and its contents.

### Planning Ahead for Drying — Preventing Damage

During the extraction process, it is sometimes efficient to plan ahead for drying challenges. This can be done several ways:

- If the structure is cold (below 70° F), begin warming the area. This can be done by simply turning on the heat in the structure, or adding a heating device.
- If a structure has high humidity (above 60% RH), consider flushing the structure to drier outside air, or bring dehumidification into the affected area during extraction. These steps help prevent a buildup of humidity and may lessen the humidity "spike" which is common when air movers are initially installed and turned on.

- If there are strong odors in the loss area that are cross contaminating the unaffected area, set up negative pressure and/or containment to reduce the spreading of the odor.

## Protecting the Carpet

Once the water migration edge is located, it is important to protect furniture from contact with the wet carpet. Simple foam furniture blocks, foil, or plastic tabs accomplish this task. Blocking furniture accomplishes a number of important goals, including:

- the prevention of color transfer between furniture and carpet (which causes staining)
- the prevention of rust stains
- the facilitating of effective and efficient drying by elevating furniture (especially low or heavy furniture such as bookcases)

If draperies, curtains or other window or wall treatments are touching the wet carpet, the appearance of items must be documented (again, photographs are helpful for this) and they must be removed from the floor. This is most easily accomplished by using a drapery hanger; pick up the curtain, loop the fabric through the hanger and hang it from the curtain rod. More complex or expensive window or wall treatments can be handled by the interior designer who installed the treatment or another appropriate specialist. Any draperies damaged by water are removed immediately and taken to a dry cleaner for restorative efforts.

In some restoration projects it is necessary to remove carpet cushion. This process will require the restorer to disengage stretched-in carpeting. Because carpet loses 80% to 85% of its strength when it is wet, it is vital to treat carpet as gently as possible until it dries.

Whenever carpet must be disengaged from the tack strip, a knee kicker and carpet awl should be used. The knee kicker is used to release the tension on the carpet and move it away from the tack strip. Then, the carpet awl is pierced through the carpet's primary and secondary backings and used to lift it up and away from the tack strip. This method of disengagement effectively reduces the possibility of delamination. For personal protection from sharp metal on the tack strip, technicians need to wear leather gloves while disengaging carpet.

Carpet is disengaged around the perimeter of the room, then rolled back in one direction to expose the cushion beneath. The majority of cushion has a skin or mesh on the top side. The purpose of this skin is to ease carpet stretching during installation. It is not a vapor barrier.

Roll the carpet, as opposed to folding it. Folding carpet places stress on the latex between the primary and secondary backings and can lead to delamination. Also, if the carpet is to be re-installed, technicians should avoid making new cuts in carpet. Preferably they should cut carpet along existing seams, but even then only when absolutely necessary. This is accomplished after the carpet is disengaged by peaking the two sides of the carpet along the seam, then cutting along the existing carpet seam using a hook blade knife (i.e., a vinyl flooring knife) or dull butter knife. Cuts must be as straight as possible and should remove as few carpet yarns as possible. This process makes reinstallation and re-seaming of the carpet much easier for the installer.

## Extraction Tools

All extraction tools rely upon the principle of airflow through the affected carpet and underlay in order to remove water. High negative pressures are created by the vacuum equipment, whether portable or truck mounted. Hoses, usually 2″ (5 cm) in diameter, are then used to connect the vacuum equipment to an extraction tool. Airflow through the tool and hose removes water from the material and carries it to the vacuum's waste tank.

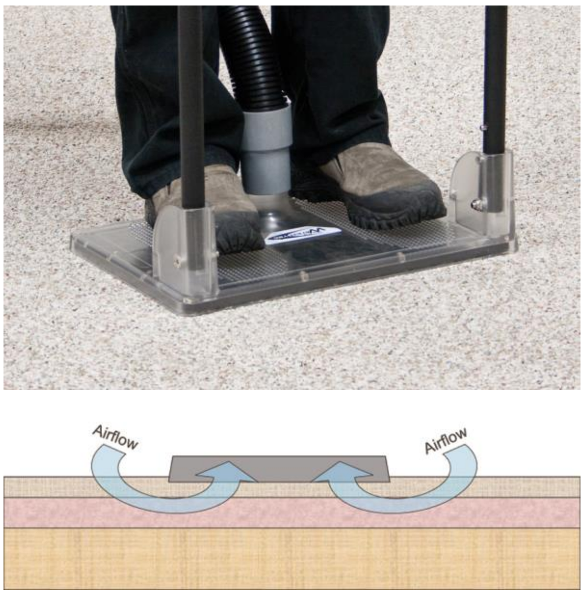
Restrictions in airflow through the tool, the material, or the hose will impede the extraction process. It is important to do everything possible to ensure that this airflow is not restricted. This is discussed further under "Vacuum Equipment."

### Light Wand

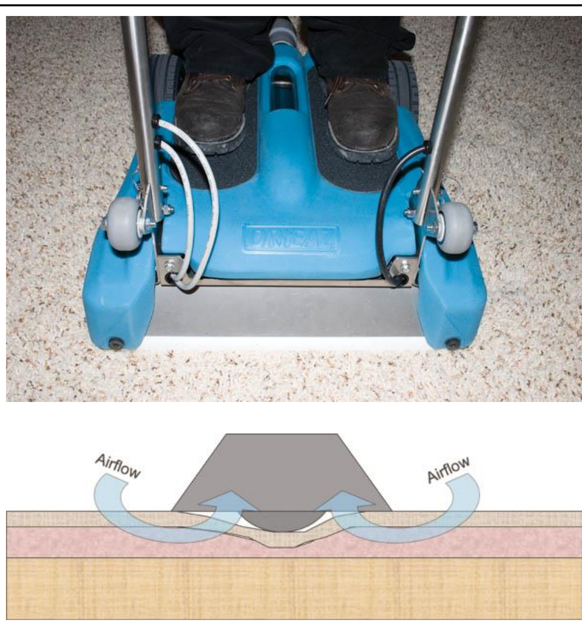
When the light wand is used to extract water from the surface of a carpet, the weight of water is greatly reduced — slowing down the migration of the water through the carpet and cushion and into the structure and materials. But the use of the light wand is only the initial step in the extraction process, and must be followed by other extraction tools or other means of physical water removal if the cushion is to be saved. If no underlay is present, as with direct glue-down carpet, a light wand is effective in removing most of the water since direct glue installations are the easiest to extract.

### Squeegee and Squeegee Wand

The squeegee wand is the best tool for removing water from hard surfaces.




*Vacuum Sealed Extraction*




*Weighted Compression Extraction*

### Deep Extraction Tools

Deep extraction tools are used to remove water from the carpet and cushion. They are either mechanical (ride on) or manual. These tools employ heavy weight to create a tight seal over the carpet and squeeze out more water from the underlay.

Currently two types of deep extraction tools exist: vacuum sealed and weighted compression. Vacuum-sealed deep extractors make a tight seal with the carpet in order to remove water from the subsurface underlay and carpet.

Deep extraction tools that are mechanical govern their own speed. When extracting water from large areas of carpet and underlay, consistent speed is critical. Using a mechanical extraction tool increases the effectiveness of the extraction process greatly by ensuring even, consistent extraction.

#### *Carpet and Underlay Type Affect Extraction Time*

Carpet construction impacts the effectiveness of deep extraction tools. Because all deep extractors require a good seal, Berber or multi-level loop carpets are more difficult to extract. Air enters the extraction tool by passing over dips created by the multiple loops or other areas that are uneven in height. Carpet that is thicker or denser with fibers will also be more difficult to extract, as it will restrict airflow. Similarly, thicker or heavier underlay is more difficult to extract because it also restricts airflow.

Lighter face weight carpet and cut pile carpets are easier to extract. As with any deep extraction, the technician must first test the extraction effectiveness by disengaging the corner and firmly squeezing the underlay (pad, cushion). It is important that the technician continue to extract multiple times until no water drips from the underlay.

## Vacuum Equipment

The vacuum equipment does the real work of the extraction process. While the extraction tool is actually in contact with the wet surface, the vacuum is what removes water from the environment. Types of vacuums used in restoration range from truck mounted machines powered by gasoline engines to portable, electric vacuums.

It is important to note that many small vacuums, such as shop vacuums, do not provide sufficient vacuum power to support water removal from carpet and underlay. Restorers must use equipment specifically designed for removing water from these materials.

## Effective Extraction Techniques

Regardless of the type of vacuum equipment being used, several guidelines must be followed to increase extraction effectiveness.

- If excessive contents are present in a room, minimize handling and speed the process by extracting the center of the room first. Then move contents to the center of the room, blocking and protecting contents, and extract the outside perimeter.
- The extraction hose must be the shortest length possible, as resistance increases with hose length.
- The extraction hose must be the largest diameter approved for the tool and vacuum equipment (refer to manufacturer's literature). On deep extraction tools, this diameter is 2″ (5 cm). Some truck mounted machines are designed to use 2 ½″ vacuum hoses.
- Loops and bends must be avoided.
- "Live" or "active" hose reels, while great for carpet cleaning, are not to be used for extraction.

## Evaluating the Effectiveness of Deep Extraction

When drying carpet and cushion (underlay) in place, one way to determine the effectiveness of extraction is by testing a portion of the extracted cushion. The number of passes needed to properly extract a carpet/cushion combination is determined by extracting a corner with a deep extraction tool, then disengaging the carpet from the tack strip. In the area that was extracted, inspect the cushion by squeezing firmly. If water does not drip from the cushion when squeezed, extraction is adequate. The same number of passes used in the corner test will be applied to the entire area. Re-engage the corner properly when the test is complete.

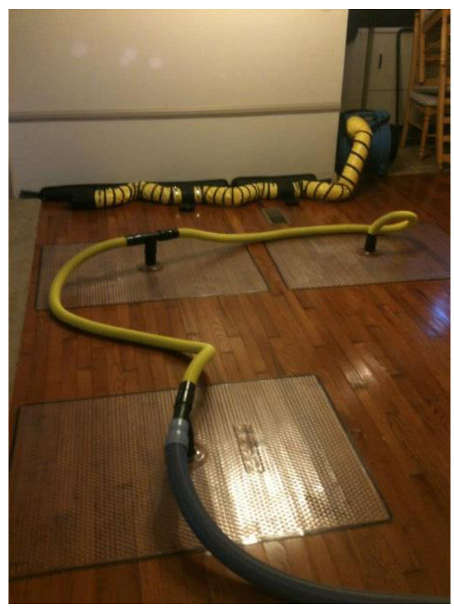
If water does physically drip from the carpet cushion, additional passes are necessary. The carpet is re-engaged, an additional pass is performed, then the cushion is re-tested. Re-test by squeezing the pad in a new area, moving approximately one foot (30 cm) from the area that has already been tested.

### *Essential Elements for In-place Drying*

Deep extraction tools combine three important elements that contribute to effective water removal: speed control, a vacuum seal and weighted compression.

- Mechanical speed control is essential for a consistent extraction over the entire carpeted surface.
- A reliable vacuum seal is essential to ensure air flows through the pad and carpet to remove water.
- Weighted compression is needed to force the air to move deeply through the pad and remove the stubborn water the light wand would leave behind.

Thorough extraction requires these elements. Without them, highly porous materials like carpet and pad cannot be dried in place. Too much water is held within these materials to rely on evaporation alone to restore them.



Vacuum panels connected to truckmount vacuum (gray hose)

### Extracting Water from Hardwood

When hardwood is being dried, it is necessary to extract it thoroughly, just like any other surface. This is accomplished using hardwood floor drying mats and a portable vacuum. Mats are placed on the floor and attached directly to the vacuum system. The time required for extraction depends on the amount of floor affected and the amount of water present. The process is complete when liquid water is no longer being visibly collected by the vacuum system. The mats must be periodically lifted from the wood floor and the surface must be wiped to remove the small amount of surface water. Then, the technician observes the rate at which additional water is being removed from the layers of floor and subfloor by negatively pressurized airflow.

## Extracting Standing Water

Standing water on the inside of a basement or crawlspace exerts pressure on the walls and/or foundation of the structure. If the water table of the surrounding ground has risen along with the interior water, equal pressure is pushing toward the inside of the structure. Equalized pressure is referred to as hydrostatic pressure.

Removing all of the interior water too quickly, while the pressure still exists outside, can result in structural failure of, or damage to, the walls. During the extraction process the depth of water must be monitored to ensure that it is actually falling at the expected rate. If the water is not receding at the expected rate, it is possible that outside water is entering due to the unequal pressure now being created by removing the inside water.

To prevent this problem, it is important to calculate the amount of water present and divide that by the flow rate of the submersible pump being used. The result will be the amount of time necessary to remove the water from the area. This information is then used to determine whether additional water is entering the area through the walls. If this is occurring, pumping efforts must be halted entirely until the water table outside recedes and/or a structural engineer or other appropriate expert has been consulted.

**To determine the amount of standing water present on a water loss:**

**Step 1** Establish the length and width of the affected area (estimate by measuring the outside of the building) in feet.

**Step 2** Measure the depth of the water in feet.

**Step 3** Multiply the length x width x depth to find cubic feet (cubic meters) of water.

*NOTE: When measurement includes inches:*
- Convert inches into a decimal by dividing the inches by 12.
- For example: 3" divided by 12 yields 0.25'. (Or, 10 cm divided by 100 yields 0.1 meters.)

**Step 4** Multiply cubic feet by 7.48 to find how many gallons of water are present. (Multiply cubic meters by 1000 for the number of liters.)

**Step 5** Multiply gallons by 8.34 to find the weight of the water present. (One liter weighs one kilogram.)

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- For example: 3″ divided by 12 yields 0.25 inch.

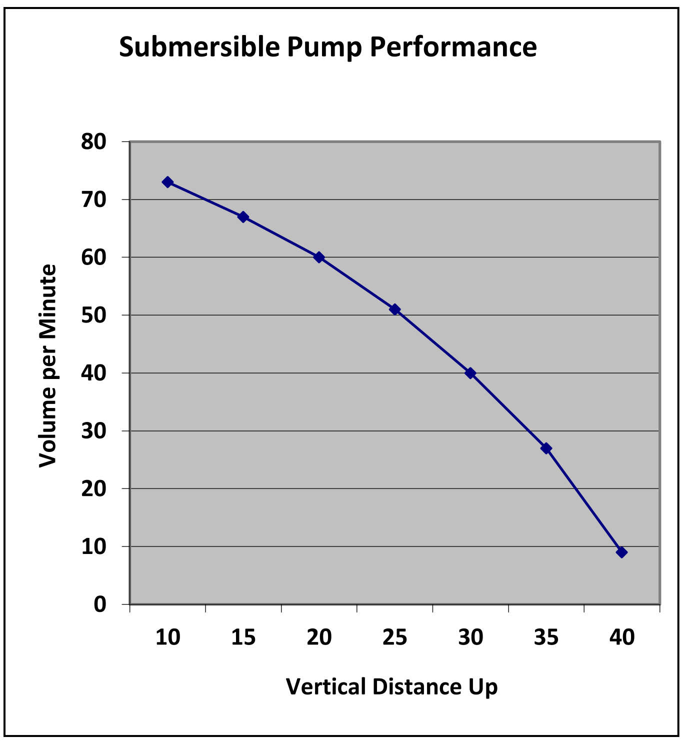
**Step 4** Multiply cubic feet by 7.48 to find how many gallons of water are present. (Multiply cubic meters by 1,000 for the number of liters.)

**Step 5** Multiply gallons by 8.34 to find the weight of the water present. (One liter weighs one kilogram.)

### *Submersible Pumps*

One of the most valuable and time-saving tools in restoration is the submersible pump. Some water intrusions result in substantial standing water, but even 1″ (2.5 cm) of standing water is significant. Every cubic foot of standing water present in a structure contains 7.48 gallons (28.3 liters) — and each gallon (3.8 liters) of water weighs 8.34 pounds (3.8 kg). Combined, these numbers can result in some amazing facts. Imagine a basement that is 20′ × 40′ (6 m × 12 m) in surface area, and consider the amount of water that would be present.

Obviously, a truck-mounted or portable extractor would be overwhelmed by this amount of water. In these cases, a submersible pump is a better tool. Submersible pumps are available in many different sizes and pumping capacities, so it is important to read the specifications for the pump being purchased.



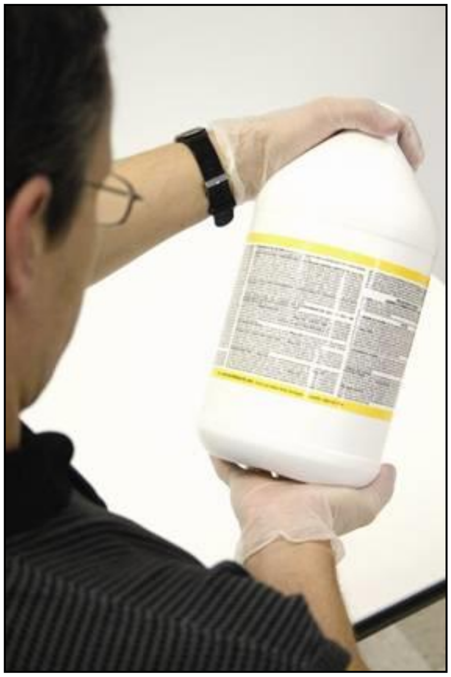

- Smaller electric pumps remove up to 600 gallons (2,270 liters) per hour, down to ¼″ (6 mm) in depth.
- Larger electric pumps will remove up to 9,000 gallons (34,000 liters) per hour, down to a depth of ¾″ (2 cm).
- Gas-powered submersibles are also available that will remove 2,200 to 26,000 gallons (8,330 to 98,000 liters) of water per hour.

These specifications for water flow all assume the water is being discharged in a downward direction. In actual use, flow may be considerably reduced if water is being pumped up, such as out of a basement. When purchasing a submersible pump, determine if the lift of the pump will be adequate for the job. Water flow is indirectly related to head pressure — when head pressure (lift) is high, water flow will be minimal. Trash pumps are generally a good choice when dewatering basements and crawlspaces. Trash pumps can pump small solids along with the water.

Controlling microbial activity at a restoration site may also require the use of chemical agents. Before deciding to use an antimicrobial or biocide, it is critical to first understand the terminology, technology and chemistry behind the individual product. The Environmental Protection Agency (EPA) has defined three levels of biocidal activity:

- **Sanitizer:** A cleaning treatment designed to reduce the number of pathogenic microorganisms to a safe level. This is the lowest level of biocidal activity.
- **Disinfectant:** A product designed to destroy or inactivate microorganisms, but not necessarily their spores.
- **Sterilizer:** A product designed to destroy or eliminate all forms of microorganisms (fungi, bacteria, viruses, etc.) and their spores.



To understand what materials the product will treat effectively and what health and safety risks they present, it is important to become familiar with the product's label. The use of a biocide or an antimicrobial agent may or may not be advisable. However, general procedures that are antimicrobial in nature are always employed, such as ensuring that building materials are dried quickly to prevent microbial damages from occurring.

### Active Ingredients

Each active ingredient commonly found in antimicrobials and biocides used in restorative drying has its own strengths, depending upon the intended application site, target organism and environmental conditions. Choosing an antimicrobial begins with understanding the efficiencies and deficiencies of each of these active ingredients.

**Alcohol** — Isopropanol, or "rubbing alcohol," is an effective antimicrobial. Unfortunately, it is extremely volatile and highly flammable. This leaves for very little dwell time and creates a safety hazard.

**Aldehydes** — Commonly found in the form of formaldehyde or glutaraldehyde. Aldehydes are non-ionic, allowing them to be used on stain resistant carpets without removing the stain-resist qualities. They are also highly inactivated by organic materials.

**Hypochlorites** — Effective against a broad spectrum as a disinfectant and sanitizer, with good deodorizing properties. Hypochlorite is inexpensive and readily available. Unfortunately, it is a strong bleaching agent, corrodes metals, is inactivated by organic matter and has limited cleaning (soil suspension) ability.

**Hydrogen Peroxide** — Works well as a “stat” against many organisms, but is effective for a relatively short period of time. Hydrogen peroxide is very sensitive to organic materials, losing effectiveness rapidly. It can bleach fabrics and cause corrosion.


**Phenolic Compounds** — Commonly used for sewage, phenols are effective against a wide variety of microorganisms. Phenols are more impervious to organic matter than other antimicrobials.

**Quaternary Ammonium Compounds** — Commonly referred to as “quats,” they are the common active ingredient in both institutional and consumer products. Quats are very safe relative to other active ingredients when properly diluted, and effective against a wide variety of organisms. Quats have good cleaning (soil suspension) properties with a high alkalinity.

**Ozone** — Effective for destroying volatile organic vapors and eliminating odors. Difficult to support sufficient penetration into many materials and can be dangerous in high concentrations. Reacts with background chemicals forming new compounds.

## When to Use Antimicrobials

Choosing the appropriate antimicrobial requires a technician to consider the following factors:

- The type and extent of contamination
- Potential adverse health effects
- Other procedures available to prevent or control microorganism growth


In conditions with high risk of exposure to organisms that can cause sickness, discomfort or disease, restorers will choose to use an EPA-registered biocide. This is especially true in circumstances where some building occupants are at a higher risk because of compromised immune systems.

Where cleaning and drying procedures alone eliminate any risks, technicians should use procedures that, in and of themselves, do not create additional risk. The risk associated with a chemical agent, in other words, is weighed against the risk presented by microorganisms. If the chemical agent carries a greater risk, then it is not used.

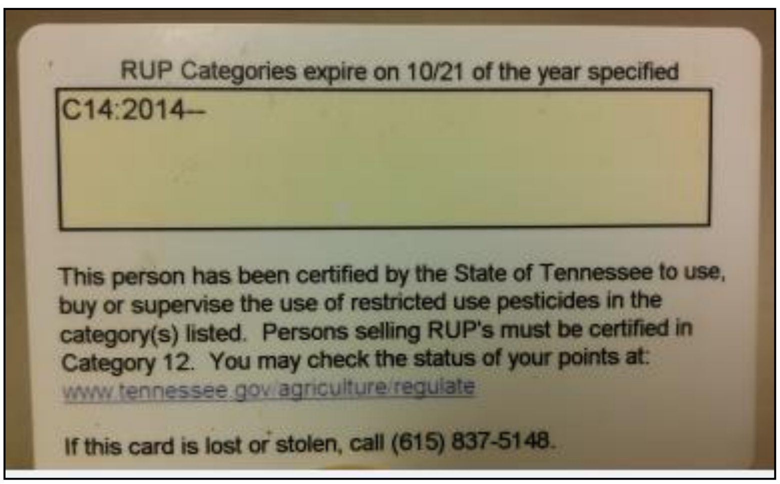
 

Many antimicrobial products can act as sanitizers, deodorizers and cleaners across a broad spectrum of building materials, while they are not necessarily biocidal on all surfaces. Products that do work as a biocide across a broad spectrum of materials for an extended period of time are generally those products with greater safety risks and, in some cases, greater risk of damaging the materials themselves.

### Applying EPA-Registered Antimicrobials

Whenever a chemical antimicrobial or biocide is used, restorers must follow the label directions explicitly. Any product that is labeled as an antimicrobial will have an EPA registration number and an approved EPA label, or, in Canada, a Health Canada registration with a Drug Identification Number. It is a violation of federal law to use these products in a way that is inconsistent with their labeling.

When using a biocide, brief the building owner and occupants first. Most antimicrobials require that the area of application be vacated by occupants and pets during application and for a period of time after application. Make the customer aware of the product that will be used, why it is being used, and how long the structure must be vacated. Also, obtain their signature on an informed consent form, documenting this procedure and the customer's approval. Finally, building owners and occupants are provided a Safety Data Sheet (SDS) upon their request.




Many states and provinces are requiring technicians who apply biocides to be certified applicators. Check local regulations before using biocides — they may be considered "microbial pest control." Some states may have reciprocal agreements with other localities. When responding to a wide-scale disaster such as a hurricane, check that state's regulations to ensure proper licensing.

### Proper Handling of Antimicrobials

1. Read the product label.
2. Use appropriate PPE.
3. Communicate with occupants.
4. Obtain consent.
5. Provide Safety Data Sheet if requested.

## Effective Application of Antimicrobial Biocides

The function of biocides is to disinfect, sanitize, reduce, or mitigate the growth of microbes. Effectiveness means accomplishing these types of results, and to do that the product must make adequate contact with the targeted microbes.

These products will not kill what they do not contact! Do not be surprised to learn that microbes which do not come in contact with the product will live on. The recommended procedures for applying biocides are aimed at establishing effective contact:

- **Preclean** — Clean and remove soils and organic matter before applying a biocide. Preclean any substances that might prevent contact of the biocide with the microbes.
- **Wet the surface appropriately** — The microbes must be exposed to a sufficient amount of the biocide to accomplish the desired effect.
- **Allow adequate contact time** — The microbes must be exposed for a sufficient time period to accomplish the desired effect.
- **Use proper terminology** — Be sure not to state that porous surfaces have been disinfected. EPA registers biocides for application only on nonporous surfaces when the intended use is disinfection, but allows biocides to be used for cleaning and deodorization on porous surfaces.

## Category 3 Mitigation Procedure with Antimicrobials

The objective of Category 3 mitigation is to remove the contaminants, while taking steps to avoid any spread of contamination either physically or through aerosolizing of particles. Contamination is removed as much as possible through cleaning processes. Alternate procedures are flushing with low pressure (20–60 psi) to dislodge contaminants and application of biocides for decontamination and disinfection. A suggested approach is:

1. Initial deodorant application for sewage odor control.
2. Removal of solid gross contaminants.
3. First low pressure, clean water rinse.
4. Initial disinfectant-cleaner application. All surfaces are then agitated with a scrub brush.
5. Second low-pressure, clean water rinse.
6. Second disinfectant-cleaner application.

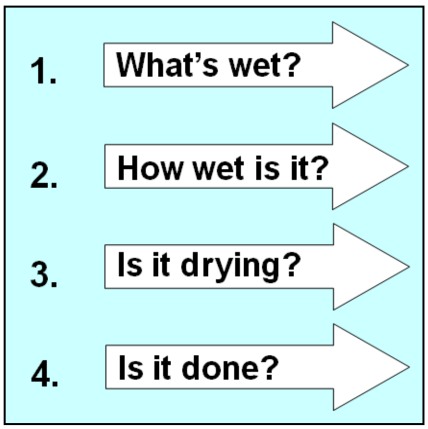
 

## Detailed Inspection: How Wet Is It? Section 6

The success of each decision made during the restorative drying process depends on the information upon which the decision was based. The process of restorative drying involves a continuous cycle of information gathering, interpretation, decision making, validation and adjustment.

### The Four "Knows" of Drying

Four questions summarize the information that must be obtained, documented and evaluated throughout the restorative drying process. When left unanswered, these questions are the source of the most common deficiencies in inspection and documentation. The four key questions, or "knows," of drying are:



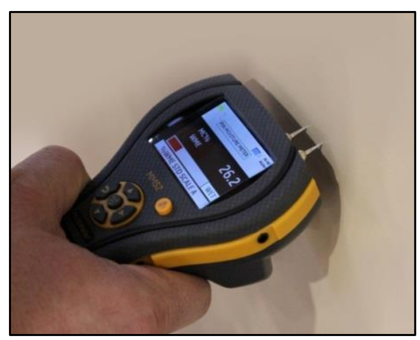

- What's wet?
- How wet is it?
- Is it drying?
- Is it done?

Only thorough inspection, monitoring and documentation will answer these four questions. A gap in this process will result in improper drying, additional water damage, and compromised structural cleanliness and integrity. Proper instruments and tools are a key ingredient to successful completion of the drying process.

### How Wet Is It?

In order to understand how wet materials are, it is important to understand the terms commonly used when discussing moisture levels, instruments and documentation.

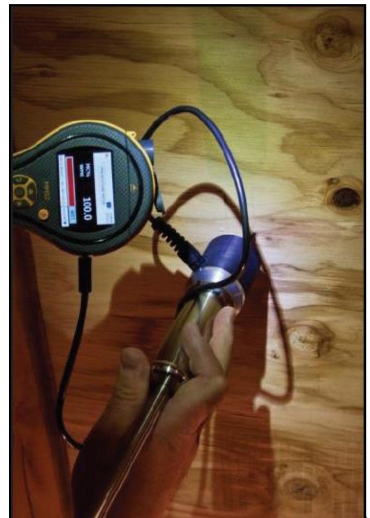
#### *Moisture Content (%MC)*




Moisture content: the amount (weight) of moisture in a material compared to its oven-dried weight, expressed as a percentage. A common misconception is that meters always measure in %MC. In fact, they rarely, if ever, measure %MC accurately. A number of factors cause the reading to deviate from the actual %MC. These factors include:

- Temperature — Changes in material temperature will cause readings to differ from the true moisture content.
- Material Variations — Many materials vary in their makeup. Variance in makeup will alter the material's natural resistance.
- Meter Calibration — Meters require periodic calibration as the result of normal use.

For these reasons, the term %MC will, in many cases, be an inaccurate term for describing the use of standard instruments to measure moisture held in common building materials.



### *Wood Moisture Equivalency (WME)*

WME will normally be the most appropriate and consistent term to use when discussing and documenting moisture findings. Wood moisture equivalency is a term used to describe comparative readings obtained using wood calibrated moisture meters on non-wood materials, but can be applied to all documented moisture readings. The proper unit for a WME reading is "points."

WME readings bear no significant value unless compared to some other control sample or benchmark. They are simply a relative reading, where lower numbers represent less potential moisture than higher readings. Technicians should consider all factors that might alter the reading of a moisture meter when evaluating the numerical values of an instrument and any changes to that value over time as drying is monitored.

Is it drying?

**Evaluation: "Is It Drying?"**

When inspections are performed properly, technicians can accurately evaluate the progress being made in the structure. Progress is defined as a favorable change in condition. More critical than the amount of moisture present in a structure is the change in moisture over time.

This length of time greatly influences the amount of damage that the structural material will suffer due to a water intrusion. Progress is a critical element in restorative drying; slow progress, or no progress, will result in damage. Documenting progress is an important part of restorative drying.

### *Monitoring Frequently*

Frequent inspection, thorough monitoring and evaluation are necessary to accurately judge progress. On average, most structures need to be evaluated for progress at least once in every 24 hour period. When a structure is evaluated daily, the restorer has the opportunity to perform several tasks that will minimize water damage, equipment usage and overall project time. This results in the return of the structure and contents to pre-loss condition sooner — and a reduction in total job costs.

Is it done?

### Is It Done? Dry Standards

The drying process is not complete until all affected materials reach drying goals, which are normally based on a dry standard. A dry standard is established by obtaining a moisture reading of an unaffected material. This reading is then used to determine a goal against which the affected materials can be compared. Regardless of the material type the meter was intended for, unaffected materials will yield a relative reading that can then be used as a control to which suspect materials can be compared. The drying process cannot be regarded as complete until moisture meters indicate the affected materials have reached the drying goals based on dry standards.

Restoration contractors set an effective dry standard for use in structural drying by obtaining this data from several materials in several unaffected environments. This then yields a range of normal moisture levels for building materials in the specific geographical region. This record then becomes a reference to evaluate suspect materials in a wet environment. When technicians must establish a dry standard for a material within the same structure being evaluated following a water loss, they should consider indoor temperature and humidity. Abnormally high humidity can alter the amount of moisture in materials that are not directly affected by water.

When establishing dry standard readings, document not only the relative value from the unaffected material, but also the meter brand and model, time of year, type of indoor environment and any appropriate material characteristic that may influence the reading obtained.

> *Dry Standard: A moisture reading obtained from a known unaffected sample that allows the restorer to set drying goals for the affected structure and contents made from the same material.*

#### *Dry Standards vs "Actual Moisture Content" Readings*

Relative readings and relative dry standards are not the same as true moisture content readings. A true moisture content reading can only be determined by comparing the monitored material to oven dried samples of the material or by using an invasive moisture meter with corrections for temperature, material type and meter calibration.

Technically speaking, actual moisture content readings are more precise; however, they are not necessary for documentation or decision making on drying projects. The *IICRC S500 Water Damage Restoration Standard* clearly accepts the reliance on relative moisture readings for drying goals and moisture measurements. Furthermore, materials research shows that complex corrections must be made for all engineered materials and chemically treated materials (Glass, Carll; 2009).

Therefore, the best tools at the restoration professional's disposal for determining drying goals and drying progress are relative moisture readings compared to a dry standard obtained with the meter in use on the project.

## Inspection and Monitoring Tools

Several tools are available for inspection and monitoring. These tools include instruments for detecting moisture, imaging equipment for inspecting confined space or cavities (such as a borescope), instruments for measuring temperature and humidity, and devices for measuring the size and volume of the affected areas within a structure. Other tools and devices are also used for measurement in the inspection and monitoring process to assist in the evaluation of environmental and structural conditions.

### Moisture Sensor


The moisture sensor is the most basic of moisture detection instruments. It is designed to detect high levels of moisture in the carpet and underlay, indicating "What is wet."

Most moisture sensors will indicate the presence of abnormal moisture levels through an audible beep. The wetter the material being probed, the faster the device beeps. A visible LED located on the handle will also blink faster in relation to the moisture of the material.

Although the amount of moisture does influence the frequency and/or intensity of the instrument's response, no numerical value is given by the device, preventing the technician from evaluating progress. This instrument is therefore a sensor and not a meter. It is best used to determine the perimeter of water migration through carpet and underlay.

The moisture sensor's limited functionality restricts its uses in other ways. Because the instrument has been designed only to detect relatively high levels of moisture in carpet and underlay, it is a mistake to attempt to measure moisture in any other materials. It is possible that the meter will give an unaffected response even if materials remain unacceptably wet. It is also a misuse of the sensor to attempt to evaluate the condition of materials after drying has begun. Moisture sensors may give false readings if high levels of urine are present in the carpet, underlay or subfloor. A weak battery can also produce false readings.

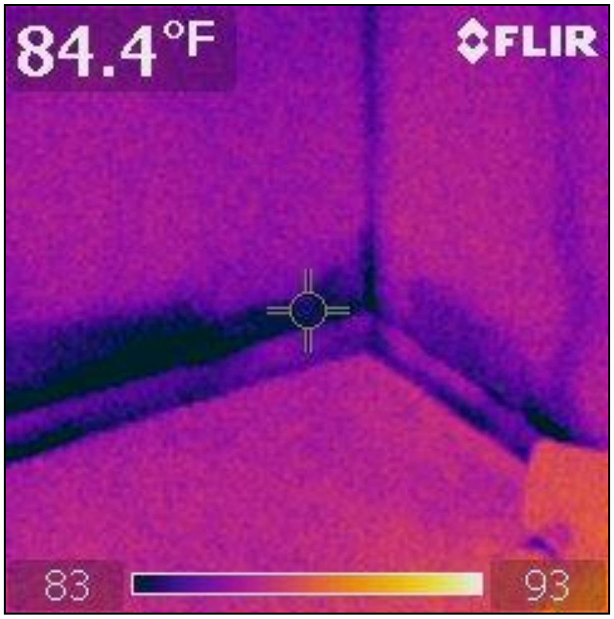
### Thermal Imaging Cameras

Thermal imaging (IR or infrared) cameras detect surface temperature differences. The camera measures thousands of temperatures across a surface, not just at one point. The temperatures are then translated into a photograph, where colors are used to represent varying temperatures.

This capability has important uses and limitations as a monitoring tool. A thermal imaging camera is often used to detect areas that may be wet. The primary way in which an infrared camera "detects" the presence of water is through the effects of evaporative cooling. Evaporative cooling is simply the surface cooling effect of evaporating moisture.

Where evaporation exists, cooling typically occurs. This cooling will leave an evident indication of moisture when viewed through the thermal imaging camera.




Technicians use the camera to visualize areas of a structure that are cooler. These cooler areas may be wet. The suspected areas should always be tested with a moisture meter to verify the thermal camera's readings. Thermal cameras only detect a surface temperature, and have many "false" readings.

Another way in which the presence of water can be "detected" with an infrared camera is through the effects of thermal capacitance. Basically, thermal capacitance is the ability for a material (or substance) to retain thermal energy. Because of differences in thermal capacity, materials (and substances) retain thermal energy for varying amounts of time. For example, water has a high capacity for thermal energy and changes temperature relatively slowly. Therefore, as air temperatures change, wet building materials can become quite visible to a thermal imaging camera as they cool off more slowly than dry materials. This is most evident as day and night impose very opposite temperatures on building exteriors, and variations result from the differences in thermal capacitance between wet and dry materials.

The thermal imaging camera has limitations for water restoration inspections. Many other factors besides moisture can influence building component temperatures. HVAC plenums, vapor barriers, air filtration, reflective surfaces, and heat transfer resistance (R) values, for example, can cause materials to gain or lose heat and produce "false readings" for a restorer using thermal imaging to locate moisture. Other possible false readings include:

- Cold inside corners
- Sunlight shadows
- Electrical heat sources
- Air infiltration/exfiltration
- Layers and gaps in the wall (Harriman, 2003).

Furthermore, materials can increase in temperature as heat energy transfers through another solid (by conduction), through a fluid like air (by convection), or as a heated surface emits heat energy through space to another surface (by radiation). So thermal cameras may show temperature differences not related to evaporation of moisture.

Due to these limitations, a thermal imaging camera is used only to help identify "potential" moisture. The visual image is valuable in establishing a map of water migration during the initial inspection. Measurements with moisture meters are needed to verify actual amounts of moisture in suspect materials. Document the location of the images and corresponding moisture readings.

### Infrared Thermometer

An infrared thermometer is a device capable of reading the surface temperature of most materials without direct contact. Readings are acquired by measuring infrared light, which will vary with the surface temperature of the material.

Surface temperature readings can be used when evaluating three areas of particular concern to restorative drying contractors:

- Potential areas of condensation and elevated humidity resulting from cool surfaces
- Surface temperature of a material to evaluate energy available for drying
- Evaporative cooling

Condensation is not the only resulting problem when cool surfaces are present. Because of the relationship between temperature and humidity, cool surfaces increase the relative humidity in the surrounding air. This impedes the drying process by retarding evaporation.

When a surface is warmer than dew point temperature, this indicates there is energy available for evaporation to take place. The larger the difference between dew point and surface temperature, the greater the potential evaporation rate.

Measuring the surface temperature can actually lead to identifying wet materials. Wet materials will release moisture through evaporation. On a surface where evaporation is occurring, cooling will normally occur as well.

Infrared thermometers have limitations as with almost any instrument. Major hindrances to the use of an infrared thermometer include reflective surfaces, distance from the instrument to the surface, and vapor barriers.

- Reflective surfaces do not emit much IR energy, so they provide inaccurate measurements for IR thermometers. Also, the target surface can reflect infrared light emitted from other materials, yielding additional false readings for the target surface.
- Infrared thermometers measure in a cone shape spreading out from the sensor's tip. Therefore, the farther the instrument is from the material, the larger the area sampled by the sensor.

- Vapor barriers cause false impressions when the user is trying to identify suspect areas. Where vapor barriers exist, little to no evaporation occurs. Even if materials are wet, evaporation may not be sufficient to create cooling measurable with the infrared thermometer.

### Invasive Moisture Meter (Penetrating, Pin-Type)

Unlike moisture sensors, moisture meters provide a numerical value for the moisture detected. This numerical value can then be documented and used to monitor drying progress. For this reason, the amount of moisture absorbed by semi-porous structural materials, such as wood, is measured most accurately with a moisture meter, not a moisture sensor.

The two types of moisture meters are invasive and non-invasive. The invasive moisture meter, sometimes called a penetrating or pin-type meter, operates on the principle of electrical resistance or conductivity, similar to the moisture sensor described above. Electrical circuits test the conductivity of the suspect material, and higher degrees of moisture result in a response from the instrument that indicates the target is “wetter.” A pair of pins is inserted into the material being tested, and the pins measure the resistance of the material to conductivity of current between the points of contact. Because conductivity varies with the amount of moisture present in the material, the moisture level can be quantified.

Invasive moisture meters offer a variety of accessories and attachments designed for various building materials and construction methods. These attachments generally include pins or probes that vary in length, diameter, tip style and electrical shielding (insulation) along their shaft. Invasive meters are commonly called “wood” meters because they are calibrated for use on wood (traditionally calibrated on old growth Douglas Fir). Some meters also include a gypsum or drywall setting, which uses a different measurement scale.

Insulated pins are able to detect moisture content gradients in materials. Moisture content gradients are differences in moisture in different areas of a single material. Depending upon the intended medium to be inspected, one probe type may offer better results than another.

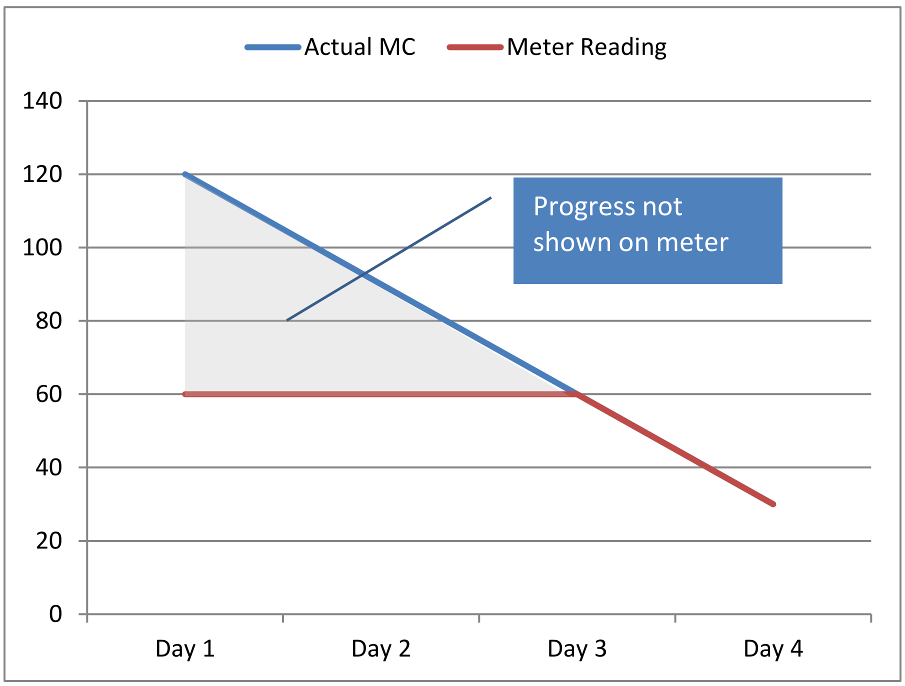
- Short (1/2″ or 1 cm) tapered, non-insulated pins
- Medium (1.5″) straight, insulated pins (Hammer Probe)
- Long (6″–12″ or 15–30 cm) straight, insulated pins.

When monitoring saturated wood, the reading displayed on a penetrating moisture meter will drift lower over time. This is simply called “meter readings drift.” The best practice is to document the readings within the first 2 to 3 seconds of driving the pins into the wood (Peterson, 2008).

Each manufacturer of invasive meters uses a different scale, but generally speaking, the different brands of meters will correlate with each other from 7% to about 30%. Above 30% invasive meters become far less accurate, and these readings would strictly be viewed as wood moisture equivalencies.

Some manufacturers stop the penetrating scale at 30%. Some meter manufacturers stop the scale somewhere between 40% and 100% and include a statement in the manual explaining about how readings are relative above 30%.

Whichever stopping point a manufacturer chooses for their meter, some situations will involve materials whose actual moisture content is above the limit. Some wood species, for example, can hold almost 250% moisture content! So even the 100% meter would not detect that a material is higher than the scale maximum.




When meter readings display the maximum value in one location on Day 1, you should also document an area which is not at maximum. This second area may show more clearly whether progress is being made.

Other significant influences on penetrating readings include: temperature of the material being monitored, type or species of material, salts in the material, chemical treatments and moisture gradients within the material.

### Noninvasive Moisture Meter (Non-Penetrating)

Non-invasive meters, sometimes called *non-penetrating, scan-type* or *pinless* meters, currently operate by either of two major technologies:

- Electronic capacitance or impedance technology, which utilizes a set of rubbery pads placed in contact with the surface of the material being tested.
- Radio frequency technology, whereby a radio frequency signal is sent into the material through a smooth plastic pad.

Noninvasive moisture meters measure either radio frequency signals or electromagnetic fields through a sample of the suspect material. Meters detect either the capacity of the material to store energy (capacitance), the material's resistance to an electromagnetic field (impedance), or the penetration of radio frequency signals in the material. Higher levels of moisture will result in higher transfer of the signal through the material. The instrument then converts this transfer rate into a relative moisture reading.


Because of their noninvasive nature and quick surveying capabilities, noninvasive meters are the most effective tools for locating abnormal moisture behind and beneath finishing materials such as ceramic tile and vinyl (resilient) floor coverings. However, readings from a noninvasive meter are less accurate than penetrating moisture readings.

Noninvasive moisture meters can give false positive readings for a number of reasons — most often because of metal hidden within or behind the material being monitored. Some common building components that influence a non-invasive meter's accuracy are:

- Corner bead on gypsum wallboard (plasterboard)
- Metal studs
- HVAC ducting
- Plumbing
- Insulation with foil lining
- Metal in walls and ceilings (such as x-ray rooms)
- Electrical wiring, conduits and boxes
- Concrete


False negative readings are also possible with non-invasive moisture meters. These false readings result from unseen air gaps behind and beneath target materials. Most non-invasive moisture meters are only capable of carrying a signal through solid materials. The presence of air will limit the signal. Applying moderate pressure with one hand while placing the moisture meter on the surface with the other hand will aid in eliminating air gaps behind these materials.

When using a non-invasive moisture meter to monitor vertical surfaces, the meter must be held horizontally, or parallel to the water line. This will allow the user to determine the edge of the moisture by looking at the edge of the meter. Most manufacturers also recommend technicians apply light hand pressure (about 3 pounds) to ensure good contact between the material and the meter (Peterson, 2008).

### *Choosing Which Meter to Use*

As with any instrument, understanding the limitations of the technology plays a critical role in properly interpreting a meter's output. Reading the owner's manual for each model will provide the information necessary for proper operation and documentation of resulting values. Also, the owner's manual will contain information regarding how often the instrument calibration must be checked. Refer to *References and Resources* (at end of chapter) for further information on calibration of moisture meters.

The main advantage of the non-invasive moisture meter is that it allows a quick scan at the surface to detect elevated moisture levels. At first glance, a non-invasive moisture meter is appealing because it does not make holes in the material. This meter, however, has two important limitations:

- Reading depth is limited, from about one-fourth to three-fourths of an inch maximum, depending on the meter.
- Surface moisture can cause false readings. This effect varies among brands of meters, so be aware of a meter's method of measurement when selecting a meter.

Invasive meters also have limitations. They do require inserting metal electrodes into the material, even though the small holes left are easily repaired and are quite minor compared to the damage that could occur if moisture is left undetected. Invasive meters detect moisture present only at the point of penetration into a material. They can detect abnormal moisture at various depths in solid materials and in layers of materials if the appropriate accessory is utilized.

Moisture meters can be utilized in ways that consider their limitations. Many restorers use a non-invasive meter to conduct a quick overall evaluation of the job site and then use an invasive meter to verify and quantify moisture levels at selected locations. Then, as the job progresses, repeat readings are taken daily to show drying progress in materials.

## Thermo-hygrometer


A thermo-hygrometer measures air temperature ("thermo") and relative humidity ("hygro"). This information is recorded in the Record of Drying Conditions (also called the Daily Humidity Record) and used to calculate other important properties of the air being monitored.

Thermo-hygrometers are used to monitor any air that can influence the temperature and/or humidity within a restorative drying environment. They are used to verify equipment operation and to evaluate the need for additional equipment, particularly with equipment intended to reduce the humidity and/or control the temperature within a drying environment.

One example of monitoring with a thermo-hygrometer is the measurement of a dehumidifier's humidity removal, or grain depression. This type of evaluation is done by taking the temperature, relative humidity and GPP of the air entering and exhausting from the dehumidifier. Technicians can estimate the water vapor removed by the dehumidifier using this difference. This measurement does not provide exact water removal data, because the volume of airflow is not represented. Nevertheless, performance can be tracked and compared as the drying job progresses. Changes in grain depression are used to evaluate the impact of other changes, such as an increase in temperature, or dehumidifier performance. Technicians should consider the accuracy limitations of the thermo-hygrometer when performing this evaluation.

Thermo-hygrometer readings can be used to assist in additional equipment and strategic decisions made as drying progresses toward the pre-determined dry standard. The table outlines the locations where air conditions are measured.

| Area to Monitor | Reason to Monitor |
|---|---|
| Affected Area | Humidity should be decreasing |
| Unaffected Area | Humidity should be normal and relatively stable. |
| Dehumidifiers | Should be removing moisture |
| HVAC (if running) | Should be cooling/heating (depending on intended use) |
| Outdoor Air | Should be drier than affected (if used as part of the drying system) |

Thermo-hygrometer readings should always be analyzed in perspective of their importance and accuracy. Best practices for monitoring a drying project require that restoration vendors properly prioritize the various types of data collected. In evaluating progress with the majority of structural drying projects, emphasis should be placed on three key areas:


1. Moisture in materials being dried.
2. Air being used to dry affected materials.
3. Mechanical systems used to control temperature and humidity.

Drying structural materials is the ultimate goal for any drying project. Therefore, this data should be evaluated first and should always receive the most attention. If materials are drying, the system as a whole is performing.

Basing other critical decisions and equipment performance assumptions on grain depression alone, or any other single air reading, will lead to inaccuracy and false determinations. To best understand progress, performance and efficiencies, restorers must first focus on material drying progress. Temperature and humidity readings are then evaluated to understand what can be changed to speed material drying, and to ensure additional damages are not caused by high humidity.

### *Using Digital Thermo-hygrometers Effectively*

Technicians should be aware that thermo-hygrometers can provide inaccurate information for a number of reasons. Operator error is often the cause while, on other occasions, it is due to instrument limitations. The most common causes of inaccurate readings are:

- Insufficient acclimation time
- Temperature or RH limits of the probe being used
- Weak battery
- Soiled probe.

Before recording a measurement, wait until temperature and relative humidity conditions stabilize. These readings stabilize when the values are no longer consistently rising or falling, and simply fluctuate slightly up and then back down. Thermo-hygrometers will acclimate faster in moving air.

The sensor in a thermo-hygrometer is quite delicate. Keep the meter in the case when not in use. Try not to expose the meter to chemical vapors such as those in a carpet solvent spotter. Also, certain plastics are harmful to the sensor, so a recommendation is to use only carrying cases supplied by the manufacturer. Do not store the meter in hot vehicles (over 140° F or 60° C), and avoid touching, washing or contacting the humidity sensor on the probe.

Even thermo-hygrometers which have been gently cared for will eventually fall out of calibration. This is because of contaminants present in any air being measured. The length of time may range from a few months to a year or more. When the sensor is out of calibration, replace it or have the unit calibrated following manufacturer's directions.

Thermo-hygrometers can be checked for accuracy in two ways:

- **Reference Sensor:** Keep a "perfect" meter in a cool dry place. This meter would never be used in the field. Compare this reference meter to the field meters to ensure the field meters are within an acceptable range.
- **Saturated Salt Solutions:** Several meter manufacturers make salt solutions available which can be used to determine if the thermo-hygrometer's performance is within an acceptable range.

## Visual Inspection Tools

When employing drying systems that will pressurize cavities and therefore create filtration, inspection of these cavities is important. A visual inspection after a water intrusion also yields valuable information when evaluating water damage, such as shifting of wall cavity insulation.

### Borescope

When evaluating cavities within the structure that are obstructed from unassisted visual inspection, borescopes are beneficial. Through the use of fiber optic technology, borescopes allow the user to see into wall cavities, beneath cabinetry, under tub enclosures, and into other hidden areas. The visual inspection process allows for a better understanding of the structure's condition.

Borescopes usually require a hole or opening of about ½″ (13mm) in diameter through which the tip is inserted. The image is transferred to an eyepiece through a long, flexible neck using fiber optics.

Many borescopes are also equipped to work in conjunction with conventional cameras and/or video recorders. Photo records of hidden cavities greatly supplement a job's documentation by visually showing how and why the restorer has made strategic decisions related to restoration.

### Inspection Mirror

A less expensive variation of the borescope is the inspection mirror, which consists of a small mirror attached to the end of a flexible and/or collapsible neck. The mirror allows for inspection of some cavities within the structure, but its use is more limited than the borescope, requiring a much more intrusive inspection process if a large opening does not already exist.

## Ambient Air Inspection Tools

On some restorative drying work sites, restorers may encounter situations that require use of tools designed for specific monitoring tasks of air quality or other properties of the ambient air conditions.

### Gas Monitors

Another useful monitoring and inspection tool, gas monitors are available as either single or multiple gas detectors. Many manufacturers will provide single gas monitors capable of detecting one of 13 (or more) toxic gases, or for detecting oxygen levels in an air sample. Multiple gas detectors monitor levels of two or more gases.


Gas monitors are also available in either standard or maintenance-free models. Standard models need frequent calibration, as often as every six months, while maintenance-free models are disposable. Disposable monitors are typically single gas monitors.

A gas monitor is an essential instrument when working in environments with either low oxygen levels or high toxic gas levels. Carbon monoxide is a concern when working under negative pressure in a structure with combustion appliances. High levels of carbon monoxide (CO) will be present if negative air pressures are sufficient enough to draw in air from outdoors through combustion exhaust flutes. This can result in a risk of suffocation. Gas monitors assist in identifying this safety hazard — the greatest risk associated with the use of negative air pressures in the restoration environment.

### Laser Particle Counters

Used to measure the amount of particulate in a sample air mass, laser particle counters test the effectiveness of air filtration systems. Laser particle counters are also used to measure the effects of various drying systems on indoor air quality.

Laser particle counters are available in handheld, large portable and remote devices. Price ranges for laser particle counters vary greatly. The factors that most influence the price of the instrument include the particle size detectable, sample time, particle size differentiation, simultaneous measurement of various particle sizes, particle size range(s), data logging features and additional functions (such as relative humidity and temperature).

Validating the effectiveness of an air filtration device (AFD) can be important, depending upon the nature of the restoration project. When using particle counters to evaluate AFD effectiveness, readings are taken at the unit inlet and outlet. Differences in particle count are compared to calculate the amount removed. Readings are also taken in the air throughout the drying environment and compared to air outdoors and in unaffected areas of the structure. Major deviation from the unaffected area in particular indicates the need for additional filtration.

## Manometers

Another instrument for measuring the properties of air, the manometer detects differences in air pressure between two spaces. Air pressure differentials are particularly useful when working to contain high humidity and other contaminants, and/or to generate airflow in difficult to reach cavities. When using air pressure differentials, accurate measurement is important to determine whether proper pressure differentials have been achieved and are being sustained.

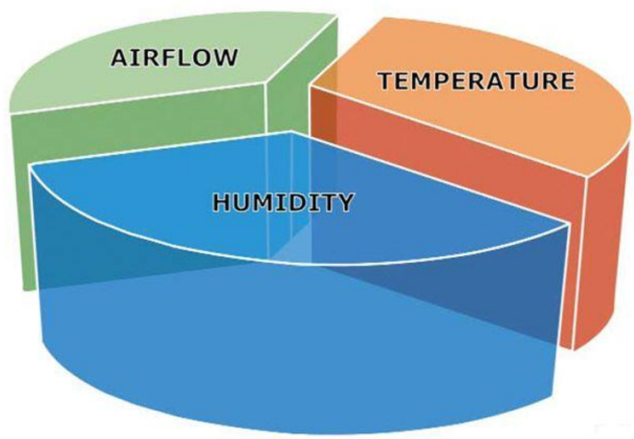
Manometers are available with analog or digital/ LCD displays, as handheld inspection instruments, or as data logging devices, and are capable of a wide range of sensitivities. Each of these variations greatly influences the cost of the manometer.

An important specification relative to restorative drying projects is the manometer's sensitivity. It must be capable of measuring differences as little as 0.02 to 0.04″ Hg, or 5 to 7 Pascals. When pressure differentials are used, pressure differences of this magnitude are necessary in order to generate sufficient control over the direction of air exchange and filtration.

Drying structural materials rapidly requires a technician to increase the rate of evaporation from wet materials. This section will explore the principles which can increase evaporation. One area of discussion will be psychrometry, the measurement of the properties of moist air.

What exactly is psychrometry? According to the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), "Psychrometry deals with thermodynamic properties of moist air and uses these properties to analyze conditions and processes involving moist air." In other words, psychrometry is the measurement system associated with evaluating the properties of moist air, namely temperature and humidity. Psychrometry allows the restorer to analyze these properties and better understand their effects on evaporation in the environment.

Three factors influence the rate of evaporation: humidity, airflow and temperature, or H.A.T., commonly referred to as the "drying pie." Each factor can be measured and evaluated in a number of ways. Each has a direct influence on the rate of evaporation (or condensation) that will occur when moisture and materials interact.




Simply put, evaporation will increase when

- wet materials are made warmer,
- when drier air is used, and
- when air is moved more rapidly across the wet surface.

After excess water has been removed by extraction, the time required to dry wet materials is determined by the rate of evaporation. As the water is evaporated, the water vapor is removed by dehumidification or ventilation.

Humidity, airflow and temperature directly affect the state in which water exists – solid (ice), liquid (water) or gas (vapor) and the rate at which the change of state occurs. It is critical to have control of these factors and an understanding of how the properties relate when drying a structure.

### The Influence of Temperature

The primary factor that determines what state water will take is the amount of energy it contains. As water molecules gain or lose enough energy to create or break bonds with one another, change of state occurs. For example, when changing from liquid (water) to gas (vapor), energy must be added.

The amount of energy available in a wet material can be assessed by measuring the material temperature (usually measured at the surface). Where the material temperature is higher, more energy is present to support evaporation.

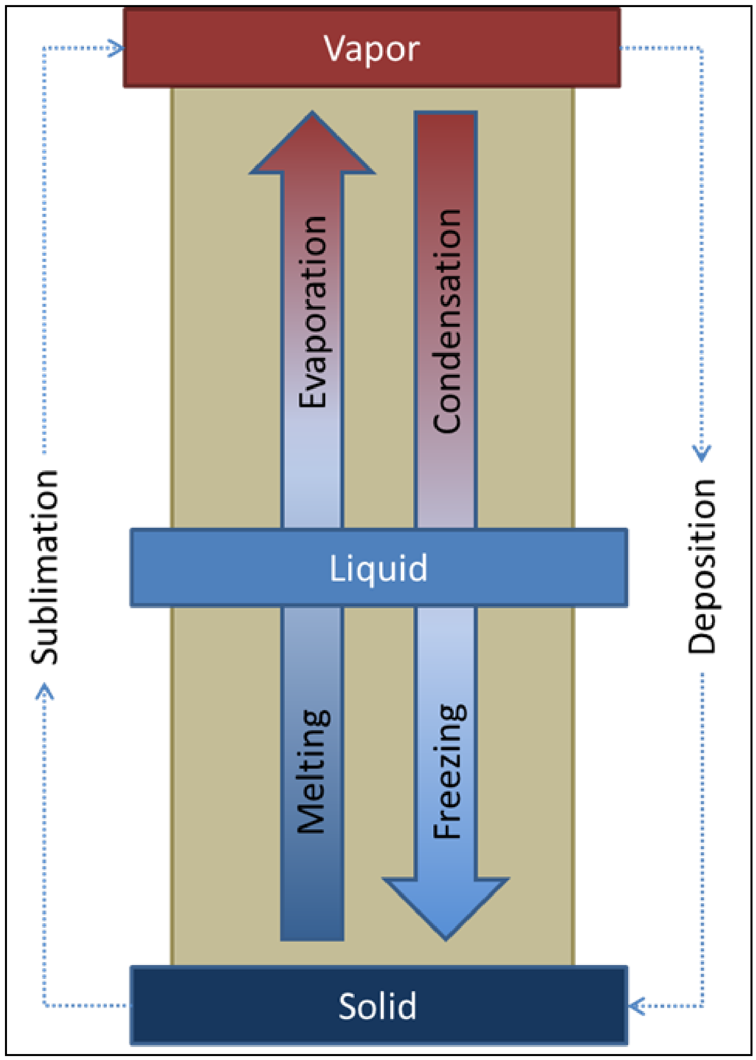
### State Changes in Water

Several changes of state can occur, depending upon whether energy is being added or removed. The amount of energy required to change the state of water is quite remarkable. In fact, it requires more energy to change water from one state to another than to change the state of almost any other substance. Here are some key principles about changing the state of water:

*Evaporation:* Liquid changing to a vapor. Occurs as energy is increased. As moisture evaporates from a wet material, the surface of the material becomes cooler because energy is released from the material.

*Condensation:* Vapor changing to a liquid. Occurs as energy is removed. Surfaces below dew point temperature will condense water out of the air.

*Sublimation:* Solid changing to a vapor (without going through a liquid phase). Occurs when solid water is exposed to a vacuum in a freeze drying chamber. Commonly known as “freeze drying,” this process can be used to restore valuable saturated books, documents, and other materials. These goods may be restorable if saturated with clean water and frozen or dried as quickly as possible (ideally within 24 hours).



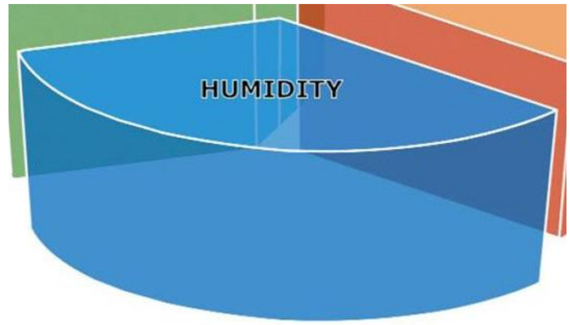

*Deposition:* Vapor changing to a solid (without entering the liquid phase).

*Melting:* Solid changing to liquid. Occurs as energy is increased.

*Freezing:* Liquid changing to solid. Occurs as energy is removed.

## The Influence of Humidity

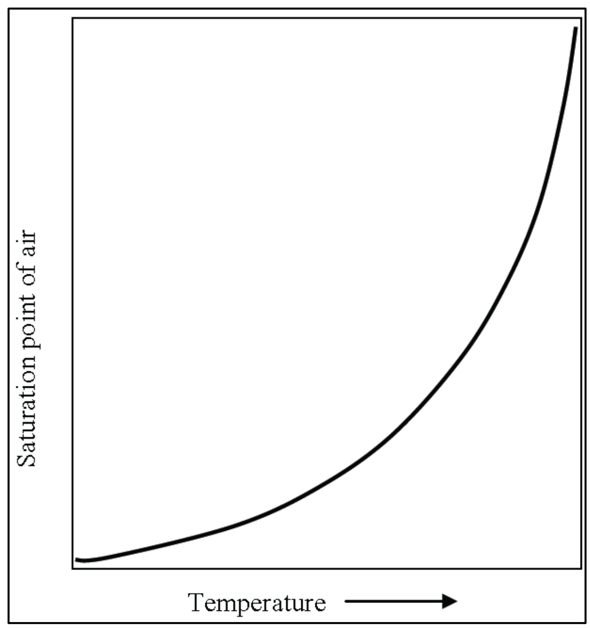
The restorer must use several different measures of humidity to fully understand how to increase evaporation. These measures are in two categories:




- The measure that relates the actual amount of water vapor present to the potential amount at a certain temperature (relative humidity).
- Measures that describe the actual amount of water vapor in the air: vapor pressure, dew point, humidity ratio (expressed in units of GPP), absolute humidity.

### Relative Humidity

Relative humidity (RH) has traditionally been used to indicate the air's moisture content. Currently the restoration industry has adopted a simplified definition of relative humidity as being the amount of moisture contained in an air sample as compared to the maximum amount the air could hold at that temperature. On a psychrometric chart RH is expressed as a percentage (%), meaning a percentage of what air at the same temperature would contain when saturated.




The reason RH is used in restoration is that hygroscopic materials have an equilibrium moisture content that is mainly determined by the RH. In simplest terms, when RH is low, materials will generally lose moisture. When RH is high, especially above 60% RH, materials will generally gain significant moisture. When conditions exceed 60% RH, the structure is more likely to suffer secondary damage.

RH does not define the water content of the air unless the temperature is given. Air can hold more water vapor when the temperature of the air increases. Therefore, changes in air temperature will change the relative humidity. Relative humidity will decrease when air temperature increases. Conversely, relative humidity will increase as air temperature is decreased.

### Specific Measures of Humidity

There are many ways to measure the actual amount of water vapor in the environment, regardless of temperature. In the restorative drying industry the weight measurement used to measure water vapor in air is grains per pound of dry air, abbreviated as GPP.

This is referred to as humidity ratio. GPP expresses the weight of water in a given weight of air (a pound of dry air). The metric equivalent of GPP is grams per kilogram of air, abbreviated as g/kg.

Specific measures of humidity give the restorer the opportunity to compare different environments on a drying project. GPP is most commonly used for this purpose.

> *Key Numbers*
> *14 ft$^3$ of air = 1 Lb of air*
> *7000 grains = 1 Lb*
> *1 gallon of water = 8.34 Lb*
> *1 ft$^3$ of water = 7.48 gal.*

GPP is directly related to dew point and vapor pressure, because all three are specific measures of humidity. Therefore GPP can be used as a constant measure for these metrics as well. When the GPP in an environment goes down, the dew point and vapor pressure decrease as well. For example, if the GPP is low inside a structure, and the GPP is high outside, it can be predicted that moisture will move from the outside toward the inside. This is not because of the GPP differences, but because the vapor pressure (associated with GPP measures) is greater on the outside of the structure.

When using humidity ratio to describe the amount of moisture in the air, restorers make use of two significant factors for proper decision making during a water loss:

- 14 cubic feet of air = 1 lb air
- 7,000 grains = 1 lb

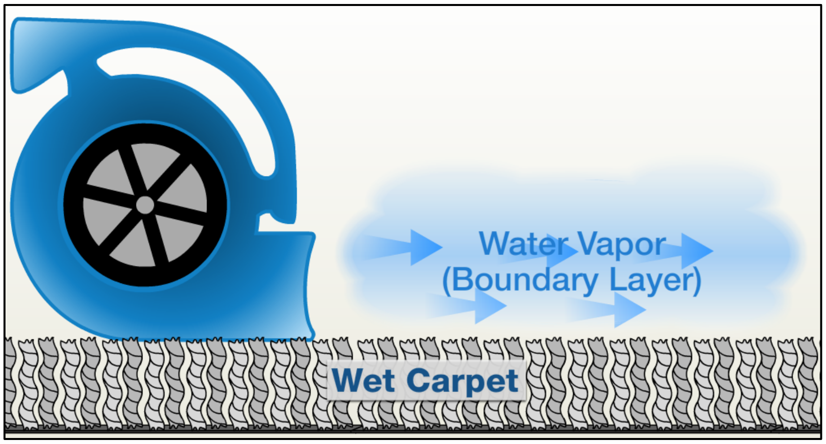
> *Humidity Ratio is the weight of water in a given weight of air measured in GPP. Has been referred to as Specific Humidity.*

With the understanding that one pound of air occupies approximately 14 cubic feet and 7,000 grains weigh one pound — a restorer can use humidity ratio to calculate amounts of water removed:

- By dehumidification systems
- By negative pressure systems (such as inter-air dryers)
- In heat and air exchange drying systems
- When flushing a structure
- During combination drying systems

## The Influence of Airflow

Properly applied, air movement in the drying environment greatly increases the rate of evaporation. This is because it creates a blending effect, ensuring that the warm, dry air created by drying equipment (e.g., dehumidifiers) is quickly and continuously placed into contact with wet materials. It also ensures that evaporated water vapor is removed from these same surfaces.




Greater evaporation rates, like those in the initial stages of drying, require more airflow to maintain low humidity along the surface. As materials dry, less airflow is necessary because evaporation rates are slower.

Another important purpose of air movement is to create air circulation between adjacent affected areas. Without airflow, humidity and temperature would vary from one area to the next. Restorers would need to install dehumidification equipment in every affected air space within the structure. This would be impractical for most applications.

## The Psychrometric Chart

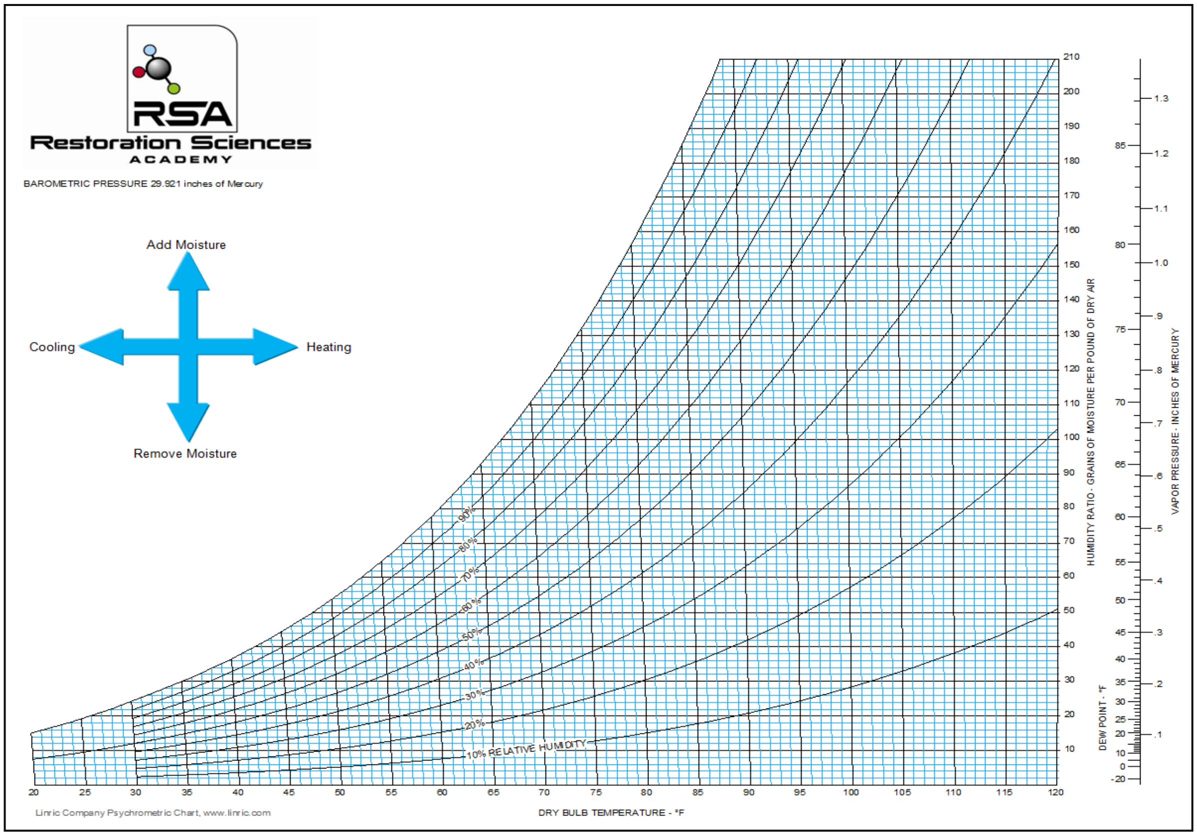
To properly evaluate temperature, relative humidity and grains per pound (or g/kg), restorers must use a psychrometric chart (see example on next page). Typically, a restorative drying technician will acquire a dry bulb temperature (either in Fahrenheit or Celsius) and a relative humidity using a thermo-hygrometer. These two readings establish the capacity of the air mass (temperature) to hold moisture and the relative amount of moisture in the air (relative humidity).

After acquiring these two readings, the technician can then employ the psychrometric chart to calculate GPP. Other calculations are also made if necessary. Once these calculations are completed, the technician compares them to surrounding conditions or previous conditions to evaluate the drying environment.

The drying environment is evaluated on the psychrometric chart in a number of ways. Using the temperature, relative humidity and GPP (g/kg), the restorer can:

- Determine if outdoor air can be used to promote drying. This is done by comparing outdoor GPP (g/kg) to indoor. Outdoor air is only used to support drying when the GPP (g/kg) outside is lower. If this is not true, then outdoor air is wetter than indoor air and is not used.
- Determine the effects of heating or cooling an air mass. This is necessary when using outdoor air. Typically, the temperature of outdoor air is manipulated (heated) as it is brought into the structure. Technicians can first calculate the outdoor GPP (g/kg), then determine the new relative humidity. When the outdoor air is heated, the GPP (g/kg) will remain the same, and relative humidity will decrease.




## Dew Point Temperature

Dew point is the temperature at which air becomes saturated with moisture and can hold no more water vapor. When air is cooled, its capacity for water vapor is reduced. Eventually, if temperature is cooled enough, the relative humidity will reach 100%, or saturation. When this occurs, the air has reached its dew point temperature.

Calculating the dew point temperature is especially important when monitoring humid air masses. Typically, the most humid air mass in a structure affected by water intrusion will be the indoor air. Restorers compare the dew point of the indoor air to surface temperatures throughout the structure. The comparison can warn of potential condensation: if surfaces are cooler than the dew point of the surrounding air, water will condense on those surfaces and possibly cause secondary damage. The comparison can also indicate a potential for evaporation: as surface temperatures are warmer than the dew point of the air, evaporation will occur at an increased rate.

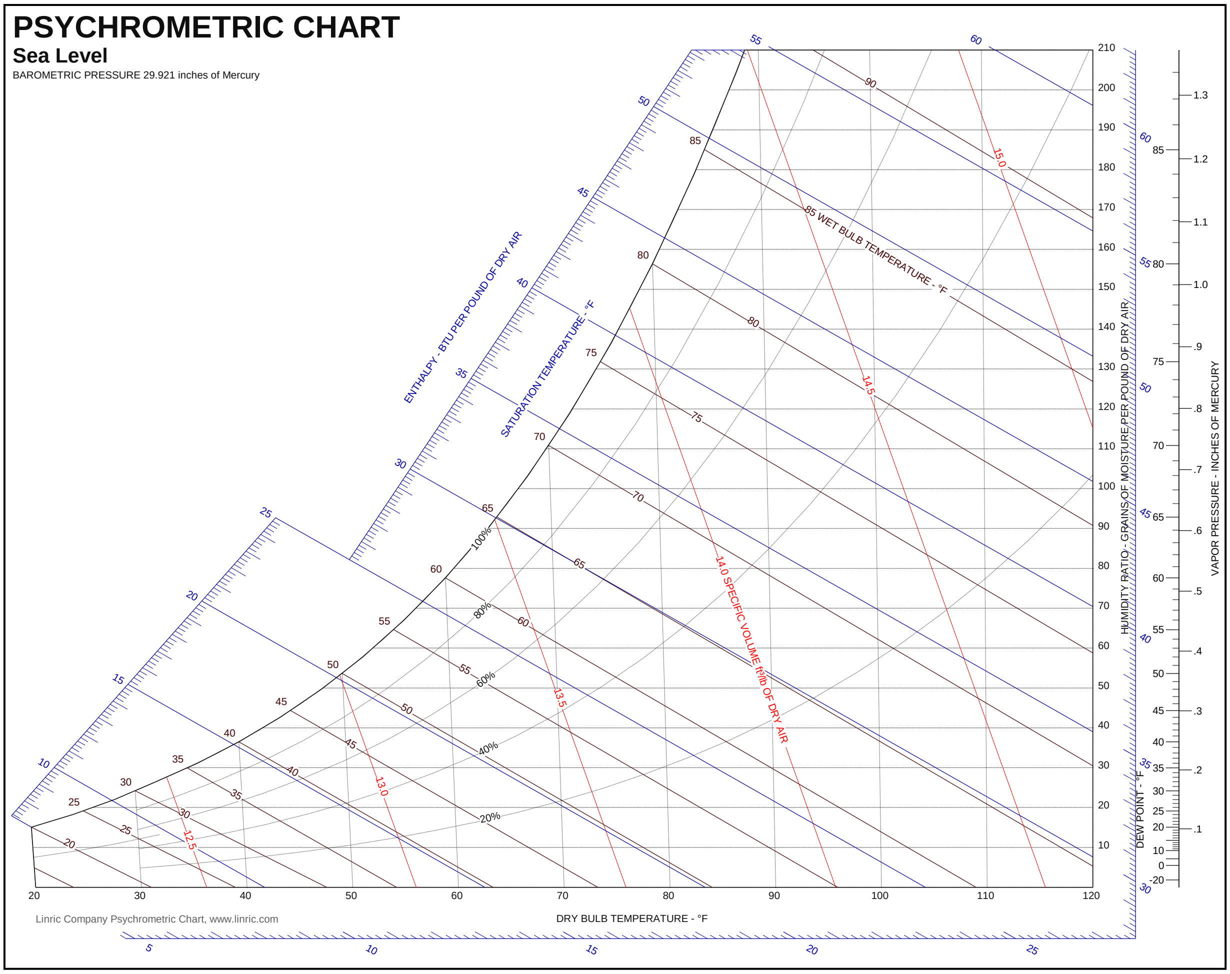
## Vapor Pressure

Vapor pressure is the force exerted by a gas on the surrounding environment or surfaces. This pressure exerted by water vapor molecules is directly related to the vapor's humidity ratio (GPP) and dew point. Vapor pressure can be calculated using the psychrometric chart in the same way that humidity ratio (GPP) is calculated. The scale for vapor pressure is immediately to the right of the scale for humidity ratio (GPP) and dew point. This is because vapor pressure, dew point and humidity ratio (GPP) are directly related to each other. The greater the weight of water vapor, the greater the vapor pressure.

Vapor pressure is the force that drives higher concentrations of humidity from one space to another — vapor pressure always seeks equilibrium. Vapor pressure is not only responsible for equilibrium between one air mass and another, but is also responsible for the rate of equalization between moisture in materials and moisture in the air.

### Additional Psychrometric Properties

An extended psychrometric chart shows additional properties of air and water vapor. These charts are typically not necessary for daily water restoration use, but can be applied in complex projects to assist the decision-making process.




**Wet Bulb and Dry Bulb Temperature** are two types of air temperatures which can be obtained using a thermometer or a thermo-hygrometer. The dry bulb temperature is simply the temperature of the air. The wet bulb temperature is the lowest temperature which a surface can achieve through evaporation. Recall that when evaporation occurs, surface temperature drops. Drier air results in a more dramatic surface temperature drop.

Restorers can apply this concept of wet and dry bulb temperatures to understand why thermal imaging cameras indicate wet materials. The wet materials are showing temperatures closer to wet bulb temperature in that environment. In environments with high relative humidity, only a small difference may exist between wet and dry bulb temperatures. This would lead to thermal imaging being virtually useless.

Another use of wet and dry bulb temperatures is as a monitoring tool. A laser thermometer can be used to evaluate materials during the latter stages of drying. When surface temperatures are the same or higher than dry bulb temperature, this indicates the materials may be dry. Follow up with moisture meter readings to document final moisture levels.

**Specific Volume** can be used when moving large amounts of warm or cool air. The restoration industry generally accepts that 14 cubic feet of air weighs one pound. The reality is that air has a different volume per pound at different temperatures and relative humidities. Air that is warmer is less dense than cold air.

Specific volume is important when analyzing performance of equipment moving large amounts of air. Examples would be large desiccant dehumidifiers, air conditioners and heating units. When airflow reaches volumes over 1,000 cubic feet per minute, determining specific volume provides a more accurate basis to show equipment performance.

**Enthalpy** tracks closely to wet bulb temperature on the chart. Enthalpy is a measurement of the energy of the air in the environment. It is measured in Btus per pound of air, and therefore relates to the specific volume of air because specific volume shows the volume of air equaling a pound.

Enthalpy is made up of two forms of energy: sensible and latent. These have been called sensible heat and latent heat. Sensible heat is the heat energy that can be felt by a person in that environment. Latent heat is the heat energy needed to suspend water in the air. Warm, dry air would therefore have a large sensible heat, with less latent heat. Cool, wet air would have a smaller sensible heat and a larger latent heat.

Enthalpy can be used to quantify energy available for evaporation. Sensible heat is the heat which affects materials in the environment. Enthalpy can also be used to understand more deeply the performance of dehumidifiers. Dehumidifier performance is greatly affected by the levels of latent and sensible heat in the environment.

## Air and Material Interactions

When air and materials interact, moisture is constantly being exchanged. Moisture is entering and leaving materials, and the air. The driving force is nature’s desire for equilibrium — which will never be reached. Besides all the properties of air previously discussed, the moisture content, temperature and permeance of materials have a dramatic effect on the rate of evaporation.

### Permeance

The ability for water vapor to move (diffuse) through a material is expressed as the material’s permeance or permeability.

Permeability factors have been established for a variety of common building materials through testing. The table outlines a list of common materials and their permeance.

| Materials | Permeance Rating (gr/h per ft$^2$ in. hg) |
|---|---|
| **Vapor Impermeable – Less than 0.1 perm** | |
| Sheet, glass fiber w/polyester resin | 0.05 perm |
| Polyethylene, 6 mil | 0.06 perm |
| **Vapor Semi-Impermeable – 0.1 perm up to 1.0 perm** | |
| Sheet, glass fiber w/acrylic | 0.12 perm |
| Exterior oil-based paint, 3 coats | 0.3 to 1.0 perm |
| Concrete, 1:2:3: mix, 8″ thick | 0.40 perm |
| Wood, 1″ sugar pine | 0.40 to 5.40 perms |
| Brick, 4″ masonry | 0.80 perm |
| **Vapor Semi-Permeable – 1.0 perm up to 10 perms** | |
| Plywood, ¼″ interior glue | 1.90 perms |
| Concrete block, hollow | 2.40 perms |
| Primer sealer, .0012″ | 6.28 perms |
| **Vapor Permeable – More than 10 perms** | |
| Carpet, commonly permeable | 10 perms and greater |
| No. 15 asphalt-saturated felt | 31 perms |
| Kraft paper, double layer | 42 perms |
| Gypsum drywall, ⅜″ | 50 perms |
| Housewrap, spunbonded olefin | 54 perms |
| Insulation, fiberglass, no paper | 116 perms |
| Air, 1″ of completely still air | 120 perms |

Materials with permeance ratings of less than 1.0 are referred to as vapor retarding materials or vapor barriers. A common vapor retarding material found in homes is vinyl wall covering. Other vapor retarding materials include vinyl sheet goods, polyethylene vapor barriers, some paints and sealers, and foil backing on insulation and wall paper. Many materials in the built environment are quite permeable. These include flat and semi-gloss paint, rebond padding under carpet, and carpeting.

Vapor retarding materials impede the drying process. Water trapped beneath and behind these materials can cause secondary damage if it is not allowed to escape in a timely fashion. These surfaces are commonly dried by injecting air into the cavity behind the vapor retardant. If drying progress is slow, the vapor retardant material must be removed.

**Vapor Diffusion** is the process by which water moves through permeable materials. Vapor diffusion is a result of differences in vapor pressure on opposing sides of a permeable material.

When vapor pressures are different, water vapor will seek equilibrium. The permeability of the material that separates the two air masses will influence the rate at which water vapor will equalize through it. The water traveling through the material will often diffuse through the material — even if cracks and crevices are not present.

**Water Activity** is a measurement of what the interaction between a material and the air will ultimately equalize at. Water activity can be measured by isolating a thermo-hygrometer on the surface of the material under plastic sheeting. Over a period of time, the micro-environment equalizes under the plastic. This indicates the moisture available at the surface of the material which may support microbial growth. The water activity is the decimal value of the relative humidity shown on the hygrometer under the plastic sheeting. (If the relative humidity is 75%, the water activity is 0.75.) A water activity of less than 0.75 limits the vast majority of microbial growth. Water activities of less than 0.60 virtually guarantee no microbial growth will occur. Materials with liquid water on the surface have a water activity of 1.0.

## Applying Psychrometry to the Drying Project

The drying process in a restoration environment is the primary tool used to prevent additional damage to wet materials. If excess water is allowed to remain in contact with materials for prolonged periods of time, several forms of damage can occur — not the least of which is microbial growth. Throughout the drying process the restorer applies psychrometry to produce the most effective drying results. Psychrometry impacts decisions about what drying system to employ, how to evaluate the effectiveness of a drying system, and how to evaluate the performance of equipment.

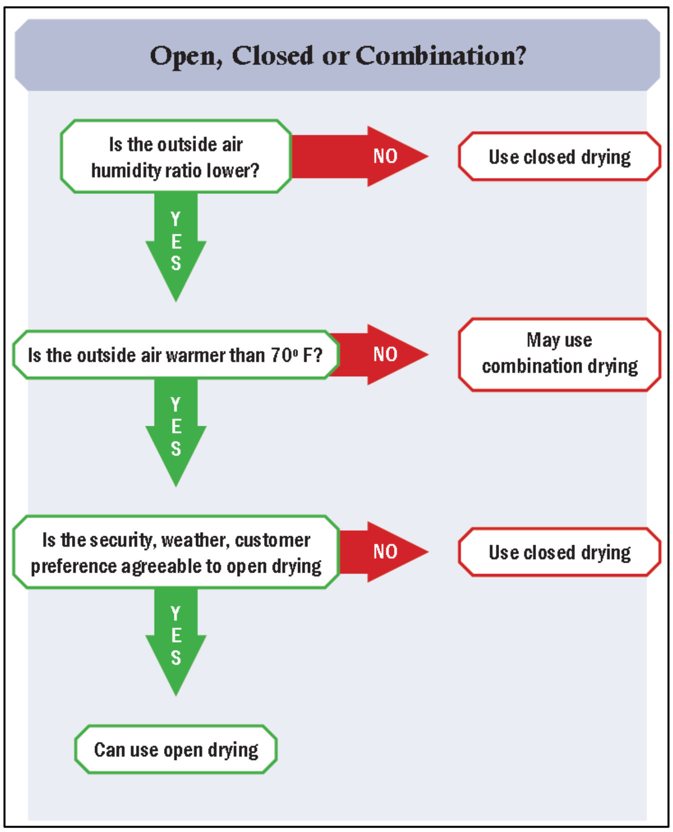
### Open, Closed, and Combination Drying Systems

Restorers have three options available to them for dehumidifying:

- Open: intentionally using outdoor air to lower indoor humidity with no mechanical dehumidification
- Closed: using mechanical dehumidification only
- Combination: using some outdoor air combined with mechanical dehumidification

Deciding which dehumidification system to use is a simple process.

1. Compare the moisture content of the indoor air and the



outside air. If the air outside is wetter (higher humidity ratio), choose a closed drying system.

2. Consider air temperature. When outside air is below 70°F (21°C), a closed system is used, or additional heat is used in conjunction with a combination drying system.
3. Consider additional factors, such as dew point, building security, changing weather, customer preference or other factors that will not allow open drying systems to be used.

Regardless of the system used, the environment is monitored frequently to ensure that the indoor humidity and temperature are helpful for evaporation. As the environment dries and as conditions change, the dehumidification system is modified as needed.

### *Implementing the Drying Systems*

**Open Drying:** When outdoor conditions are favorable for open drying systems, several options are available.

- Using ventilation fans installed in the structure.
- Opening windows wide.
- Using air movers to create pressure differentials and air exchange.
- Using heat and air exchange.

**Closed Drying:** Closed drying involves the use of mechanical dehumidification inside — while keeping the area isolated from outside air. Make sure that ventilation fans and fresh air ventilation systems are closed.

**Combination Drying:** Combination systems merge the benefits of both open and closed drying: the use of available, dry air from outside and the control offered by a closed system and mechanical dehumidification. The best choice depends on outdoor conditions. When outdoor temperatures are cold, use of outdoor air must be combined with adequate heating to maintain a warm air temperature in the area being dried.

If combination drying is determined to be appropriate, the following options are available to the restorer:

- Temporary flushing or ventilation.
- Using ventilation fans installed in the structure, or opening windows slightly, for slow, continuous ventilation.
- Using air movers to increase the indoor-outdoor air exchange. Additional heat, such as forced air heaters, is typically used with this option to heat outdoor air.

## Evaluating the Strength of a Drying System

There are several ways to evaluate a drying system. Possibly the simplest way is to make use of temperature and relative humidity readings in the affected area. Generally, warmer temperatures and lower relative humidities will be better drying conditions.

When evaluating the strength of a drying system, consider the energy available in a material for drying. Elevating the temperature of a wet material will increase the energy and, therefore, the vapor pressure associated with the moisture in the material. This is important to note, as evaporation occurs when vapor pressures in warm materials are higher than the vapor pressure in the surrounding air. High vapor pressure then "pushes" toward low vapor pressure in order to equalize. The greater the difference in vapor pressure, the greater potential there is for evaporation. This potential can be measured and evaluated in several ways.

### Surface Temperature vs Dew Point

Higher surface temperatures generally lead to faster drying. The amount of drying potential can be evaluated by comparing the surface temperature of the material to the dew point temperature of the surrounding air. If the surface temperature of the material is higher than the dew point temperature of the surrounding air, evaporation may occur. The greater the difference in these temperatures, the greater the potential for drying will be. The opposite is also true — when materials are cold, water will evaporate more slowly. If the material is cooler than the dew point of the surrounding air, condensation (the opposite of evaporation) will occur.

### Vapor Pressure Differential

As discussed earlier, the vapor pressure in air influences the direction in which water vapor will move. Pressure will always move from high to low. This pressure is calculated using a psychrometric chart. Measuring vapor pressure associated with moisture in materials, however, requires additional information.

Understanding the relationship between air vapor pressure and material vapor pressure requires knowledge of two additional terms: Equilibrium Moisture Content and Equilibrium Relative Humidity.

The amount of moisture in a material and the relative humidity of the air immediately surrounding it have a very direct relationship to each other. In fact, the relationship is so direct that the amount of moisture in a material can be measured using a hygrometer. By containing a sample of air at the surface of a material (or within the material) and allowing that air to achieve an equilibrium with the moisture content of the material itself, the relative degree of saturation can be measured. A material holding very little water compared to its "saturation" will support a very low relative humidity. Conversely, a material near saturation point will support very high relative humidity. This relationship is best understood using an Acclimatization Chart or Equilibrium Moisture

Content (EMC) chart. An EMC chart shows the relationship between moisture content and the psychrometric properties of air. Although temperature, GPP (g/kg), vapor pressure and relative humidity all have an effect on the amount of moisture in a material, relative humidity is the most closely related. An increase in relative humidity will result in an increase in moisture content.

This fact can also be stated in the reverse: An increase in moisture content will result in an increase in relative humidity, if the air at the surface of the material were allowed to acclimate with it. This relates to vapor pressure because when the humidity is measured at the surface of the material (or internally), the humidity created by the moisture level is known.

This humidity value, referred to as an Equilibrium Relative Humidity (ERH), and the surface temperature of the material can be placed on a psychrometric chart to calculate the vapor pressure of the material. Where temperature and ERH intersect, a horizontal line can be drawn to the right to calculate the material vapor pressure.

The restorer can then compare the material vapor pressure to the vapor pressure associated with the surrounding air. If the vapor pressure in the air mass is greater than the material vapor pressure, drying will not occur. Restorers have two options for solving this problem: either increase the material vapor pressure or decrease the vapor pressure of the air.

**Equilibrium Moisture Content**

| RH | 30° F | 40° F | 50° F | 60° F | 70° F | 80° F | 90°F |
|---|---|---|---|---|---|---|---|
| 20% | 4.6 | 4.6 | 4.6 | 4.6 | 4.5 | 4.4 | 4.3 |
| 30% | 6.3 | 6.3 | 6.3 | 6.2 | 6.2 | 6.1 | 5.9 |
| 40% | 7.9 | 7.9 | 7.9 | 7.8 | 7.7 | 7.6 | 7.4 |
| 50% | 9.5 | 9.5 | 9.5 | 9.4 | 9.2 | 9.1 | 8.9 |
| 60% | 11.3 | 11.3 | 11.2 | 11.1 | 11.0 | 10.8 | 10.5 |
| 70% | 13.5 | 13.5 | 13.4 | 13.3 | 13.1 | 12.9 | 12.6 |
| 80% | 16.5 | 16.5 | 16.4 | 16.2 | 16.0 | 15.7 | 15.4 |
| 90% | 21.0 | 21.0 | 20.9 | 20.7 | 20.5 | 20.2 | 19.8 |

For Oak Species Hardwood – Moisture Contents are approximate and subject to variation.

Material vapor pressure can be increased by raising the material's temperature. The effect of raising temperature is calculated using a psychrometric chart. The new, higher temperature is drawn to intersect with the ERH line obtained from the initial surface (or internal) humidity reading. This ERH does not change because it is directly related to the amount of moisture in the material. It will not decrease until the material becomes drier. The new vapor pressure is determined by drawing a horizontal line to the right where temperature and relative humidity intersect.

Decreasing the air's vapor pressure requires dehumidification. Lowering the GPP (g/kg) of the air will decrease the vapor pressure of the air because they are directly related. Traditionally, the air vapor pressure is the focus of restorative drying because lower humidity prevents many forms of secondary damage.

Vapor pressures of both materials and of air can be evaluated to maximize the rate of evaporation. If material vapor pressure is lower than air vapor pressure, drying cannot occur. This will be common when materials are cool, when trying to dry materials that are already relatively dry, or when humidity in the drying environment is relatively high.

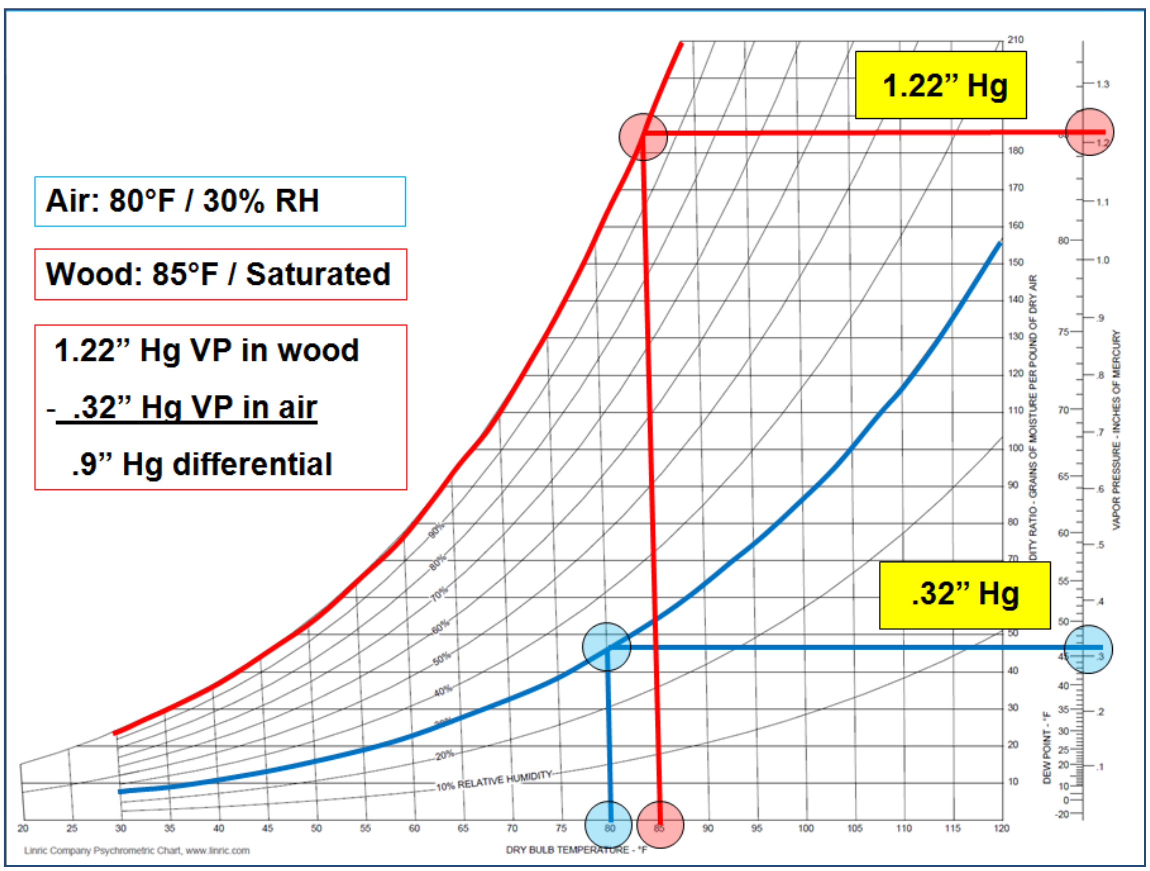
### Estimating Vapor Pressure Differentials

A simple way to estimate the vapor pressure differential between a material and the surrounding air is to assume that the material is saturated with water, instead of using a hygrometer to determine actual ERH. Plot the material's surface temperature on a psychrometric chart where it intersects the saturation line (100% in air). Plotting the surface temperature at saturation will result in a reading for material vapor pressure. Material vapor pressure would then be compared to the vapor pressure of the air to calculate a vapor pressure differential.

The psychrometric chart pictured below shows an example of estimating a vapor pressure differential. A material which is saturated and had a surface temperature of 85 F would have a vapor pressure of 1.22″ of mercury (Hg). Air in the example has a vapor pressure of 0.32″ of Hg, yielding a vapor pressure differential of 0.9″ of Hg.

This calculation is a "best case" estimate, and the actual vapor pressure differential could be significantly less. This is especially true toward the end of a drying project when materials are no longer saturated.

**Estimating a Vapor Pressure Differential**



## Evaporation versus Condensation

Restorers can utilize multiple ways to evaluate the potential for evaporation on a drying project:

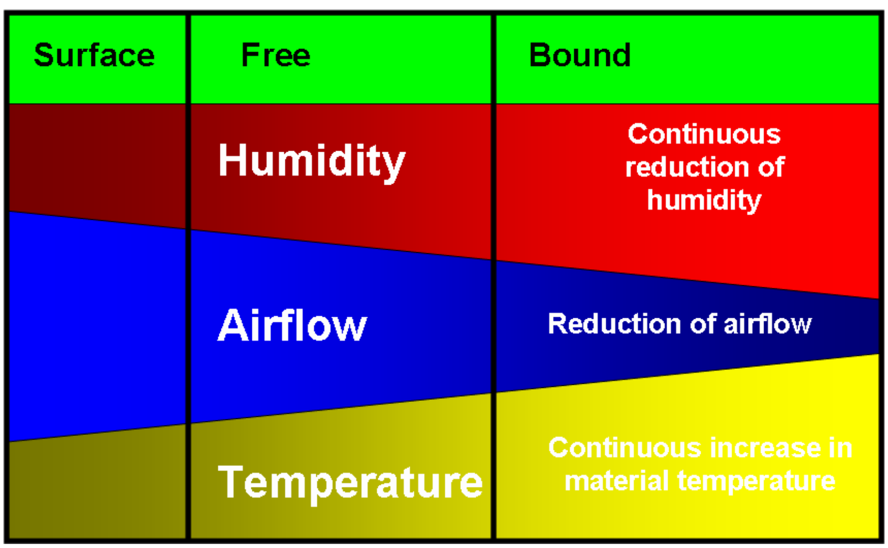
- High temperature and low relative humidity
- Surface temperature compared to dew point temperature
- Vapor pressure differentials.

Unfortunately, no one drying condition is perfect for all drying projects. Some believe that temperature alone determines whether evaporation or condensation will occur — where surfaces are cool, condensation occurs, and where surfaces are warm, evaporation occurs.

Actually, condensation and evaporation are both occurring at the same time. Any wet material is constantly changing in moisture content. The material continually loses moisture which evaporates into the surrounding air and gains moisture as water vapor condenses from the surrounding air. The water's temperature and the air's humidity are primary factors in what exactly happens. An effective drying system balances humidity control, airflow and temperature.

## Stages of Drying and the Drying Rate

Wet structural materials do not dry at a consistent rate. Rather, evaporation of moisture from materials occurs in stages, and the rate of evaporation varies from stage to stage. Each stage can be described by the evaporation rate and the form of water remaining to be evaporated.




Stage 1 is characterized by the fastest rate of evaporation. In this first stage of drying significant amounts of liquid water are present in the structure. *Surface water* from material surfaces and *free water* within materials nearest the surface are evaporating quickly. A large amount of airflow combined with moderate temperature and humidity is effective at evaporating surface water.

Stage 1 has been called the "Constant Rate" drying phase since sufficient moisture is available in wet materials to allow for constant and continuous evaporation. The restoration industry discussions about evaporation commonly refer to evaporation of water from a liquid pool, such as a swimming pool or water reservoir, and compare this to the Stage 1 Constant Rate drying phase. A direct correlation can be drawn between the humidity of air and the rate of evaporation from a liquid surface. The greater the difference in vapor pressure between the water vapor in the air and in the material, the greater the evaporation rate will be.

Evaporation = Airflow × Vapor Pressure Differential

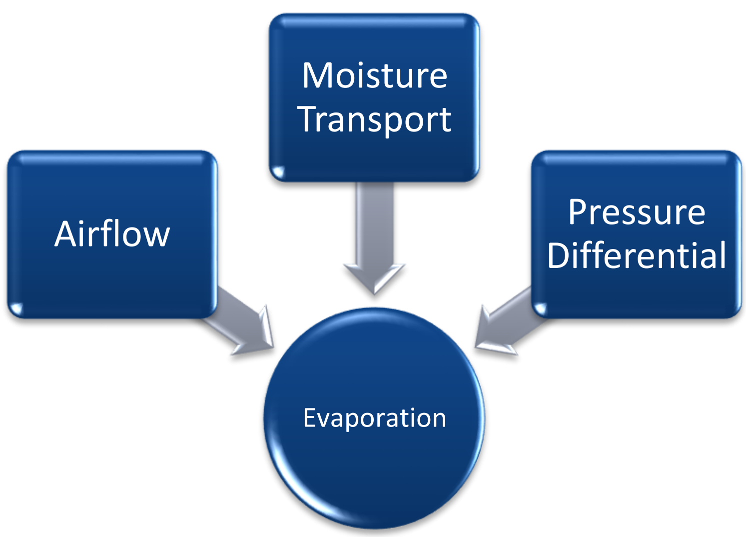
After surface water is evaporated, however, the drying process becomes much more complex. Both the Stage 2 and Stage 3 of drying are known as "Falling Rate" drying phases because the amount of moisture available for evaporation has fallen off. Once the liquid, surface water has evaporated, further evaporation occurs only as free water migrates toward the surface of materials and bound water diffuses as vapor through materials. The drying rate is now subject to a greater number of variables. These variables include the porosity and permeability of the material, the hygroscopic nature of the material, and the distribution and depth of penetration of the water.

The transition from simple to more complex evaporation — from constant rate to falling rate — typically slows the overall evaporation rate dramatically. At this point, evaporation is happening deeper in the material — not necessarily at the surface. Air speed begins to become less relevant because the air is no longer in contact with the evaporating surface. In other words, evaporation calculations can assume a near-zero velocity of air — leaving only vapor pressure differences to generate and support drying. The other variables such as permeability then become restrictions to evaporation.

Evaporation = Vapor Pressure Differential

### Changing the Drying Strategy

The relationship between the complexity of the Stage 2 and 3 drying phases and the overall drying success is not yet fully understood. Research by experts in building science and materials science continues to focus on how best to facilitate continuous evaporation. Researchers agree on the following key points:




- **Airflow:** Airflow begins to have a diminishing influence on the evaporation rate from wet building materials after the first phase of drying is complete (e.g., after the majority of surface water has evaporated).

- **Moisture Transport:** Drying rates are directly influenced by the moisture transport properties of the specific material being dried. Moisture transport properties refer to the movement of water in both a liquid and a vapor state through a material.
- **Pressure Differential:** The force that drives the drying process is an imbalance in pressure between the water within the material and the water vapor surrounding the material.

Experts generally agree that each of these factors influence drying rates. However, in the falling rate phases of the drying process, only one of these factors can be manipulated to speed drying. As materials become drier, the influence of airflow diminishes, and the influence of moisture transport is a constant (e.g., we cannot change that property without damaging the material). Only the third factor — managing pressure differentials — can be changed to speed drying.

## Managing Vapor Pressure Differentials

Managing pressure differentials means managing the difference in pressure between the wet material and the air surrounding the material. The greater the difference between these two, the faster the water will evaporate from the material. Restorers have two options for managing vapor pressure:

- **Increase the material vapor pressure** (the vapor pressure of the water in a material is made higher) — Elevating vapor pressure in a building material is actually quite simple: warm up the material. Heat adds energy to the water in the material, and the higher the temperature of water within the material, the more likely it will evaporate.
- **Decrease the vapor pressure of the air** (the vapor pressure in the surrounding air mass is made lower). — Reducing the air water vapor content through dehumidification or ventilation will lower the vapor pressure of the air in direct contact with a material, increasing the pressure differential.

During the Falling Rate drying phases, vapor pressures are a key to maintaining constant evaporation and drying progress. The aim of restoration, however, is to provide an economical and effective drying solution, so the restorer should not focus on one option over the other. Rather, the restoration approach must adapt procedures for managing pressure differentials while evaluating the potential for contamination, damage, and higher cost to the project.

### Balancing Humidity, Airflow and Temperature

In recent years the restorative drying industry has given more attention to bound water, increasing vapor pressure within building materials, and applying heat directly to materials. This attention has led to some suggesting that high temperature alone is the driving force in drying materials. Actually, in order to achieve an efficient drying environment, temperature must be balanced with humidity control and airflow. Used alone, high temperatures may lead to secondary, unintended damage.

High heat, while beneficial for evaporation, may actually lead to the creation of more liquid water. Condensation can occur in unexpected areas and may cause secondary damage during the initial stages of drying. Condensation occurs when the surface temperatures are below dew point, but dew point can be reached at high temperatures. When drying with high temperatures, the potential for secondary damage due to condensation in interstitial cavities is real.

Risks are involved in elevating vapor pressure. Creating too much vapor pressure in many building materials can cause damage. Adding heat to the water in materials does increase evaporation. However, heating all surfaces of a material evenly may reduce secondary damage. Always use caution when adding heat to materials!

## Pressurization

Pressurization of structures is useful to assist the drying process, especially when:

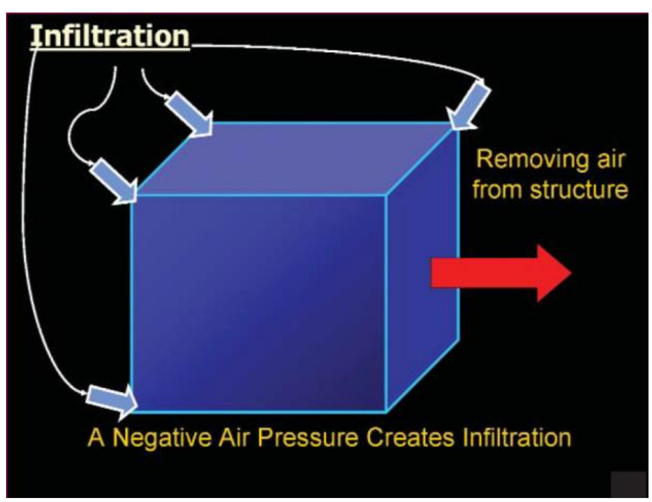
- Outside air is drier and helpful for drying materials.
- Contaminants are present in a structure. Consider the use of pressurization to control the spread of airborne contaminants. Pressures are a great ally in controlling airborne contaminants when used properly.

However, pressure differentials can lead to disaster if not used properly. Because the result of pressure differences is so dramatically advantageous or disastrous, pressures are closely monitored in a contaminated environment.

Formulate a pressurization plan that will best suit the job; then, monitor the pressure and the resulting air movement to ensure proper containment. The most critical rule that applies to air pressures is to keep the most contaminated area negatively pressurized, and the cleanest area positively pressurized.

### Negative Pressurization Causes Infiltration

Negative air pressure is created by removing any volume of air from a space. Where a negative pressure is created, air will move from neighboring spaces or from outdoors to “make up” for the air removed. The air that does enter the space will enter through cracks and crevices and will carry heat, humidity, particulate or any other airborne agent. This process is referred to as infiltration.




The desired result of the negative air pressure is that all air is entering or infiltrating into the space that is negatively pressurized. This prevents any air in this space from exiting into unaffected areas and allows for a great deal of control over any particulate or vapor in that air.

Strong negative air pressure can cause combustion appliance exhaust to back draft into the structure. This can result in a build-up of carbon monoxide in the structure, causing asphyxiation and even death.

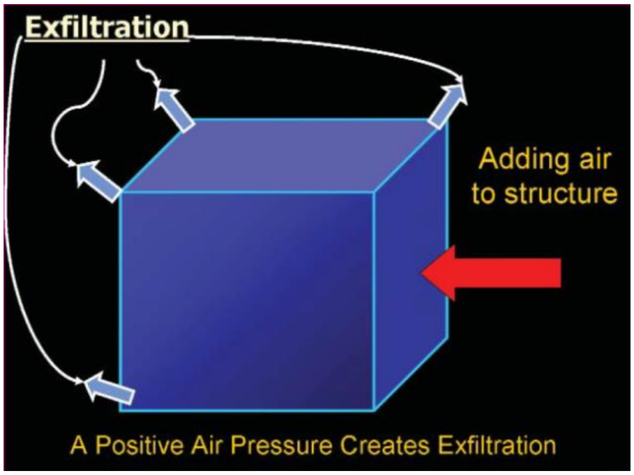
Two examples of when a negative pressure will be appropriate are:

- when drying crawlspaces or
- when drying wall cavities with suspected contamination.

Crawlspaces are commonly unclean, unsanitary environments. When dried, they are held under a negative air pressure relative to the living area of the house to prevent particulates and odors from entering the air space above.

### Positive Pressure Causes Exfiltration

Positive air pressures are created by adding air to a space. Whenever air is added to a space, an inequality is created in air pressures. This inequality will result in the exfiltration of air into neighboring air spaces. Air will exit through cracks and crevices and will carry with it any airborne particulates, odors, or vapors.



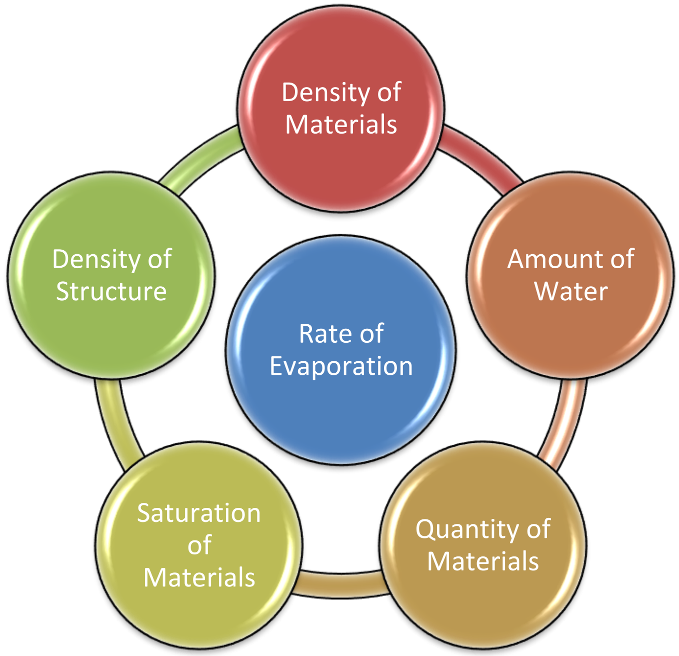

Positive pressure is used whenever a space must remain uncontaminated or dry compared to neighboring areas. However, creating a positive pressure is often quite challenging. In order to create a positively pressurized clean room, access to an unlimited supply of clean air is critical. In order to create a positively pressurized dry room, access to unlimited dry air is needed. This air is typically only available when the outdoor air is usable as clean or dry air. Positive pressures are only used when ex-filtrating air will not adversely affect unaffected areas. An example of when positive pressures are beneficial is when ex-filtration will occur through targeted materials that need to be dried, forcing warm dry air through affected interstitial cavities.

Never use positive pressures in a space that contains a known or suspected contaminant. Exfiltrating air could carry the contaminant to unaffected areas.

Desiccant dehumidifiers can create slight pressure differentials. When installed to draw in outside air through the process intake, *positive pressure* is created in the affected area. When installed to exhaust reactivation air out of the area, *negative pressure* is created in the affected area.

Restorative drying contractors who use the most efficient drying systems will succeed because they save money for their customers, make money from their efforts, and reduce liability on every drying job. The best professionals manipulate and control as many factors as possible in their drying system to finish each job as efficiently as possible.




## Classes of Water: Rate of Evaporation

A tool used to determine equipment needs is water classification. Classes of water describe the potential rate of evaporation based upon the amount of wet surface areas and the porosity of materials affected. Equipment types and quantities are then determined based upon the initial estimated humidity load defined by each class.

### Class 1

With a Class 1 water intrusion, evaporation will progress at a slow rate because there is minimal water present in the structure. Class 1 intrusions have the least amount of water absorption, with less than 5% of the area surfaces (floors, walls, and ceilings) being wet porous materials. Class 1 may involve low evaporation materials (concrete, plaster, masonry) that are only lightly affected and have absorbed minimum moisture. Some examples of common Class 1 water intrusions are

- A concrete basement floor that only absorbed a small amount of water.
- Low porosity materials (such as plywood, concrete and structural lumber) that absorbed minimal moisture.
- Little or no wet carpet or cushion (padding) remains.
- Losses where carpet and underlay have been removed and there is no wet gypsum wallboard and a small amount of water is absorbed by remaining materials.

### Class 2


With a Class 2 water intrusion, evaporation will progress at a significant rate. Class 2 water intrusions affect porous materials in more than 5%, and possibly as much as 40%, of the area surfaces (floors, walls, and ceilings). Wet porous materials have absorbed a significant amount of moisture; however, low evaporation materials have only absorbed minimum moisture. Some examples of common Class 2 intrusions are:

- A loss that includes wet carpet, cushion and water wicking up gypsum wallboard.
- A structure that was affected by Category 2 water and where the underlay was removed, but wet carpet, drywall and structural materials remain.
- Structures with no wicking on walls but where the carpet and underlay are being dried in-place.

### Class 3

With a Class 3 water intrusion, more water is present than with any other class; evaporation progresses at the fastest rate. Class 3 water intrusions involve the greatest amount of water absorbed by materials with more than 40% of the area surfaces (floors, walls, and ceilings) being wet porous materials. Low evaporation materials have absorbed minimum moisture. Some examples of Class 3 losses include:

- Second floor water supply failure saturates entire areas below with large amounts of water (second floor could be Class 1 or 2 while the main floor would be Class 3).
- Overhead water supply pipes malfunction, affecting entire areas with large amounts of water.
- Entire areas of carpet and underlay are wet, together with wet walls, structure and insulation (moisture wicking up or water coming down from above).

### Class 4

A Class 4 water intrusion results in a specialty drying situation. Typically, wet materials present in a Class 4 situation require a longer time to dry. Water has saturated deeply into the materials and is held or trapped as bound water. This excess water is bound to other molecules and must be freed (evaporated) before the water vapor can move toward the surface (and eventually into the surrounding air mass). Evaporation occurs at a slow rate. Low evaporation materials and building assemblies having significant absorption are common to Class 4 intrusions and include hardwood, plaster, brick, deeply saturated concrete, deeply saturated ground soil and stone.

- Plaster and lath walls that are deeply saturated.
- Hardwood floors in residential construction.
- Very old construction with multiple layers of building materials.
- Gymnasium, concrete or dirt floors.

Use of desiccant and/or LGR dehumidification is necessary in Class 4 situations, and larger vapor pressure differentials will be needed for successful drying.

## Drying Equipment

### Equipment Safety

Safety is a primary concern on all restorative drying jobs. Equipment left at the site may produce safety concerns, and company liability must be limited as much as practical and reasonable. Equipment is made safer by following some simple steps:

- Check power cords to ensure they have a grounded electrical plug and are free of cuts and frays.
- Drawing too much power through a circuit or a lightweight extension cord is a serious fire or shock hazard. The National Electric Code (NEC) states that no more than 80% of the amperage available on a circuit can ever be used continuously.
    - When the NEC is applied to 15 and 20 amp circuits, these circuits are used at no more than 12 and 16 amps, respectively.
    - Add up the amperage of all equipment on a single circuit to determine how much can be safely placed on the circuit.
- Outlets on dehumidifiers must not be directed toward furnishings or structure items, as over drying may occur.
- Always plug equipment into Ground Fault Circuit Interrupters (GFCI) or a residual current device.
- Use only equipment that is safety certified (UL, ETL, CE, CSA, C-UL Listed).

- Restorers must maintain their safety certified equipment properly. This includes replacing cords that are damaged and replacing damaged inlet and outlet screens. All safety compromised equipment must be taken out of service until proper repairs are made.

## Air Movers

Of all the tools used in structural drying, air movers are the greatest in number. Regardless of design, the function of the air mover is quite simple: it is the tool designed to blend the air at the surface of wet materials with other air in the affected structure. By doing so, the air mover helps accelerate the rate at which warm air heats surfaces.

Some of the many factors that influence evaporation rates can be influenced or manipulated by the restorer, while others are almost completely out of a restorer's control. Air movement is one influence on evaporation that we can indeed control. First, however, we must understand air moving equipment and the role air movement plays in the evaporation process.

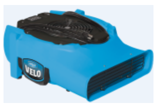
### Air Mover Types and Specifications

Different drying situations require different amounts of airflow and pressure. Power at the job site can often be limited, and temperature cannot be allowed to increase uncontrolled. Because of the variety of situations encountered in restorative drying, a range of air mover types have been developed to suit these individual needs.

Air movers are compared in several ways:

- **Amp draw:** The amount of power the unit uses.
- **Volume:** measured in cubic feet per minute (CFM). This measurement is useful when describing how much air is flowing through an air mover or other device. The CFM will be reduced when the blower encounters resistance like ducting or pulling air out of a cavity.
- **Velocity:** measured in feet per minute (FPM). The speed of the air as it exits the air mover. Faster airflow translates into more removal of a boundary layer.
- **Static pressure:** measured in inches of water column. Static pressure is needed from an air mover when attempting to force air through ducting, or pull air through resistance.

| | |
|---|---|
|  | *Carpet dryers* (high velocity air movers) are the most common type of air mover. They have good velocity and airflow, use 4–5 amps of electricity and have enough pressure to blow air into cavities or float carpet. |
|  | *Low profile centrifugal air movers* provide high velocity air movement from a small-sized unit (half the height of carpet dryers and shorter in length). They use low amps (1.2–1.9 amps), but still deliver a broad-path airflow for drying across surfaces. The small unit is very portable. |
|  | *Low pressure axial air movers* are specialized air movers used to move large volumes of air with low amp draw. They are used most often during in-place drying. They use very low amps (1.5–3.0 amps) and produce significantly more volume of airflow than carpet dryers. However, axial air movers produce little or no pressure, so they cannot be used for ducting air. |
|  | *High Pressure (HP) carpet dryers* are specialized carpet dryers, fitted with a higher horsepower motor. They are best used for powering vent/manifold systems or floating large areas of carpet. They use much more power (10–12 amps) than standard carpet dryers. |
|  | *High pressure axial air movers,* commonly called ventilation fans, are used to move large volumes of air through ductwork. These can be used with several venting systems to dry cavities, but are most often used for producing large positive or negative pressures. |
|  | *Inter-air drying systems* are used to dry cavities such as under cabinets, wall cavities and under hardwood floors. They have high static pressure and low airflow. |

## Role of Air Movement for Evaporation

Two aspects of air movement influence evaporation of moisture from materials:

- **Velocity** — The speed of the air moving across surfaces.
- **Volume** — The quantity or amount of air moving during a period of time.

Velocity is a multiplier in the evaporation process, multiplying the rate that evaporation occurs. The velocity of airflow is comparable to wind speed. Higher wind speed will result in higher evaporation rates. Likewise, the faster the velocity of air moving over a wet surface, the better the rate of evaporation will be. Velocity is measured in feet per second (FPS), feet per minute (FPM), or miles per hour (MPH), and can be determined using an anemometer.

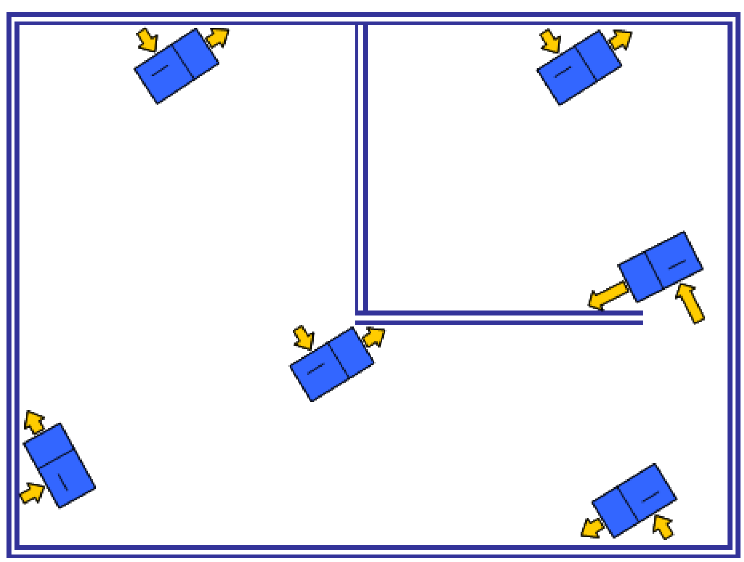
Volume is critical to the circulation of air. Airflow used for drying must have high wind speed, but that wind must be dry air. The source of dry air usually is a mechanical dehumidifier, though it could also be the outdoor environment. Regardless of the source, the dry air must be distributed or circulated throughout the affected area, much like the heated or cooled air from a home air handling system must be distributed throughout.

Moving air from one location to another is a product of mass, or volume, and is usually expressed in Cubic Feet per Minute (CFM). We measure air movers in terms of CFM to indicate how much air the air mover is able to move around.

Restorers can better control air movement when they understand the roles of air volume and air velocity. Volume is not velocity. Adequate velocity is critical for increasing the rate of evaporation. Adequate volume is important when trying to circulate warm, dry air throughout especially large and complex structures.

## Installation of Air Movers

Air movers are placed in the environment to ensure rapid evaporation across all affected surfaces. The number of air movers necessary depends upon the number of wet surfaces, the amount of water present, and the ability for air to reach each wet material (e.g., wall cavities, behind cabinets, under contents).



The IICRC S500 Standard offers a recommendation for air mover installation quantities based on the amount of wet surface area in affected spaces.

For the initial phase of drying, air movers should produce continuous airflow across affected material surfaces. A step-by-step process for determining the proper number of air movers is:

- Place one air mover for each affected area.
- Add one air mover for every 50 to 70 sq. ft. (4.6–6.5 sq. m.) of affected floor area.
- Add one air mover for every 100 to 150 sq. ft. (9.3–13.9 sq. m.) of affected wall surfaces (above 2 feet) and ceiling surfaces.
- Add one air mover for every room offset or inset greater than 18 inches (45.7 cm).

This calculation should provide an appropriate amount of air movement for most water intrusions. In situations where limited flooring surface is affected and the primary wet areas are lower walls, a different calculation is applied. If water has migrated less than 2 feet into the room's floor area:

- Add one air mover for every 14 linear ft. (4.3 m) of affected perimeter of walls.

This calculation is not intended to be combined with the step-by-step calculation above. Restoration professionals should use professional judgment when determining air mover quantities. Adjustments may be needed to ensure airflow circulates throughout the affected area and direct airflow covers affected open areas as well as the lower portions of affected walls.

Once the number of air movers to be installed has been determined, several factors will influence their actual placement. These factors include: the type of material affected, the degree of saturation, the accessibility of the actual wet surface, power availability and equipment availability. Below are some general guidelines for installation of air movers:

- Air movers are directed toward the wall at a 5° to 45° angle, depending upon the type of air mover.
- The air mover's snout will almost touch the wall, which means within 1″ (2.5 cm) of the wall but not rubbing it.
- All air movers in each area will face the same direction to ensure that air movers are not pushing against each other.
- When placing air movers, consider the need for circulation throughout the affected area and also velocity across the wet materials.
- Specialty air movers may be necessary if building cavities require airflow.

### Air Mover Applications

The restorer can take several steps to preserve and protect the environment while increasing air mover effectiveness:

- When drying wall cavities using high pressure air movers or inter-air drying systems, increase the number of holes or injectors per cavity if additional airflow is required. Make these holes below the baseboard line, if possible, to reduce repairs.
- To speed evaporation inside a wall cavity, blow dehumidified or heated air into it through the air mover. This setup increases the potential rate of evaporation by increasing the temperature of the materials. The effect is an increase in the vapor pressure differential between the wet materials and the air.

  The dehumidifier exhaust CFM and air mover CFM will be different. Therefore, do not connect the outlet and inlet of the two machines directly with ducting. Either duct the dehumidifier to the inlet of the air mover (stopping the ducting at the air mover inlet) or simply place the dehumidifier output near the air capture zone of the air mover.

- If inter-air drying systems are used on negative pressure ("vacuum mode") and you have a concern of spreading contamination, ensure that the air output of the air mover is HEPA filtered. To do so, duct the output of the inter-air dryer into a HEPA filtration device.
- Follow manufacturer's directions to decontaminate the equipment properly.

- Use high pressure axial fans in tandem to control air pressure. For example, if negative pressure is needed in an area, but the duct length is long, simply place a second air mover in line to continue moving air over long distances. This can be particularly useful when ventilating spaces in large structures and large basements with no immediate outdoor access.
- If air movers or other equipment are used in a crawlspace, the overall pressure in the crawlspace should be neutral or negative to prevent cross-contamination into the living areas. Positive pressures can force air from the crawlspace to enter the living space.

## Air Mover Adjustments

Restorers can consider adjusting the quantity and positioning of air movers as a drying project progresses. With current practices, many restorers are possibly not placing enough airflow at the beginning of a project and, on the same loss, may have too much airflow at the end of the project.

Airflow is one aspect of the drying pie, together with low humidity and adequate temperature (in the air and in the affected materials). All three aspects must be managed to promote rapid evaporation and vapor pressure differentials between the wet materials and the air.

Air movers are especially needed at the beginning of the water project when evaporation is occurring most rapidly. Materials that absorb water quickly (i.e., carpet, pad, drywall) also release that water quickly. During this "Constant Rate" Stage 1 phase of drying, airspeed is critical for evaporating surface water. More airflow (rather than less) is better for promoting continuous evaporation.

As the project progresses, however, the need for rapid airflow decreases. After surface water has evaporated, a much slower rate of evaporation occurs during the "Falling Rate" Stage 2 and Stage 3 phases. Airflow is no longer multiplying the evaporation of moisture. The airflow can be reduced to one air mover per room or area (approximately every 100 to 150 sq. ft. of wet surfaces). This small amount of airflow is needed for circulation in the drying environment.

### *How Much Airflow Is Needed?*

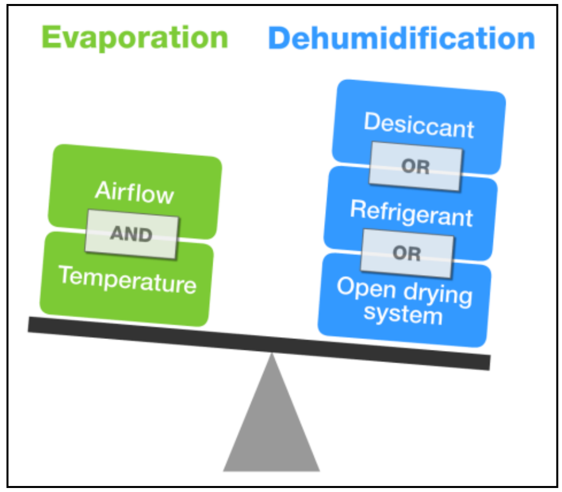
Much research concerning airflow and drying has been completed on industrial wood products as well as on food products. The science from these industries relates to the water damage restoration industry since wood and food products are hygroscopic, just like many components of wet structures. The research says that more airflow is needed at the beginning of the process and less is needed at the end. The studies also suggest how much airflow is effective:

- During the Stage 1 (Constant Rate) period most studies specified airflow rates between 600 to 700 feet per minute (6.8 – 8.0 mph).
- During the Stage 2 and 3 (Falling Rate) period all studies specified airflow rates between 100 to 250 feet per minute (1.1 – 2.8 mph).

These recommendations are useful to water damage restorers for installing an appropriate amount of airflow to start a project, and also for reducing airflow once they determine surface water is no longer present.

## Dehumidifiers

Dehumidification reduces the moisture content of the air. Dehumidifiers balance the drying system by removing the moisture that air movers sweep away from wet materials. This balanced drying system is achieved when the rate of dehumidification is greater than or equal to the rate of evaporation.



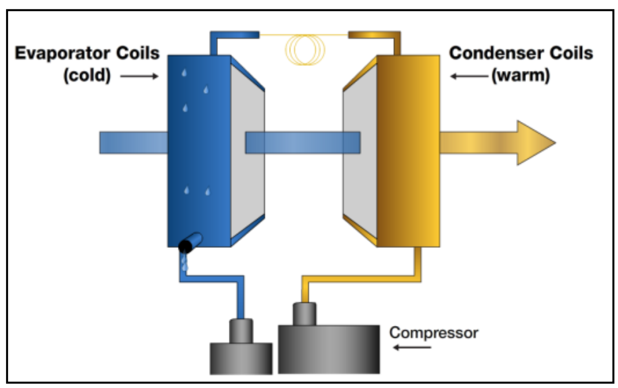

Restoration technicians must understand how many dehumidifiers to place and which type of dehumidifier is best suited to the situation at hand in order to keep the drying system balanced. If the rate of evaporation is allowed to exceed the rate of dehumidification, secondary damage can occur.

## Principles of Refrigerant Dehumidifier Operation

A number of technologies are available for mechanical dehumidification, and in addition, some specialized systems provide dehumidification by exchanging wet indoor air with air outside the structure. Each of these systems fills a specific need for the professional restorer.

Refrigerant dehumidifiers — both Conventional and Low Grain Refrigerants — are manufactured with a few key components:

- The cold coil (also known as the evaporator coil) is where the water from the air condenses. The cold coil is typically 20° to 30° F below the dew point temperature of the ambient air.
- The hot coil (also known as the condenser coil) is where the dehumidifier purges waste heat, which makes the air exiting the dehumidifier thirstier.




- The compressor is used to pressurize the refrigerant into the hot coil and pull refrigerant from the cold coil.
- The capillary tube connects the cold and hot coil and maintains the pressure difference between the two coils.
- Electronics control the defrost sensors, timers and other options.
- The defrost mechanism melts ice off the coils when the cold coil gets below 32° F (0° C).

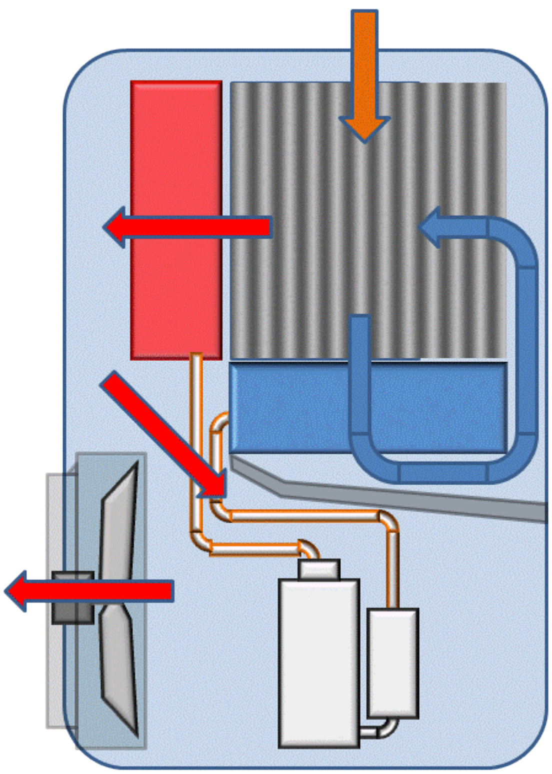
***Conventional Refrigerant***

Conventional refrigerant dehumidifiers are the most basic portable dehumidifiers in the restoration industry. They remove water from the air through condensation. Because of this fact, they are more efficient in higher humidity conditions. Refrigerant dehumidifiers work best between 70° and 90° F (21°–32° C).


Conventional refrigerant dehumidifiers work by pulling air across a cold coil. As air moves across surface of the coil, the air temperature drops below the dew point. When the air is cooled below dew point, the water vapor changes into a liquid state and is deposited on the coil.

Conventional refrigerant dehumidifiers operating in ideal conditions are effective in lowering high humidity to a safe level of approximately 40% relative humidity, or about 55 GPP. They are not capable of reducing the humidity adequately in Class 4 losses, which involve large amounts of bound water. They simply cannot get the air in the drying environment dry enough to "pull" enough moisture from saturated materials. For this type of loss, restorers must turn to another type of dehumidification technology: Low Grain Refrigerants (LGRs).

***Low Grain Refrigerant***



LGRs are more energy efficient than other dehumidifiers in most drying situations. They work well in high humidity and also work efficiently in drier conditions. LGRs will produce lower GPP, and therefore lower vapor pressures, than conventional refrigerant dehumidifiers. LGRs will continue to remove water vapor down to 34 GPP, depending on conditions. They work in conditions that will render conventional refrigerant dehumidifiers ineffective.

An LGR achieves this higher efficiency by incorporating a pre-cooling device (or other technology), which supplies the unit with cooler air to process. The supplemental pre-coolers used do not require electricity, and they make it easier for the cold coil to remove water from the air. This results in a much broader operating range for temperature and humidity, and dramatically increased water removal while using less power.

In many ways, LGRs are similar to conventional refrigerants. For instance, many LGRs also work most efficiently in conditions of 70° to 90°F (21°–32° C). In other ways, LGRs are very different from conventional refrigerant dehumidifiers. Because of the pre-cooling effect of the supplemental components, their energy efficiency, water removal potential and low humidity performance are much greater. For these reasons, LGRs are the best choice for most drying situations.

High temperature LGRs are also available which continue to work above 90° F (32°C) and will continue to have significant performance up to 125° F (51° C). These dehumidifiers utilize several different methods to achieve performance in hotter conditions; follow manufacturer directions to ensure the unit is set up properly. While high temperature LGRs are able to continue working in temperatures above 90° F (32°C), be aware that their performance improves when used in environments between 70° to 90°F (21°–32°C).


**Pre-cooling Systems in LGRs**

The factor that has the greatest effect on dehumidifier performance is the difference between the dew point of the intake air and the temperature of the intake air. This factor indicates how much work the dehumidifier has to do to remove water. When the air coming into a dehumidifier is closer to dew point, the cold coils do not have to cool the air as much to reach dew point and remove moisture. The greater the difference between ambient temperature and dew point temperature, the harder the dehumidifier must work and the smaller the amount of water vapor that will be removed.

A low-grain refrigerant overcomes this problem by adding additional cooling power to the system. Pre-cooling applies thermodynamics to cool the incoming air even more. LGRs pre-cool the air though one of three types of pre-cooling systems:

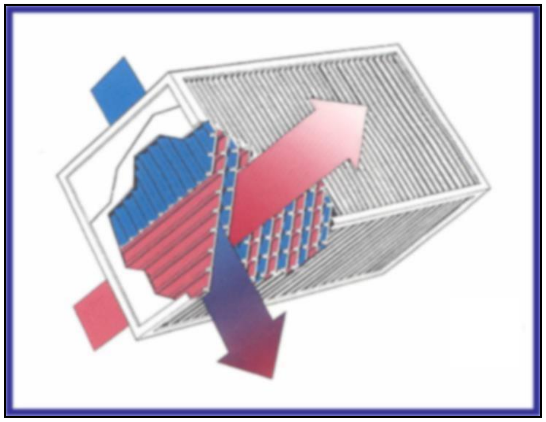
- Heat pipe
- Thermal siphon
- Air-to-air heat exchanger

The **heat pipe** is a looped system of coils that surrounds the cold coil. Refrigerant within the pipe collects heat from the incoming air, so the refrigerant heats and evaporates. The heated, evaporated refrigerant is transferred to the back side of the cold coil where it is cooled and condensed. This cooled refrigerant is then transferred to the front of the coil. This cycle repeats over and over, continually supplying cooled refrigerant to the front of the cold coil and pre-cooling the incoming air.

A **thermal siphon** is a similar technology to the heat pipe, but is designed to work with a “stacked” hot and cold coil and fits into a much smaller dehumidifier chassis.

An **air-to-air heat exchanger** is a plate-type air to air exchanger, made of corrugated plastic or aluminum, which places warm incoming air immediately beside the cooled air that is leaving the cold coil. This results in the removal of heat from the incoming air, which is then transferred to the air entering the hot coil.



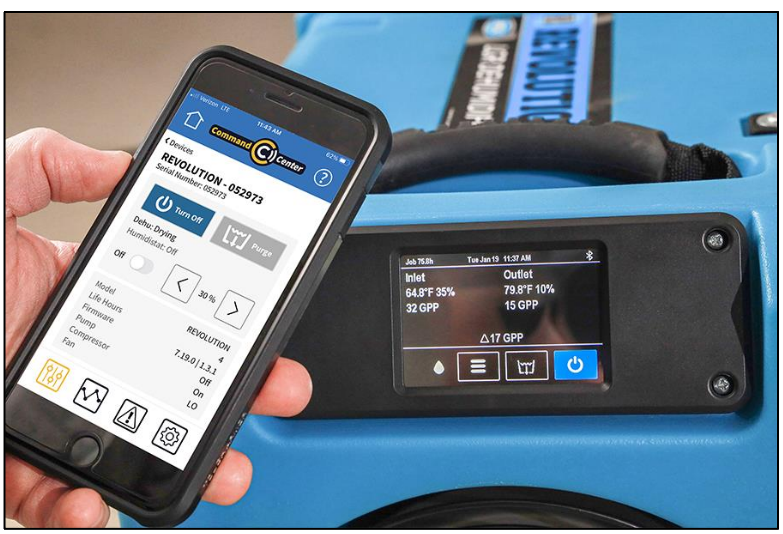
The heat pipe and air-to-air heat exchange systems work effectively. Both, however, require extra space (and weight) as well as more materials in the manufacturing process. Some of these materials, such as copper and aluminum, are quite expensive. Continued development in dehumidifier design has some manufacturers looking at ways to eliminate this cost, and achieve LGR performance characteristics at a lower material cost.

### Increasing LGR Performance

Restorers can improve the performance of refrigerant dehumidifiers through procedures that relate to coil conditions.

**Cooler Air** — In a hot structure, provide the dehumidifier with cooler air to the coils. This can be achieved by placing the dehumidifier intake near an air conditioner output. If the HVAC system has ceiling diffusers, duct the air conditioner output into the intake of the dehumidifier.

**Clean Coils** — An LGR unit may not perform as expected because the dehumidifier coils are not clean. Dehumidifier coils work on the principle of energy exchange. The copper tubes and aluminum fins exchange energy with the air flowing through the system. During operation, a dehumidifier is exposed to large amounts of dust and other contaminants. If filters are not properly maintained, the amount of contamination deposited on the coils increases exponentially and the coils are soon covered with a thick layer of gunk. This gunk acts as an insulator between the air and the coils, also restricting airflow through the coils. Both factors will considerably reduce the heat-transfer capabilities of the coils.




Cleaning the coils of a dehumidifier is a simple process and should be performed regularly as specified by the manufacturer of the machine. Look in the user guide for directions.

### Defrost Controls on LGRs and Conventional Refrigerants

Both conventional and low grain refrigerants require a defrost control mechanism. When air entering the refrigerant dehumidifier is very dry (has a low dew point), the refrigerant system will run cooler.

Eventually the system literally freezes up. The incoming air is very dry and provides too little energy. Less energy is absorbed by the refrigerant system, and the temperature on the coil eventually reaches the freezing point. Ice on the coil will greatly reduce the dehumidifier's performance. To counter this problem, most dehumidifiers are equipped with an automatic defrost cycle that turns off the cooling process long enough to let the ice melt.

There are two main types of defrost control systems:

*Time temperature defrost* systems turn off the compressor and keep the blower running, pulling air across the frost and melting it over time. Dehumidifiers with time temperature defrost systems will work down to 55°F (13°C). At colder temperatures, these defrost systems are not able to defrost effectively.

*Hot gas bypass* defrosts use the refrigerant in the "hot coil" to quickly melt the ice, dumping it into the cold coil through a bypass valve. Dehumidifiers equipped with hot gas bypass defrost systems can operate in very cold conditions — as low as 33°F (0.6°C).

### Desiccant Dehumidifiers

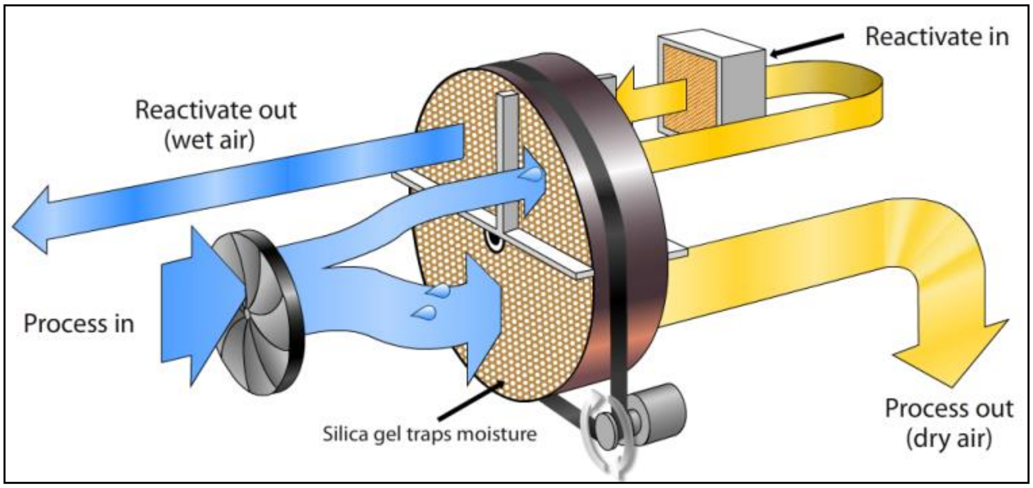

Desiccant dehumidifiers utilize chemical attraction instead of condensation to remove water from the air. Because they do not use condensation, they are not limited by low dew point temperatures, and when used properly, they produce the lowest vapor pressure of any dehumidifier. Portable desiccant dehumidifiers work best in cool and/or dry environments. The cooler and drier the air going into the desiccant, the drier the air will be coming out.

Desiccant dehumidifiers contain the following key components:

- A desiccant wheel with a grid of small air passages, similar to a large bundle of coffee straws, is impregnated with silica gel (the same silica that is used in the packets that keep shoes dry). The desiccant wheel rotates slowly through the different airflow zones of the desiccant, as it works to remove moisture. The size of this rotor and the speed at which it rotates varies, depending on the unit's specifications for target humidity and air volume. Most of the cost of desiccant dehumidifiers is in the desiccant wheel.
- The blower on a desiccant moves the air through the desiccant wheel. Most portable desiccant dehumidifiers use a single blower. Normally, 75% of the air is dried and sent through the wheel, exiting the unit as warm, dry process air. The remaining 25% of the air is used to remove moisture from the wheel, exiting the unit as warm, wet reactivation air.

- A heater boosts the temperature of this reactivation air, so that it can drive out the moisture that has collected on the desiccant rotor. Hot air removes moisture from the silica by adding enough energy to the water molecules to overcome the chemical attraction they have to the desiccant media (e.g., silica gel). This function of a desiccant dehumidifier requires a high level of power consumption.
- Electronics include switches, sensors and a small motor that rotates the desiccant wheel and controls the unit's operation.



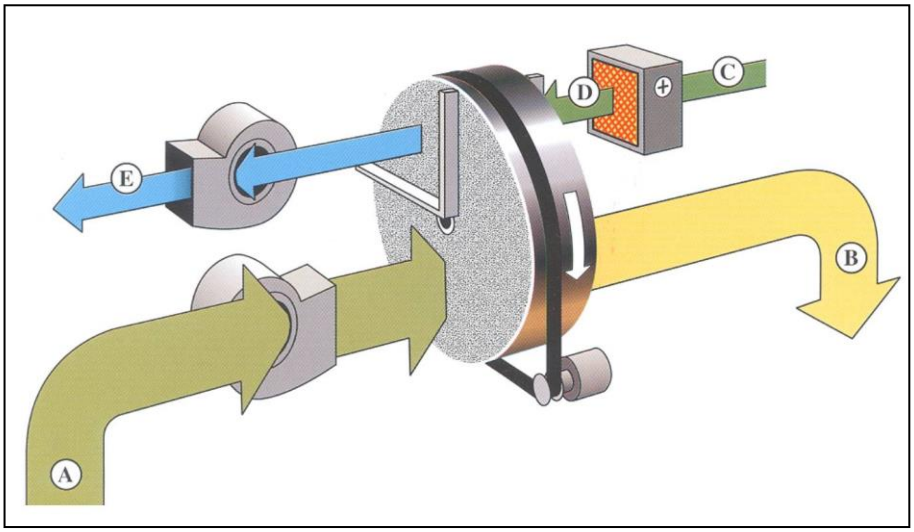

*Airflow diagram of a "three-hole" desiccant. This type of desiccant will always cause a pressure differential in the environment.*

- Outlets and inlets are necessary to control the desiccant's airstreams.
  - Process air inlet — where 75–100% of the unit's airflow enters and typically contains a filter. Provide cool, dry air for best performance.
  - Process air outlet — where 75% of the air that entered the process inlet is returned as warm, dry, processed air for drying.
  - Reactivation air outlet — where 25% of the process inlet air or separate intake is exhausted as extremely warm, humid air. This air is normally exhausted outside of the building.
  - Reactivation air inlet — Some desiccants have a fourth opening as a separate intake for the reactivation air.

Desiccants are commonly used to dry dense materials (hardwood floors, plaster and lath walls, etc.) due to the large vapor pressure differentials they can create between the surface and the air. Desiccants excel at large loss drying, because they can be made in virtually any size.

Desiccants do not collect water in a pan for automatic pump-out. Instead, they produce damp reactivation air, which must be vented outside the structure using temporary ducting. This venting often results in a pressure differential in the drying environment. The dry "process air" is ducted into the affected area.

Desiccant dehumidifiers range in size and configuration dramatically. Desiccants used in restorative drying can be as small as a roll-on suitcase or as large as two semi tractor-trailers. Large desiccants are often self-contained dehumidification systems, utilizing onboard generators and running on propane or diesel fuel. When large catastrophic events occur, such as hurricanes, large desiccants can provide a means of dehumidification when little or no power is available.




A Process Air In

B Process Air Out

C Reactivation Air In

D Heated Reactivation Air

E Reactivation Air Out

*Airflow diagram of a "four-hole" desiccant. Depending on the installation in the structure, a four-hole desiccant may or may not create a pressure differential.*

### *Using Desiccant Dehumidifiers Properly*

A desiccant's efficiency can be increased by maximizing airflow and providing appropriate temperature and humidity. Some of the ways that performance can be enhanced with a desiccant are highlighted below:

- Keep the reactivation air duct as short as possible. Long ducting will restrict airflow through the reactivation chamber and will inhibit water removal from the rotor. Long duct runs also can cause the reactivation air to cool below dew point and fill the duct with water. This can cause damage to the dehumidifier and the structure.
- Duct the process air inlet from the coolest, driest air available at the job site — whether from outside air, cold air from the air conditioner, or air from the unaffected area. Cold air enhances desiccant performance for two reasons:
    - Cold air is normally drier air, and the drier the process air going into a desiccant, the drier the process air coming out.
    - The rotor is dried using very high temperatures and must be cooled after reactivation, as a hot rotor will not collect water vapor. The process inlet air is used to cool the rotor, and the cooler this air, the faster the rotor will return to operable temperature.

- In cases where the desiccant is too far from a window or exit, duct the warm, wet air into a refrigerant dehumidifier. The refrigerant can easily collect much of the moisture from this warm, wet air.

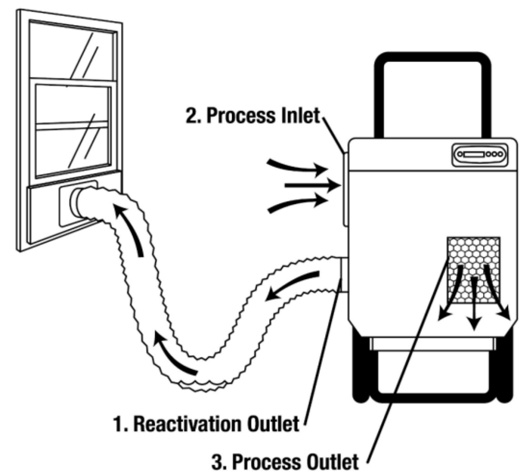
### *Four Ways to Install a Desiccant Dehumidifier (Three Hole)*

#### Dehumidifier Placed Inside the Affected Area

Used when a desiccant dehumidifier will fit in the affected area.

***Recirculate*** affected air when it is drier and cooler than unaffected areas. Duct *reactivation outlet* out of the structure.

***Exchange*** the affected air when unaffected or outside air is cooler and drier. Duct *process air inlet* from outside. Duct *reactivation air outlet* out of the structure.



Inside Recirculation Desiccant Setup

#### Dehumidifier Placed Outside the Affected Area

Used when the drying environment is small or inaccessible, or when a large desiccant is in use.

***Recirculate*** affected air when it is drier and cooler than unaffected areas. Duct *process inlet* from affected area. Duct *process outlet* into the affected area.

***Exchange*** the affected air when unaffected or outside air is cooler and drier. Duct *process outlet* into the affected area.

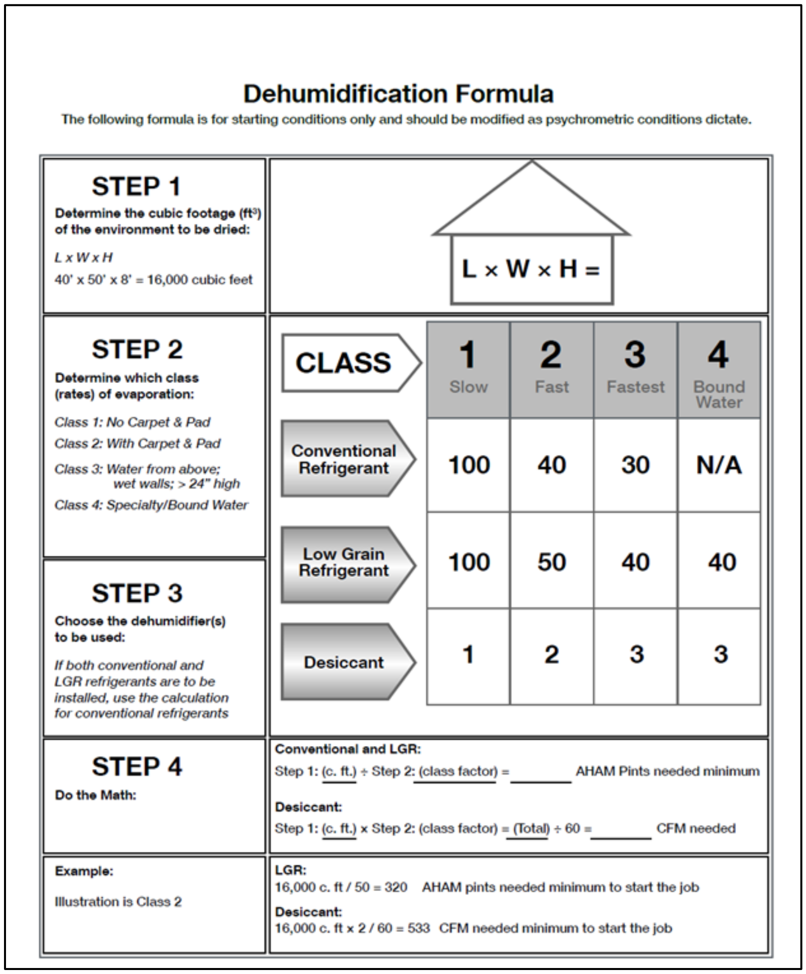
### Guidelines for Utilizing Dehumidifiers

| When to Use Which Dehumidifier | |
|---|---|
| LGR | • Use in most residential / small commercial situations.<br>• Good for warm/high humidity conditions.<br>• Adequate for drier conditions down to 34 GPP. |
| Portable Desiccant | • Use for difficult to dry situations, such as difficult class 4 losses involving low porosity materials.<br>• Use if a structure cannot be warmed to a temperature where LGRs would be effective. |
| Conventional | • Use for simple/small losses or as a backup. |

Dehumidifiers are tools that simply remove water from the air. Much like any other tool, in some situations a dehumidifier will work well, and in other situations a certain technology will be inefficient.

### Determining How Many Dehumidifiers to Place

Placing the right number of dehumidifiers helps ensure the indoor humidity does not linger above 60% RH for any length of time, and is brought to 40% RH or lower within 24 hours. One way to determine how many dehumidifiers to place is to use the Simple Calculation method. Follow these steps:




1. Determine the volume of air (in cubic feet or meters) in the affected area. Multiply area's length by width by height.
2. Determine the classification of water loss, or the initial rate of evaporation based upon the type of materials affected and degree of water intrusion. Classes range from Class 1 to Class 4.
3. Check the Initial Dehumidification Factors table. These factors are based on how many cubic feet of air will be dehumidified by one pint of dehumidifier capacity, or, in the case of desiccants, the number of air exchanges per hour needed.
4. Determine the capacity of the dehumidifiers which are available.

*Note:* When using refrigerant or LGR dehumidifiers, note the dehumidifier rating. Ratings are expressed in the number of pints of water removed at 80°F (27°C) and 60% RH in 24 hours. This rating system was developed by the Association of Home Appliance Manufacturers (AHAM). For desiccant dehumidifiers, note the process-out airflow is measured in cubic feet per minute (CFM).

Once all the factors are known, determine the initial amount of dehumidification needed:

- Use the Dehumidification Factors table to determine the “factor” that will be used. The class of water loss and type of dehumidifier are both noted in the column and row headers of the table.
- Once the factor has been identified, use the following formula for LGRs and conventional refrigerants:

  cubic ft. ÷ factor = AHAM pints required

- For desiccant dehumidifiers, use the formula:

  cubic ft. × factor ÷ 60 = CFM required

The product of the formula represents the minimum CFM (for desiccants) or AHAM pints (for refrigerants) required. This total is then compared to the dehumidifier’s published rating. The appropriate number of dehumidifiers is then installed to ensure that the minimum requirement is met. For example: if 330 AHAM pints are required, and 100 pint dehumidifiers are available, four are installed.

### *Factors in Dehumidifier Placement*

It is necessary to use the following guidelines when applying the initial dehumidification formula:

- Formulas are intended for initial installation only. After the initial installation, the dehumidification may need to be increased or decreased based on change or lack of change to psychrometric and other moisture readings.
- If LGRs and conventional refrigerants are mixed on a job, use the formula and steps for conventional refrigerants.
- If the formula calls for a certain CFM or AHAM pint (liter) removal, add enough dehumidification to the site to cover that capacity. Providing less dehumidification than needed can cause an unbalanced drying system and secondary damage.
- The required CFM or AHAM pint removal should not be doubled. Placing too much dehumidification on a loss creates heat problems.

The dehumidification chart was designed to create a balanced drying system that achieves the goal of 40% relative humidity or less within 24 hours. A relative humidity less than 40% is generally a good drying condition.

*Equipment formulas are intended for initial installation only!*

The LGR and conventional refrigerant factors themselves are the number of cubic feet of affected air each pint of dehumidification will handle. The desiccant factors are the number of air changes per hour (ACH) needed for each class of loss. For example: a Class 3 loss will require three air exchanges per hour through a desiccant dehumidifier.

### *Detailed Calculation for Dehumidifiers*

Another way to determine the capacity of dehumidifiers required is to use the Detailed Calculation method. This method considers details such as outside weather conditions and characteristics of the structure being dried to adjust the capacity of dehumidification.

- **Build-out density** — Density is the degree of openness in the structure: a warehouse or convention ballroom is very open, while an office suite of small rooms is very dense. Dense structures restrict the restorer's ability to move low humidity air throughout the affected area. Higher density could also involve more affected wall materials that must be dried.
- **Building construction** — Standard or common construction is usually easier to dry. Examples are no insulation inside interior walls, single layers of drywall, and typically painted wall surfaces. Complex construction presents drying challenges due to multiple layers of drywall (fire-rated walls), wall assemblies with interior insulation or foam panels for sound absorption, and various commercial-grade building materials.
- **Class of Water —** Class is an estimate of the expected humidity rise from evaporation.
- **HVAC** — An inspection of the building's HVAC system should determine whether the system will support the drying effort by helping to maintain conditions appropriate for evaporation.
- **Outside weather** — Outside conditions can either help or hinder the drying effort depending on the climate of the region and the season of the year. The impact of outside weather is estimated by considering both the expected GPP outside and the building's looseness or tightness in allowing infiltration of outside air.

The Detailed Calculation method figures a base pints per day (for refrigerants) or a required CFM for one air exchange per hour (for desiccants). These numbers are then increased or decreased based on the five factors above, resulting in an adjusted capacity of dehumidification.

## Heat and Air Exchange Drying

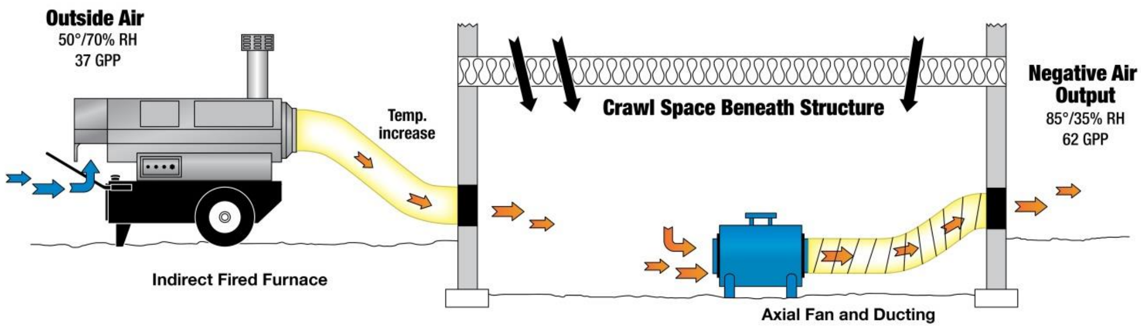
Heat and air exchange drying employs outdoor air and supplemental heat to facilitate evaporation and humidity control.


The process is similar to those used by lumber mills during kiln drying. Very high temperatures are used to increase the vapor pressure associated with free and bound water in the structure. As moisture evaporates, wet air is exhausted to the outdoor environment to control indoor humidity.

Exhausted air is replaced by heated outdoor air.

The heated outdoor air is relatively dry, and is promptly placed in contact with the wet surface to continue the cycle until materials reach their drying goal.




A major difference between kiln drying and structural drying is the restorer's access to the number of affected surfaces. In a kiln, lumber can be accessed on all sides. Materials are separated to ensure that the hot air can effectively heat the entire material, thereby maximizing the internal vapor pressure associated with water in the material. Air is then evacuated from all sides, ensuring that all evaporated water vapor is removed.

In a wet structure, restorers often do not have access to all sides of affected materials unless invasive methods are employed. If all wet surfaces are made immediately available to the heated air, the method can work effectively. This requires the removal of several finish materials, the application of several inter-air drying systems, or access to subsurfaces by other means.

If any affected surface or subsurface is not in immediate contact with the hot and dry air, water vapor can collect. Humidity can increase and may eventually result in secondary damage. If surfaces (which are in direct contact with hot, dry air) are allowed to dry at a greater rate than subsurfaces, damage such as checking, splitting or warping can occur.

When considering the use of heat and air exchange, restorers need to take into account the temperature limits set by occupants, sensitive contents, changing weather and psychrometric factors. Heat and air exchange can be used to dry structures in circumstances determined appropriate after each of these factors have been addressed.

Forced air heaters used in restoration are typically indirect fired furnaces. Indirect fired furnaces, also called mobile furnaces, are placed outside a structure and pump heat into the affected area either by blowers or liquid heat exchangers. Diesel or propane burners create the heat to increase the temperature inside the structure, but noxious fumes are vented outside.

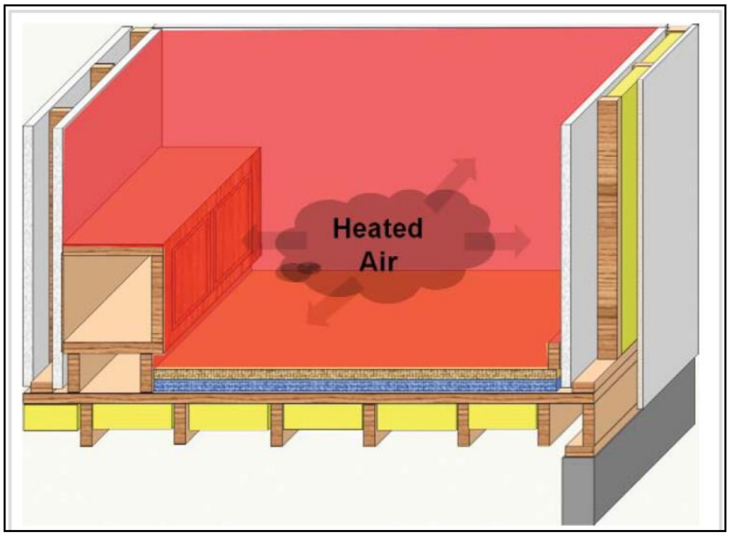
Outside air acts as the dehumidifier. Forced air heaters and air exchange devices offer the ability to make outside air "thirsty" to remove moisture from the structure. Forced air heaters are most effective when the outside air is dry. Warm, dry air is ducted into the structure from the heater, gathers moisture from the structure, and is then vented out the opposite end of the structure with forced air.

### Procedures for Mobile Furnaces

Indirect-fired furnaces have the advantage of not introducing any combustion by-products or additional moisture to the drying environment. To maximize efficiency and safety when using forced air heaters, observe the following procedures:

#### *Provide Adequate Airflow*

An indirect-fired furnace must always be operated outdoors and ducted into the space being heated. Pay close attention to the ducting. Avoid sharp bends and kinks that restrict airflow, and only use the length of ducting needed to reach the target area.




A mobile furnace performs best when operating at maximum airflow. Take care to allow for the free flow of air around the furnace when it is operating. This will help to ensure adequate air for combustion as well as for delivering heat to the target area.

When introducing heated air into a crawlspace or basement, direct the ducting through the widest opening available. Use a basement window or access panel if possible.

#### *Adjust the Burn*

Mobile heaters are usually factory-set to provide the correct air/fuel ratio for atmospheric conditions found at sea level. At higher altitudes, the amount of oxygen in the air is decreased, which can reduce the efficiency of the furnace, causing excessive fuel consumption, oily build-up on the burner nozzle and sooty exhaust. Consult the owner's manual on how to adjust the air/fuel ratio for higher altitudes. Adjustment is needed if the exhaust smoke is dark, black or white. The mobile furnace should produce a clear exhaust when operating with a proper air/fuel mixture.

Other factors can influence burn efficiency, such as fuel quality. Adopt a best practice of checking the furnace for proper operation every time the heater is used.

#### *Use a Remote Thermostat*

A remote thermostat allows precise control of the temperature in the affected area. Maintaining a steady temperature can reduce fuel consumption while maintaining the ideal drying temperature inside the structure. Of course, thermostatic control is critical for providing safe, comfortable, temporary heat in occupied areas. In many cases, using the thermostat will also significantly increase the run time between refueling.

### *Use Negative Air Pressure*

Establishing negative air pressure in the target area can help prevent moisture, odors and contaminants from spreading to unaffected areas through cracks, crevices and openings in the structure walls. It can also accelerate drying. An area has negative air pressure when air is removed from the space, resulting in a lower air pressure inside the target area than outside.

To create negative air pressure in the affected area, follow these steps:

- Close or block any large openings between the affected area and other parts of the structure.
- Select an opening between the affected area and the outdoors to use as an exhaust, preferably on a side opposite of the location where the heated air is being ducted. A window or crawlspace vent hole usually will serve as an exhaust opening, provided it does not restrict airflow.
- Place one or more air mover(s) in the selected opening for directing air out of the space.

Take note of the CFM produced by the heater. As long as more CFM is exhausted from the space than is ducted in from the heater, negative air pressure is maintained within the target area.

A smoke pencil or smoke stick can confirm the presence of negative pressure. Light the smoke stick inside the target area and hold it near a crack or crevice on an outside wall. If negative pressure has been established, smoke from the pencil will drift away from the crevice and into the negatively pressurized space. If the smoke drifts into the crevice, adequate air pressure in the space has not been created.

The air movers exhausting air from the target area have a dual function. Primarily they produce a negative pressure. As a second function, however, they remove hot, wet air containing the evaporated moisture from the structure.

To provide temporary heat in a living space, the heating system should be set up to provide positive pressure. This is usually accomplished by ducting the heater into the space to be heated — just make sure the doors and windows are closed. Use the remote thermostat to help provide steady, comfortable heat for the occupants.

### *Observe Safety Warnings*

Heed all safety warnings provided with the owner’s manual, especially when operating a heating device involving flammable and explosive fuel. Ensure that fuel is contained in safety certified containers that are stable and secured. Ensure that the furnace exhaust flue is working properly and that noxious fumes are not ducted inside the structure. The owner’s manual provides additional safety warning and cautions.

## Air Filtration Devices

Air filtration devices (AFDs) are needed in water restoration work whenever high levels of dust, smoke, or other particulates are present (or being added) to the air. AFDs are especially important if there is strong air movement, contaminated water or a contaminated structure. Typically, at least one of these conditions is true in every drying environment.

Air filtration is even more important when building occupants are at a significant risk for discomfort from elevated levels of particulates in the air. This concern may be particularly relevant if the occupants are very young, elderly, have respiratory problems or a compromised immune system. In these cases, air filtration devices must be employed.

AFDs are always used whenever drying in a structure with a known contaminant. Special care must be taken — including proper cleaning and air filtration — when wall cavities and flooring surfaces or subsurfaces are known to carry a high degree of organic debris, soils, allergens or other undesired particulates.

AFDs — often called negative air machines, air scrubbers, HEPA units or air filters — offer several stages of filtration, including:

- Pre-filters — Designed to catch large particles. Replaced daily or at least with each job. Often available in two stages for varying particle size.
- Carbon filter — Often optional. Designed to absorb organic vapors, thereby reducing odor.
- Primary filter — Often made of HEPA (high efficiency particulate air) media. Designed to capture 99.97% of particles down to 0.3 microns in size.

### AFD Applications

Determining the amount of air filtration needed is similar to how desiccant dehumidifier CFM is determined. The factors involved are:

- Cubic feet or cubic meters of air in the area to be filtered.
- Air exchanges necessary, ranging from 4 to 12 (or more!) depending upon conditions.
- Math (Multiply the cubic feet by number of air exchanges, then divide by 60); this will provide the CFM needed to effectively filter air in the affected area.

This formula can be expressed as:

Cu. Ft. × ACH ÷ 60 = CFM necessary

Where:

Cu. Ft. = Cubic feet of air in the affected area

ACH = Air exchanges necessary per hour (4 to 10)

60 = Minutes in an hour, to convert cubic feet per hour to CFM

Place AFDs evenly throughout the structure in order to capture the most particles. AFDs are most effective when installed as multiple units with lower CFMs — as opposed to fewer units with higher CFM — to greatly increase the capture zone in the affected area. If this is not possible, and only one large AFD is used, it must be placed in a central location. AFDs can also be placed in the air stream of the structure's HVAC system or in the air stream of the air movers to increase the capture zone of the AFD.


At the conclusion of the project, AFDs should be sealed before the unit's fan is turned off. This prevents the particles trapped in the filters from re-contaminating the environment. Filters should be replaced before the unit is used again. Follow manufacturer's directions when replacing filters on an AFD.

## Drying Chambers

One way to gain efficiency in a drying environment is to set up a drying chamber. A drying chamber is defined as the area in which the restorer will manipulate and control temperature, humidity and airflow to promote evaporation. Drying chambers can be set up in a number of ways, including:

- Closing doors
- Taping up plastic sheeting
- Erecting semi-permanent barriers with plastic sheeting and expanding poles, shower rods, etc.

Inside the drying chamber is the best location for basic wet (salvageable) furnishings. They will dry along with the structure. High value furnishings may require other processes.

Doors can be closed or left opened depending on what will produce effective drying. Often closing doors that separate the affected and unaffected areas is beneficial. Within affected areas, however, removing doors from their hinges prevents the restriction of airflow along affected walls and allows for good air circulation throughout the affected area. Be sure to remove doors if walls immediately behind them are wet. If doors obstruct airflow to a portion of the affected area, either leave them open or remove them; a closed door will cause an unbalanced drying system and potential secondary damage (from lack of dehumidification). Always label the doors that are removed, for easy resetting in the same location at the end of the job.

*Inside the drying chamber is the best location for basic wet (salvageable) furnishings.*

Drying chambers can be an effective procedure for containing the potential spread of contaminants. Isolate contaminated materials by erecting containment barriers. Containment is even more effective when negative air pressure is maintained in the contaminated area. Negative air pressure is produced by exhausting air from the area with an air filtration device (AFD) while using barriers to restrict incoming air.

## Electricity

Electricity is an absolute necessity for effective structural drying but is also a major source of potential safety hazards. Nearly all of the equipment on a restorative drying job site runs on electric power, so technicians must be familiar with basic principles of electricity. With this understanding, restorers will make educated decisions regarding the amount of power available, accessing it safely, managing heat loads, using supplemental power such as generators, and directing customers on power consumption costs.

Electricity is the lifeblood to the restoration effort. Without electricity, the tools used to facilitate evaporation and dehumidification cannot operate. Therefore, limited electrical power directly hinders the effectiveness of a restorer. Being able to identify power sources and use them to a safe but maximum level is critical.

The safe maximum requires a great deal of respect. Federal, local and provincial laws and codes prevent the average person from meddling with power sources, and many of the procedures necessary for maximizing power availability require a licensed electrician. Technicians should never try to modify any electrical circuit in a home or in a piece of equipment if they are not licensed and authorized.

## Principles of Electricity

To work safely around electricity, a restorer should understand what electricity is and how it is measured.

> *Electricity is a flow of electrons inside an electrical conductor that can be used to do work.*

In restorative drying, this work is usually a motor turning a fan or compressor, or a heating coil producing heat. Electricity can be measured a number of ways, including volts, amps and watts:

- **Voltage** is also called volts. Voltage measures the force of an electrical current, expressed as the electrical potential or “push”. Most electrical devices in U.S. residential buildings require 110–120 volts to operate. Some devices need more force to operate; for example, electric range cooktops and clothes dryers require 220–240 volts.
- **Amperage** is also called amps. Amperage measures the amount of electrical current flowing through a circuit at a particular moment. Electrical circuits are designed and rated to carry a certain number of amps, and they should not be loaded with more than 80% of that amperage. For example: a 15 amp circuit should not carry more than a 12 amp load.
- **Wattage** is also called watts. Wattage measures the work that electricity produces per second. Watts are calculated by multiplying the force (voltage) of an electrical current by the amount of current (amps) flowing through the circuit. The calculation is commonly referred to as kilowatts (increments of 1,000 watts).

The relationship between amperage, voltage and watts can be expressed as:

amps × volts = watts

## Power Availability

In the average residential structure, power is supplied in the form of 230 volts and between 100 and 200 amps. When a structure is being supplied with 230 volt service, yet the power is being consumed at 115 volts, the available amperage is doubled. In other words, 200 amp, 230 volt power is equivalent to 400 amp, 115 volt power.

Several devices are available to step down the 230 volt power. These devices are often referred to as temporary power distribution panels, or power boxes. Power boxes are normally intended for construction use and are designed to be hard-wired to temporary power poles installed by local utility companies. However, power cords are available that will allow the power box to be plugged into the 230 volt outlets available in many modern homes (e.g., range outlet, dryer outlet).

Temporary power supply boxes should only be used when both the box and the power cord:

- Have been constructed by a licensed electrician,
- Are UL listed and approved, and
- Do not require the technician to make any further modifications.

Another resource for additional power is the portable generator — appropriate for the many circumstances in which power availability is either minimal or non-existent. Portable generators range in size dramatically, with smaller units capable of powering only a single 15 amp circuit, and larger units capable of powering an entire home.

Whenever a generator is used, it must be properly sized to meet the power demands of the drying equipment. To calculate the needed generator size, first evaluate the structure and its equipment requirements. Once the amount of equipment necessary has been established, the following formula can be used:

*Kilowatts Required to Run the Equipment*

$kW = (Ta \times V) / 1{,}000$

- Ta = total amperage requirement
- V = voltage requirement
- 1,000 = watts per kilowatt
- kW = kilowatts per hour

Generators are typically rated in kilowatts per hour (kWh). The formula above will calculate the total number of kilowatts necessary to run the required equipment. To calculate how much equipment can be run by a generator, the following formula can be used:

*Generator Capacity in Amps*

$kW = (Ta \times V) / 1{,}000$

This formula will calculate the total amperage available, given the kilowatt rating of the generator. As with any electrical circuit, the capacity of the generator must not be used at a 100% load continuously. The National Electric Code (NEC) states that electrical circuits must be run at no more than 80% of total capacity, if run continuously.

## Electrical Costs

Building owners will often share concerns about the cost of electricity consumption. While equipment will consume a great deal of electricity, the total cost is usually far less than most building owners would estimate. Additionally, this cost is normally a covered expense under insurance policies. Most insurance companies will reimburse the building owner based on a comparison of previous year and current year utility bills. If a more immediate answer is necessary, an estimate is calculated using this formula:

Amps × volts × 24 ÷ 1000 × cost per kWh = cost per day

On average, the cost per piece of drying equipment is $1.00 to $1.50 per day, and this rule of thumb can also be applied to answer inquiries. Ultimately, the building owner must contact the insurance company for direction when requesting reimbursement for electrical costs.

## Managing Heat Produced by Equipment

All electrical devices produce heat as a by-product of using electricity. If large amounts of equipment are placed in a structure, this heat can spiral out of control quickly. When evaluating actual heat energy, the appropriate measurement is the British Thermal Unit (BTU). A BTU is a specific unit of heat, much as grains are a specific measurement of water vapor.

British Thermal Units are often expressed in increments of 12,000 BTUs per hour, or one “ton” of heating or air conditioning. The heat produced by drying equipment can be estimated by using this formula:

Amps × volts × 3.4 = BTUs per Hour

Common ways to offset heat in structures include:

- Using the structure’s air conditioning
- Installing portable air conditioning
- Using cool outdoor air (by setting an air mover on negative pressure to bring in cool, dry air)

When using outdoor air, restorers can keep the structure from getting too cool by running the air mover on a thermostat; this way, the unit turns off before the structure cools too much.

Building materials used in construction today vary greatly from materials used in the past. Many of today's structures are built as "paperboard palaces," using primarily engineered materials that have been designed with cost, handling and availability constraints in mind — not durability. The fact is: many of the components used in modern building materials do not endure well when exposed to elevated moisture levels. Yet, such exposure is unavoidable.

When abnormal levels of moisture are introduced, many materials will begin to change in one way or another. Some changes — such as severe swelling and splitting — can be drastic and quite obvious. Other changes, such as hidden microbial growth, are just as serious but not as visible.

## Removing Moisture from Materials

The rate at which moisture moves through materials depends upon two primary factors: the type of material affected and the degree of wetness. The type of material affected will vary in permeability (ability for water to pass through the material), hygroscopicity (ability to absorb water), thickness, density, temperature and "R" factor (resistance to heat transfer).

Each of these characteristics will influence the way in which water travels through the material. The degree of wetness will influence moisture movement, in combination with other material characteristics, by indicating the type of water being addressed. Water will be present in one, two or three forms:

- Surface water
- Free water
- Bound water


Free water is evident in wood when it appears dark, or saturated.

**Surface water** is readily available at the surface of a material. It is liquid, visible and will evaporate readily. All materials are capable of supporting surface water. Surface water is best removed physically using mechanical extraction equipment or other physical means. Minute amounts of remaining surface water are readily evaporated using large amounts of airflow and moderate temperature and humidity.

Due to the ease of access to surface water, extremely warm temperatures and low humidity are not necessary for a sufficient rate of evaporation. Surface water yields the fastest evaporation rate.

**Free water** is present within a material but is not bonded. It exists in cavities, open pores and other air spaces within the material. It is liquid, generally visible by a darkening of the material (e.g., wood) and can evaporate readily. Most materials are capable of supporting (containing) free water. Materials not capable of retaining measurable amounts of free water are non-permeable, non-porous materials such as vinyl, vinyl composition, steel, rubber and some other solid, synthetic materials.

Free water is best addressed with sufficient airflow, warm temperatures and moderately low humidity. Because free water is not readily available at the surface of the material, lower humidities and warmer temperatures are more necessary than with surface water.

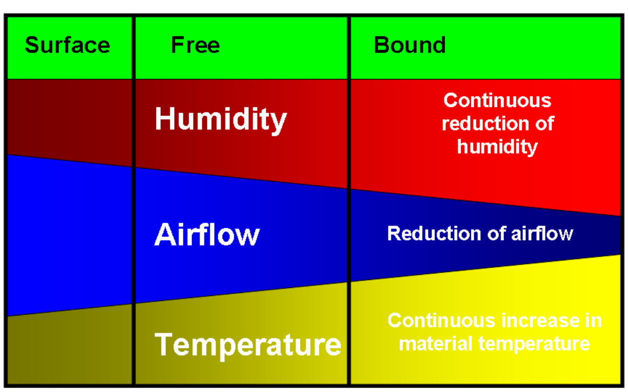
As the free water nearest the surface of the material is depleted, lower humidities and warmer material temperatures are necessary in order to maintain the rate of evaporation. Free water will evaporate quickly.

**Bound water** is absorbed by the material and held captive by chemical bonds. It is similar to vapor in that it is not fluid, yet similar to a solid/liquid in that it is bonded to other molecules. Because it is bound to other molecules, it must first be freed before it can be removed.

Airflow is least effective when trying to remove bound water from within a material. Because the moisture must first be freed (evaporated) before it can begin moving toward the surface (and eventually into the surrounding air mass), materials will dry fastest if they are warm and the surrounding humidity is very low. Bound water evaporates very slowly in comparison to free and surface water.

Wet indoor environments are an accumulation of varying building materials at varying degrees of saturation. Evaluating materials to understand what form of water they support will yield an understanding of how quickly moisture will evaporate, what rate of airflow is necessary across wet surfaces, how much heat will be required, and how low humidity must be in order to facilitate an acceptable rate of evaporation.

If surfaces are properly evaluated, progress will be most evident in the initial stages of the drying process. In fact, surface water should be eliminated in the first several hours. After that, free water will begin to evaporate from the most porous and permeable materials (e.g., carpet, wall board with permeable paint). Materials that are retaining bound moisture will remain wet or possibly increase in moisture content during this stage.




As free water begins to dissipate, humidity will begin to drop. The rate of evaporation will slow dramatically, allowing for humidity control to yield a net reduction in overall atmospheric moisture content. As the humidity continues to drop, bound water will eventually respond. This process can be sped up with the appropriate balance of temperature applied to affected materials.

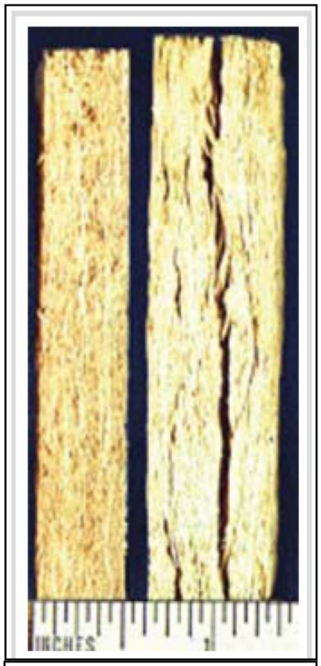
An increase in material temperature will help maintain the initial rate of evaporation, as warmer materials will most directly affect bound water. The process of applying heat to bound water counteracts the chemical bond the water has with the material. Several limitations and complexities exist when increasing material temperatures. Restorers must be aware of these problems in order to prevent severe secondary damage.

### A Drying Principle for All Materials

The variety of installations in a structure can pose a challenge for technicians seeking a good approach to drying a material or surface. The basic rules of psychrometry offer a drying principle: wet items will dry faster if drier air is supplied, with adequate airflow, at a good drying temperature. To select the most effective drying techniques for affected building materials, restorers should inspect the building assembly construction and then apply this drying principle to the situation.

## Flooring and Structural Systems

Building assemblies combine various building materials or components into a structural system. The assemblies can be constructed in configurations that trap moisture and require aggressive drying procedures. Flooring systems and structural framing assemblies usually employ wood, masonry (concrete), or steel materials.



*Effect of water on chipboard*

Wood represents the most common category of building material in today's structures. The image on page120 shows a variety of wood materials commonly found in structures built today. Wood has undergone the most significant change over the last several decades. Where solid wood was used in days past, engineered wood has been substituted. These changes have been fueled by the need to reduce building material costs as available resources have declined. Additionally, a desire for more resilient materials has bred the engineering and the manufacturing of "was-wood" substitutes containing a variety of additives that can complicate the monitoring and drying process.

### Natural, Solid Wood

Natural wood is found as a structural member (e.g., studs, plates, joists, beams, rafters, trusses), as a finishing material (e.g., finished flooring, base trim, crown molding or coving, doorways, cabinetry), and as a component of many types of contents. Two primary types of natural wood are found in structures — hardwoods and softwoods. Hardwoods are primarily found as a finishing material, while softwoods are primarily used as structural components.

*Pre-existing damage* of natural wood is found in the form of microbial growth, staining, splitting, warping and bowing. The most evident and telling features present when solid wood has sustained pre-existing damage: a darkening or staining from metal fasteners and staining from microbial growth.

Chronic water problems cause severe microbial damage that manifests itself in the form of rot. In order for wood to sustain damage from wood decaying fungi (rot), moisture contents must remain above 20% MC for extended periods of time. However, microbial damage can still occur in wood at lower moisture contents.

Surface fungi grows on wood over shorter periods of time and at lower moisture levels. For example, particular strains of Aspergillus and Penicillium can grow when lumber is near or above 16% moisture content. Although the growth of surface fungi does not alter the function of structural lumber, it is aesthetically damaging and its impact on human health is still being studied.

*Primary damage* is of little concern with natural wood. Although wood is a hygroscopic material, it absorbs moisture from air relatively slowly compared to other building materials. As moisture absorbs into wood, the immediate changes are minimal. When addressed promptly, the absorbed water will not create an irreversible condition (damage).

*Cupping and crowning* of hardwood flooring result from moisture content differences between the top and bottom of the board. Cupping will generally be the first indication of abnormal moisture levels as the bottom and sides of the board absorb moisture. The bottom of the board will then expand, bending the edges of the board upward and creating a cupped appearance. Cupping is not permanent damage and should be dried in most cases.

*Crowning*

*Cupping*

*Buckling*

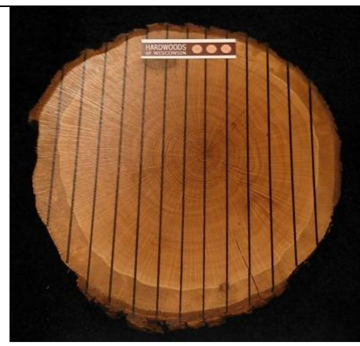
*Secondary damage* will occur if the response to elevated moisture levels in and around wood is delayed. Many of the same types of damage discussed under pre-existing damage can occur, such as warping and microbial growth. These are all forms of permanent damage. In other words, if any of these items occur, the wood material will require more than drying; it will need to be sanded, refinished, sealed, painted, or even replaced.

Damage is most likely on a hardwood floor when the moisture in the bottom of the board begins to migrate to the top of the wood, causing the board to expand on top. This results in excessive horizontal pressure and buckling. In most cases, the damage caused by buckling cannot be repaired, and the floor will have to be removed and replaced.

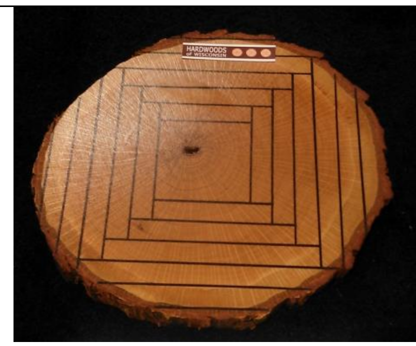
### *Quality of Hardwood*

The likelihood of permanent damage is related to the way in which the lumber was milled or cut. Wood that is quarter sawn (hardwood) or flat grained (softwood) has been cut such that the annual rings create straight, parallel lines down the face of the board. Wood that has been cut in this fashion will have less dimensional change in its width as it absorbs moisture. It is more resilient to visible changes such as warping.

*Rift and Quarter Sawn*



*Live Sawn*



*Plain Sawn*

Lumber that has been plain sawn (hardwood) or edge grained (softwood) has been cut so that the annual rings create “flares” down the face of the board and form a curved grain visible on the cut-ends of the lumber. Lumber that has been cut in this way is less expensive to produce and results in a greater yield from each log. However, it absorbs and releases moisture more readily, will incur greater dimensional change, and is more likely to warp.

**Plain sawn hardwood**

**Quarter sawn hardwood**

### *Types of Natural Wood Products*

**Unfinished Solid Hardwood:** Solid wood flooring that is sanded and finished on site. Solid hardwood is a single piece of wood usually ¾" thick, but occasionally of different thicknesses.

**Pre-Finished Solid Hardwood:** Essentially this is solid wood flooring that has been sanded and finished in the factory, instead of on site. This often results in a more durable finish.

*Pre-Finished Solid Hardwood*

**Moldings:** Natural wood is used for moldings and decorative trim. Wall trim moldings, wainscots, chair rails, door and window moldings, and floor moldings, such as baseboards, are examples where natural wood provides a quality finish appearance to a building interior.

## Engineered Lumber (Was-Wood)

Many structures today are built using a variety of manufactured wood products. These products are used for subflooring, base and trim, floor joists, studs and even in finished flooring materials and wall paneling. The nature of each material varies depending upon the process and material used to engineer the final product. To understand the different ways in which the product will respond, be familiar with the different types of materials.

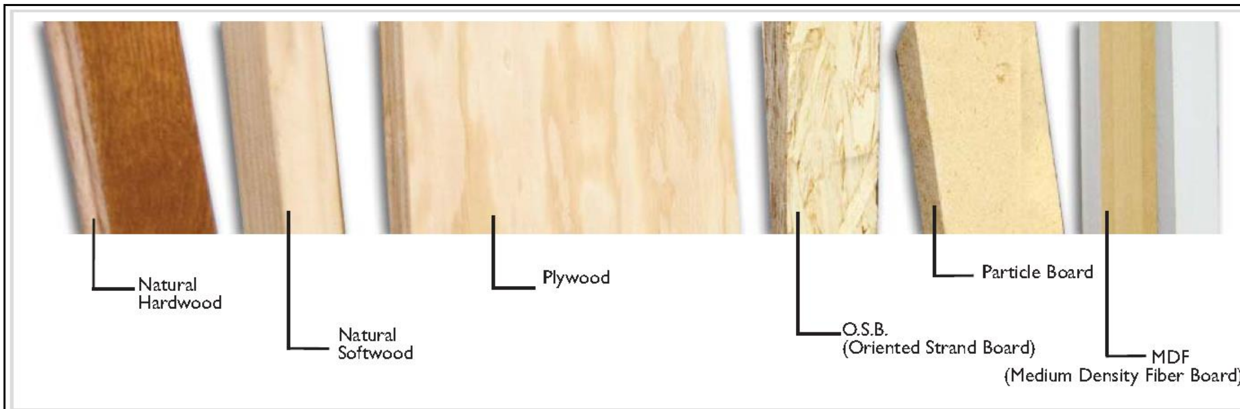
*Engineered Hardwood*

The more the fiber has been processed and re-adhered (laminated) in the manufacturing of the engineered product, the more rapid and dramatic the effects of wetting.

- **Plywood** represents the "was-wood" material with the least engineering, and thus the most natural fiber bonding. It is resistant to swelling and delamination due to its wood veneer assemblies which are glued under extreme pressure.
- **Com-Ply** consists of sheets of veneer, much like plywood, on its surface. However, the core of the product consists of much smaller fibers, not veneer. Here, much artificial adhesive is used and very little of the wood fiber is naturally bonded. This results in a greater potential for delamination.
- **Oriented Strand Board (OSB)** consists of large chips of wood laminated to form a single sheet. The amount of adhesive used is drastically greater than that of plywood, resulting in a much greater likelihood of permanent damage. This is also

true of particle board. Particle board consists of even smaller fiber, however, and more adhesive.

- **Laminated Veneer Lumber (LVL)** is an engineered dimensional lumber used for structural components such as studs, beams and joists. Its composition is similar to OSB. In the case of LVL, strips of natural wood fiber are laminated to form a dimensional product, as opposed to a flat sheet. Water affects LVL in much the same manner as OSB.
- **Medium Density Fiberboard (MDF)** consists of the smallest natural fiber. It can be compared to thick paper sheets. Because it is the "least" natural in state, it suffers the most permanent and rapid damage.




Each of these engineered wood products can be found in a variety of areas throughout a structure.

- Plywood is used as a subflooring material, sheathing, a layer beneath the finished floor, and as the base for an engineered hardwood floor.
- Oriented Strand Board, or OSB, is used in many structural components, including engineered joists, sheathing, roofing and shear walls.
- Com-Ply, which looks like plywood but has an OSB core, is used as a subflooring material.
- Particle board is used as an underlayment for hard surface flooring and would normally be removed and replaced if wet and damaged.
- Medium density fiberboard (MDF) is often used in inexpensive trim and baseboard material, and damages very easily. It is usually removed during the initial stages of drying.

### *Engineered Wood Finish Flooring and Contents*

**Bamboo Flooring:** An engineered floor that is made exclusively of bamboo. It can be dried if the surface is not damaged.

**Engineered Hardwood:** Wood flooring that consists of layers of wood with the top layer of veneer being pre-finished (also called laminated wood flooring). The layers are placed in opposite directions like plywood to provide structural stability. While this wood can be dried, it is often removed due to surface damage.

**Plastic Laminate Flooring:** Flooring that is made of medium density fiberboard and has a resin saturated paper on the top layer, which is the appearance layer. It is normally removed in water restoration due to its construction and installation components, specifically vapor barriers installed under the floor.

*Bamboo flooring – Vertical Grained*

**Personal Contents and Furnishings:** Engineered wood materials are also commonly used for the construction of contents. Entertainment centers, shelving, cabinetry, dressers, vanities, tables, various stands and other furnishings are each made with a varying array of building materials. An important step in the inspection process is to identify each of these materials upfront. Knowing what material is used will aid in identifying pre-existing, primary and secondary damage.

## Concrete

When evaluated as a single component, concrete is quite immune to water damage.

Whether exposure extends over a period of time, occurs just once, or happens at intermittent intervals, concrete will withstand elevated moisture levels. But when concrete with elevated moisture levels has contact with other materials, damage to these materials may result, particularly the failure of newly installed finish flooring products. For this reason restorers should inspect concrete for moisture even though the excess water will not cause damage to the concrete directly. Elevated moisture levels should be dried to an appropriate level — the dry standard — as with any other affected building component.

## Concrete Board

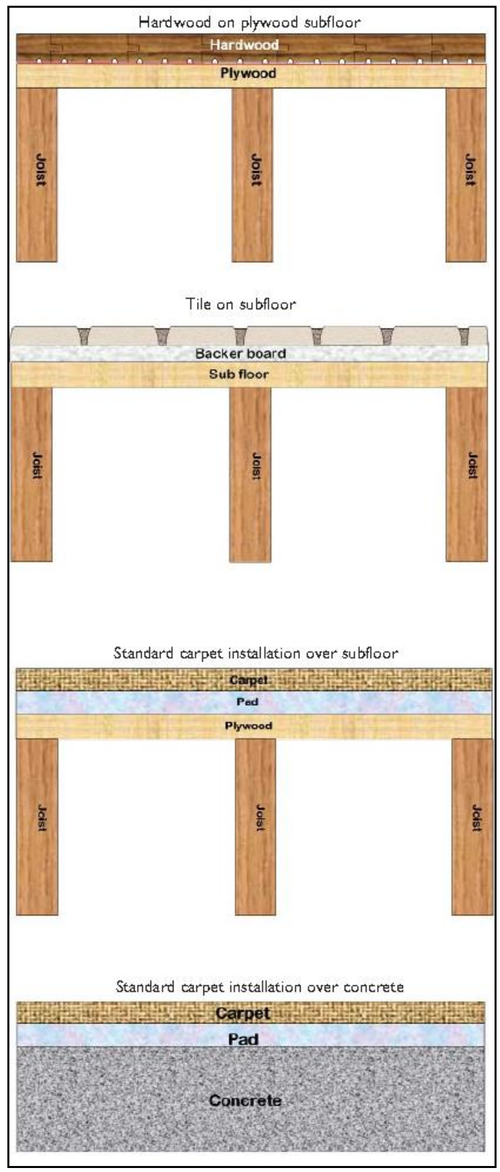
Concrete is also encountered in a pre-fabricated product known as concrete board, also called cement board, concrete backer board, etc. These prefabricated concrete products contain no aggregate and consist primarily of concrete and a fiber (fiberglass or cellulose). Concrete board is most commonly encountered as a backing material (substrate) for tile installations. Its properties are similar to concrete. It is resistant to water damage, sustaining little to no damage from water intrusion. The challenge for drying is the inability of concrete board to release water. It will dry relatively slowly and will therefore lengthen the amount of time that neighboring materials are exposed to excess water. Secondary damage is of concern with neighboring materials.

## Gypsum Concrete

Gypsum concrete is a mixture of gypsum, cement and sand, and is used in the construction industry as a lightweight alternative to regular concrete. Construction workers commonly refer to gypsum concrete by the name Gyp-Crete, the brand name for the product manufactured by the Maxxon® Corporation.

Gypsum concrete is most commonly installed beneath tile flooring, around radiant heat systems and as a leveling material over wood and/or concrete subflooring. It is comprised of gypsum and sand and may also contain aggregate, wood chips, vermiculite or other materials. It is water soluble and may show signs of pre-existing water damage. Deterioration of gypsum concrete can lead to hollow sounding tile floors as the product cracks or softens to dust. For these problems to occur, gypsum concrete must be excessively wet over extended periods of time. When such problems are discovered during a temporary water intrusion, the damage is pre-existing.

Primary damage is of little concern with gypsum concrete. Secondary damage, however, will occur if this material is allowed to remain wet. Secondary damage will include deterioration, release of finish materials, cracking and dusting. Moisture in the gypsum concrete will also secondarily damage finish materials such as hardwood flooring and other building materials, like wallboard, if the gypsum concrete remains wet.




## Procedures for Drying Floors

If a wet floor is not drying, it is important to remember the basic rule regarding evaporation: evaporation will increase as materials are made warmer, as air is made drier, and as air is moved more rapidly across the wet surface. Under this principle, there are several options for action beginning with the least disruptive:

- Add more direct airflow on the surface and subsurface of the floor.
- Provide drier air to the floor with desiccant dehumidification.
- Dry the floor from both the bottom and top (“sandwich drying”).
- Feed air movers that are blowing into the floor with dehumidifiers.
- Warm floor surfaces with heat lamps.
- Remove wet flooring completely.

Drying technology can answer the challenge of nearly every flooring system. Here are examples of floor drying challenges and the generally accepted resolution:

- Wet carpet and underlay installed over hardwood flooring. Discard underlay, remove carpet and focus on drying hardwood and subfloor. Dry wood floors with drying mats or injection type systems, or with tenting and warm dry injected under the tent. All three approaches can be combined.
- Wet underlayment under vinyl flooring. Remove the vinyl and discard it if underlayment is saturated and/or damaged; vinyl is a vapor barrier and time required to dry underlayment will be dramatically reduced when the vinyl is removed.
- Partial Floating of carpet. This can be a way to achieve drying of all surfaces simultaneously. The procedure allows warm dry air to have more contact with wet flooring. Ensure that carpet is properly engaged and not "flopping."

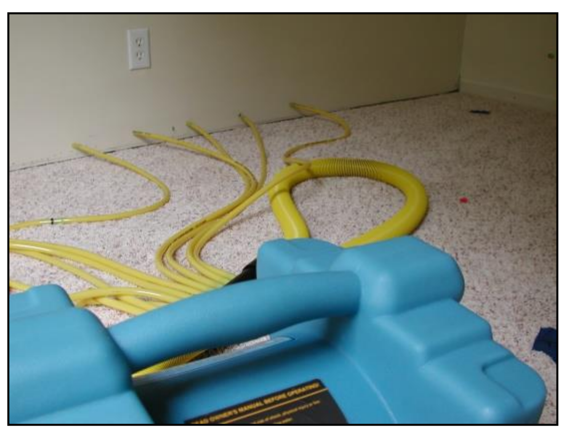
The following materials normally cannot be restored when damaged, and are removed: medium density fiberboard (MDF), particle board, laminate flooring, and parquet floors.

## Wall and Ceiling Systems

Wall and ceiling systems usually employ gypsum products. Plaster is still used in some wall systems. Walls may be covered with a variety of finish materials including ceramic tiles, vinyl or paper wallpapers, and wall coatings.

### Gypsum Wallboard

Gypsum occurs as a mineral in nature and has been mined for use as a component of fertilizer and many building materials. Wallboard constructed of gypsum sandwiched between paper — Drywall® is the common trademark — is second only to engineered wood materials (especially MDF) in its vulnerability to rapid and dramatic change when exposed to elevated moisture levels. However, gypsum has a much greater ability to recover.



Wallboard installed vertically on walls absorbs water through wicking (capillary suction). The amount of wicking which can occur would depend on the amount of water present and many other factors. Wicking occurs fairly rapidly during the first several hours of water intrusion, and then slows toward equilibrium with the material and the air. Wicking of 6 inches (15 cm) can occur in three hours and a maximum height of 17 inches (43 cm) when the wallboard is submerged in ½ inch of water (Greenwell and Menetrez, 2004).

Wallboard will sustain primary damage if it is nearly saturated. This primary damage will occur in overhead, horizontally suspended wallboard. Wet overhead wallboard will lose structural integrity and sag, also posing a significant safety concern. This sagging will result in permanent damage and requires that the wallboard be removed.

Secondary damage is also possible with gypsum wallboard. Microbial growth will occur on the paper surface of the gypsum wallboard if allowed to remain wet for long periods of time. In most cases this damage will require removal of the affected wallboard, preferably before dying procedures begin or continue.

If the wallboard has not sustained primary damage, it will restore. During the drying process, all of the gypsum's original strength is restored. When dried, gypsum will normally be slightly stronger than before wetting and sometimes also more brittle. This change is normally not a concern when dealing with drywall installed vertically on studs. Minimal swelling will sometimes occur, causing tape joints and fastener heads to become visible, which will be repaired during the restoration phase of the job.

### Lath and Plaster

An older style of wall and ceiling finishing is lath and plaster. This is a very durable installation and requires careful drying efforts such as injecting air into the airspace or wall cavity behind the lath.

*Lath and plaster demonstration in the historic home of Ulysses S Grant.*

*Notice the layers involved in finishing.*

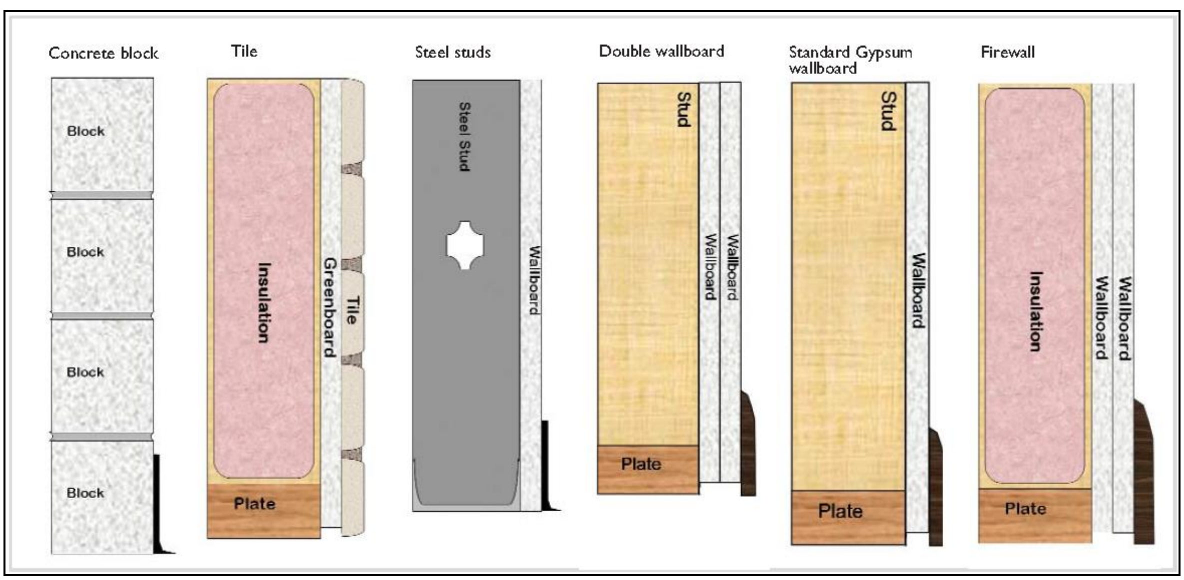
Lath is the material which holds the plaster in place. There are three types: wood lath, metal lath and rock lath. Wood and metal lath were commonly used in construction before the early 1900s. Wood lath is thin wood strips nailed at right angles to wall studs or floor/ceiling joists. Metal lath is a mesh that is attached to the structural members. Rock lath (also called "blue board") is sheets of gypsum with special bonding paper on the surface. In cases where the lath is applied to masonry, furring strips are used so that the plaster does not pick up moisture from the outdoor environment. Therefore, in all properly applied plaster, an airspace exists behind the lath which can be used for drying.

The actual plaster is very durable material. The older style plaster is lime plaster. Lime plaster is a mixture of lime, sand, water and animal hair and is applied in three coats. This plaster can be up to an inch thick when properly applied. When lime plaster was used in construction, it could take more than a year to dry! Gypsum plaster became popular because it shortened construction time considerably. Gypsum plaster is similar to the joint compounds used today. Once the plaster has cured, it is difficult to tell the difference between lime and gypsum plaster. Drying procedures for lime and gypsum plaster are the same — inject warm dry air into the space behind the lath.

### Procedures for Drying Walls

If a wet wall is not making drying progress, there are several options for increasing evaporation. Beginning with the least disruptive:

- Add more direct airflow on the outside of the wall.
- Move the dehumidifier output so that it is closer to the wet surface.
- Carefully remove baseboards and continue airflow along outside of wall.
- Drill holes below baseboard level to allow wall to breathe and continue airflow along outside of wall.
- Blow direct airflow into the wall using air movers or inter-air dryers.
- Feed air movers that are blowing into wall with a dehumidifier.
- Warm wall surfaces with direct heat.
- Completely remove all wet wallboard and all wet insulation.




Because walls are covered with a wide variety of finished surfaces, wet walls present a significant challenge to restorers. For basic walls with a single layer of wallboard and flat paint, the only drying tool needed is an air mover blowing warm, dry air along the wall.

In structures where the surface of the wall is covered with a non-permeable surface (i.e., a vapor barrier such as vinyl wallpaper, high gloss enamel paint) or multiple layers of wallboard are installed, it may be necessary to remove base molding, drill holes and introduce air movement. Airflow in the wall cavity increases the rate of evaporation and allows the wall to dry from both inside and out. When drywall is installed over concrete block, it is generally dryable if there is no insulation in the airspace between the gypsum and the block.

When monitoring wet drywall or plaster, beware of false readings from non-invasive meters. Metal studs, metal lath and the density and composition of plaster cause non-invasive meters to read a higher WME value. Try to find an unaffected portion of wall in the same structure to compare meter readings of wet and dry areas. An alternative to moisture meter readings on lath and plaster is to use ERH monitoring methods described in the section on concrete monitoring (see page 148).

### Procedures for Drying Ceilings

When ceilings are affected, drying procedures are similar to wall drying. If the ceiling is sagging or otherwise damaged, wet wallboard is drained, removed and discarded. This not only removes water from the structure and speeds drying, but it also eliminates a potential safety hazard: wet, sagging ceilings can fall and cause injury.

## Other Building Systems, Finishes and Contents

Drying procedures for various other building materials and systems are determined based on several factors. Did the water intrusion result in malodors, visible stains, contamination, or loss of structural integrity? Can the materials be monitored and restored without being removed? Must the materials be removed so as to access other areas? Common situations in residential drying are carpets, cabinets, and personal contents items.

### Carpet

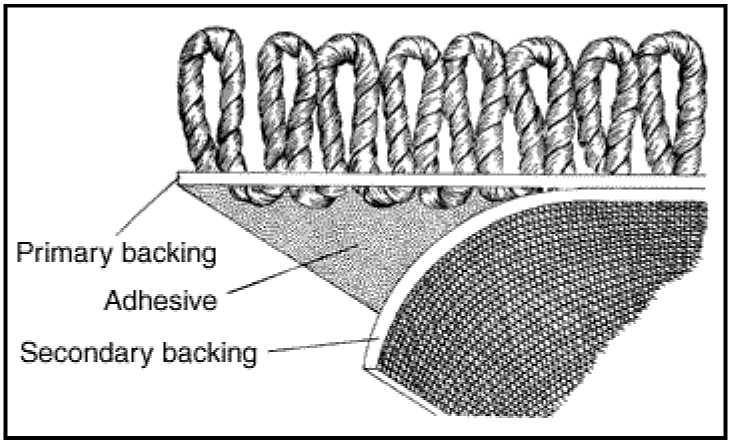
When inspecting water-damaged carpets, a restorer should identify the type of carpet affected and assess pre-existing conditions. Restorers need some knowledge of the way carpet is made and the types of materials used.

#### *Carpet Construction Methods*

Two construction methods are commonly found in residential structures:

**Cut pile** — Nylon and polypropylene fibers are used to make the most common type of residential carpet: cut pile. The fibers are tufted into a polypropylene mesh backing (primary backing) and adhered using a latex adhesive. The face fiber is a continuous yarn that is tufted into the backing, then the yarn is cut, and therefore named a "cut pile". The primary backing is then laminated or adhered to a secondary backing, using latex adhesive. This secondary backing serves as a structural reinforcement. The latex adhesive is hygroscopic and will lose strength when wet.




**Berber** — The second most common carpet in residential construction is berber carpet, which is constructed similarly to cut pile. The most significant variance with Berber carpet is that the yarn is left intact when tufted into the primary backing. The continuous yarn then forms a loop pile where no end of the fiber is visible.

### *Methods of Installation*

There are two primary methods for carpet installation:

**Stretched-in carpet** is the most common method of installation found in residential structures. Stretched-in carpets are typically installed over a carpet underlay (pad, cushion). Around the perimeter of the room, a wooden strip (called "tack strip") is installed that contains tacks angled slightly toward the wall. The carpet is installed by forcing it toward the walls to form a tight, taut and secure stretch. The carpet is held in place as the backing is placed over the multiple tacks. This process is completed using specialized tools — a power stretcher and a knee kicker.


**Direct glue carpet** is most commonly found in commercial structures. "Double stick" methods are also used when an underlay is glued to the subfloor, then the carpet is in turn glued to the underlay. Glued down carpets are most commonly glued directly to the subfloor. Many glue-down carpets consist of yarns adhered to a much more dense backing than is used for cut pile or berber carpets. Backing materials are often made of rubber or other dense closed cell foam.

### *Inspecting Damages*

Once the carpet type has been identified, the restorer inspects for pre-existing conditions. Stretched-in carpet installations can show signs of many pre-existing conditions. These may be the result of previous water intrusions, but they can also be the result of improper installation and handling, insufficient care and maintenance, or improperly specified underlay.

Pre-existing conditions found in stretched-in carpet include:

- Separating seams
- Rippling appearance
- Delamination
- Fraying or damage to fibers
- Loss of fibers or "balding" of fibers
- Staining and microbial contamination.

The most common carpets used in structures today consist of synthetic fibers and will not suffer directly from water intrusion. Primary damage typically will not occur if the excess moisture is addressed correctly and if the carpet is handled properly.

## Contents

Understanding the influence moisture has on contents begins with material identification. Materials such as engineered wood, natural wood, and fabrics are all common in building contents and all warrant further attention.

Many contents are at risk for primary damage. A number of cellulose-based materials are found in contents ranging from papers and cardboards to MDF and particle board. When wet, these highly hygroscopic materials will rapidly swell and, in most cases, become permanently damaged.

Secondary damage for these materials can occur in every form previously mentioned. Specific types of secondary damage associated with contents are typically:

- swelling
- staining

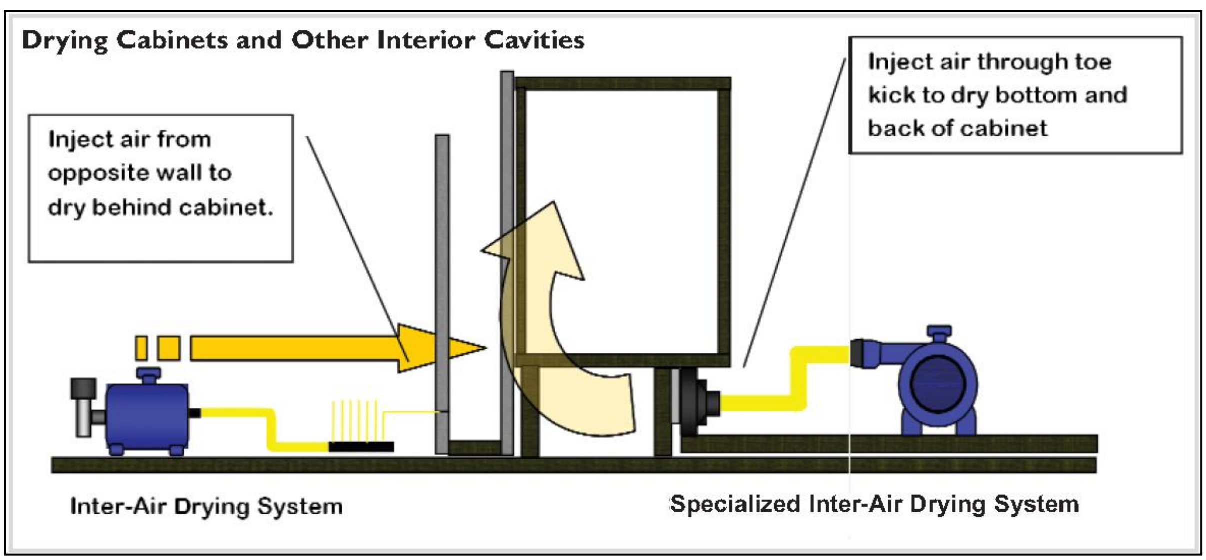
- color transfer
- delamination of surface/finish material

Fabrics may not be colorfast and can transfer color. In addition, wooden legs or trim can transfer tannin to wet surfaces and cause staining. Rust can also stain the carpeting when metal legs are in contact with wet materials.

During the initial inspection restorers should carefully check contents items for pre-existing damage. Pre-existing conditions may exist in the form of scratches, wear, cracks, warping and other signs of use, mishandling and poor maintenance. When drying a water damaged structure, restoration technicians need to handle and move contents. They should document any pre-existing damages observed during inspection. If this damage is not documented, the restorer may be blamed for causing damage that was already present.

## Procedures for Drying Cabinets

When drying cabinets, restorers seek ways to minimize damage while ensuring that the materials dry thoroughly. Specialized equipment is available to generate warm, dry airflow in hidden structural cavities. Most access to a standard cabinet is through the toe kick, a cosmetic cover which hides the under cabinet support. This toe kick is easily replaced in all standard installations. When access is not available through the toe kick, holes are drilled through the shelving in the bottom of the cabinets, through the wall immediately behind the cabinets, or through the back wall of the cabinet itself.



### Temperature Limits of Common Building Materials and Contents

When drying a structure, temperatures may elevate for a number of reasons. To prevent secondary damage from heat stress, observe these temperature limits for materials:

| Temperature Limits of Common Items | |
|---|---|
| **Material** | **Limit** |
| Refrigerators and freezers | 110° F |
| Dishwashers | 150° F |
| Ceramic tile | 160° F |
| Concrete | 150° F |
| Gypsum | 125° F |
| PVC (in electrical, plumbing, windows, etc.) | 140° F |
| Plaster and lath | 160° F |
| Roofing shingles | 190° F |
| Vinyl flooring | 85° F for normal temperatures,<br>up to 158° F for no more than 7 days |

*Moon 2006*

### Drying Crawlspaces

Crawlspace drying is a simple process, as long as the number one safety rule of crawlspace drying is followed: Always dry crawlspaces under a negative pressure. If positive pressure is used to dry a crawlspace, exfiltration will occur, pushing particulates and odors into the living space of the structure. Even the cleanest crawlspace is filled with dust, mold spores, dead insects or worse.

Drying with a neutral pressure is acceptable, but hard to implement in the field. To ensure that a negative pressure is created, more air (CFM/CMH) is removed from the crawlspace than is added to the space. Negative pressure, verified with a manometer, is critical to occupant and worker health and safety when contaminants are present.

Other important factors when drying crawlspaces:

- Crawlspaces are dangerous places. Follow all appropriate safety recommendations.
- Use submersible pumps to remove as much water as possible. Dig a shallow hole in dirt crawlspaces in which to place the pump to pull water to a deeper level (without clogging).
- If using dehumidifiers to dry a crawlspace, calculate cubic feet by measuring the outside of the structure and multiplying by average crawlspace height. Then use the formulas on page 102.

- If using air movers, calculate the number needed based on square feet as described on page 90 and 91.
- Heat has fewer limits in unoccupied spaces; use warmer, outdoor air to promote evaporation.

Effectiveness of the drying system is verified in a various ways. For example, if dehumidifiers are being used in a crawlspace, restorers document their performance by using grain depression. If a heat drying system is being used, the negative air output (exhaust) is compared to the outdoor air. The resulting difference in humidity ratio is an indication of the moisture that is being removed.

Each day of a restorative drying project is another chance to impress the customer. Just as creating good first impressions were important, customer-oriented service continues to be vital. Keep all of the following in mind:

- Customer-focused attitude
- Good appearance
- Clear communication
- Focusing on the work that needs to be done now
- Planning for the work that needs to be done the next day

## Monitoring

The monitoring process differs from the inspection process. While an inspection involves gathering data to accurately evaluate the current condition, monitoring involves a series of repeated inspections to accurately evaluate and document changes in conditions. For the initial inspection, the technician used moisture meters to evaluate the extent of the water intrusion. For monitoring the site, the technician repeats moisture measurements and records them every day during the drying process to determine if the materials and assemblies are drying. Adjustments to the drying system can be made based on these readings.

“Repeated” is the key word. To accurately assess change in condition, conduct inspections the same way each time. To help keep inspections consistent, consider these general principles:

- Determine how wet items are:
  - Monitor daily in most circumstances.
  - Use the same meters in the same locations each day.
- Determine if wet items are drying:
  - Drying progress indicates that equipment is working.
- Determine if affected items are dry:
  - As affected items become dry, equipment use can be scaled back.

*Document Meter Used:* The technician should identify the instrument used because meters vary significantly from manufacturer to manufacturer and from model to model. Two inspections of the same material using different meter models will yield two entirely different readings. This leads to inaccurate conclusions and improper drying decisions. Proper inspection and monitoring forms include areas for recording the meter model and settings used.

*Document Location:* Moisture levels fluctuate throughout a material for numerous reasons, both across its surface and at varying depths. For this reason, it is important to document the exact location and method in which the meter was used. Removable colored dot stickers and painter's masking tape are valuable tools for ensuring consistency in monitoring.

*Document Method:* Inaccuracies in the monitoring process also result from differences in or the incompleteness of documentation. For example, when recording the height of water migration up a section of wallboard, the technician should note where the measurement begins (from the surface of the carpet, or from the top of the baseboard) — not just how high it is on the wall. All of this information must be documented and/or clearly marked at the inspection point in the structure.

Technicians must learn to interpret the numbers displayed by the meters. Since the technologies used in an invasive meter and a non-invasive meter are quite different, direct comparisons between the measurements each device produces are impossible. Also note that no direct correlations exist among the various numerical scales from manufacturer to manufacturer, especially for non-invasive meters. One model might have a scale of 1 to 20, while another might use a scale of 1 to 999. The values expressed in the various scales should not be compared to one another.

Finally, restorers monitor the affected materials to verify that the structure is dry. Before removing equipment from that area, use meters to check that the structure has reached the drying goals established at the beginning of the project. This last — and most important step — allows the restorer to sign off with confidence that the job was done right.

### Methods for Monitoring

*Average Moisture Content:* Average moisture content is obtained by taking readings in several locations across and throughout a material. The data is then averaged to show the overall moisture level of the material. Because moisture will equalize in many ways and for many reasons, individual readings will increase, decrease and even remain the same while the average moisture level taken as a whole decreases.

*Moisture Mapping:* Moisture maps are drawings of affected rooms or areas with corresponding moisture levels for the structural materials in each area or room. Moisture mapping is useful in identifying the actual size of the affected area and the locations where instruments are being used to monitor progress. Obtaining readings in specific, marked locations ensures consistency by allowing subsequent monitoring to occur in the same location.

### *The Dot System*

The dot system employs the use of removable, colored dot stickers to indicate the relative amount of moisture present in a material. Typically, either three or four colors are used in the system. Each color represents either the level of moisture or the intended restoration procedure.

During the initial inspection, a four-color system can be used to communicate intended restoration procedures. Green, yellow and red dots indicate moisture levels in affected materials that will be dried. Blue dots indicate affected materials that are scheduled for removal. The moisture level that corresponds with colored dots will vary depending upon the instrument being used. By general definition, the dot colors represent the following amounts of moisture:

- **Green** — Within acceptable tolerance of the dry standard
- **Yellow** — Abnormally wet but not saturated, at risk for secondary damage
- **Red** — Near saturation, high risk for secondary damage
- **Blue** — Material scheduled for removal

When using the dot system, technicians track moisture based on the size of the area that is wet (i.e., “What is wet?”) as opposed to the actual moisture level (i.e., “How wet is it?”).

*Example:* When monitoring gypsum wallboard, the inches (centimeters) of migration up the wallboard are documented:

- Use a measuring tape to measure from the floor surface to the colored dot placed on the wall, and document this height.
- Further documentation could include photographing the walls with the dots in place.

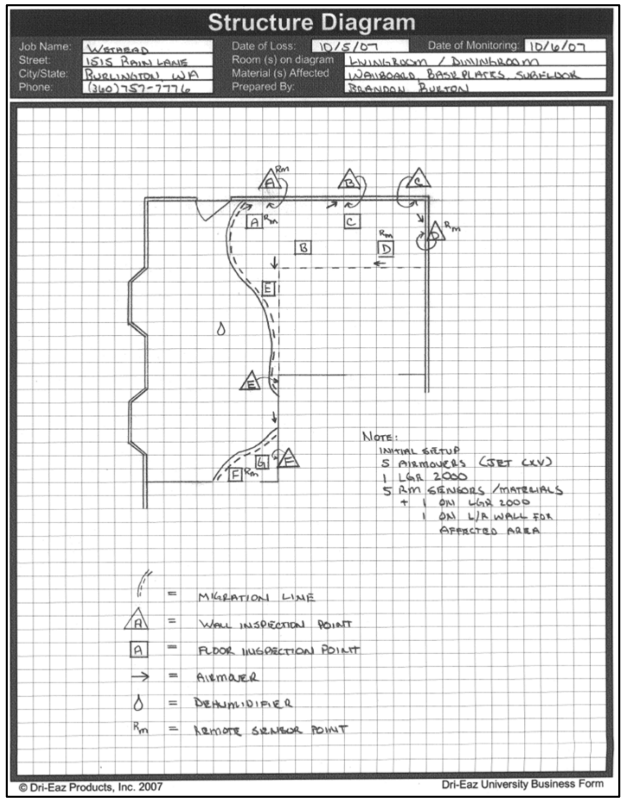
The dot system can also be recorded using lines on a moisture map to show the extent of migration. Regardless of how the system is evaluated, it must be documented. A helpful step is to date the colored dots being used, or number them in relation to the days of drying. This will assist in the evaluation process since multiple dots are used over the course of drying.

## Reports and Documentation

A saying in legal circles maintains: "If it is not documented, it did not happen." The restorative drying industry would do well to heed the saying and record all events and activities of significance related to a job in progress.

High quality and diligent documentation will ensure that the information sends the message it is intended to deliver, and will get the invoice paid faster. Incomplete paperwork, sloppy penmanship, inaccurate information or inconclusive data damage client rapport and can lead to incorrect assumptions.




Moisture documentation of restoration work should include each of the following components:

1. Record of Moisture Content (RMC)
2. Moisture Map — a diagram or sketch indicating the water migration boundaries, inspection points, and moisture levels of the affected areas.
3. Record of Drying Conditions (RDC), also called a Daily Humidity Record.

At the very least, these documents are maintained in order to confirm that proper drying conditions were established and that drying goals were met. Without appropriate records of humidity and material moisture contents, a restorer cannot demonstrate that efficient, effective drying was achieved.

## Documentation Restorers Should Obtain and Maintain (S500-2021)

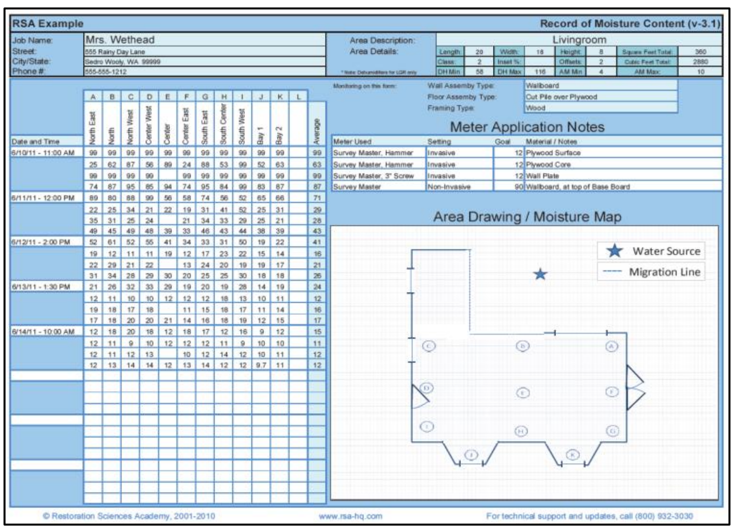
While this is not an exhaustive list, to the extent these documents exist, documents and records should be obtained and maintained by the restorer to include the following:

- the water damage restoration contract and/or the emergency mitigation authorization;
- psychrometric records;
- materials moisture level and moisture content records;
- the scope of work and water damage restoration plan;
- materials related to project limitations on Standard compliance or deviations from Standard compliance (including complications, complexities, or conflicts);
- environmental reports made available to the restorer on projects with Category 3 water;
- written water damage restoration recommendations from specialized experts;

- contents and personal property inventories of items removed, cleaned, restored, or disposed);
- permits, permit applications, lien notices and lien releases;
- change orders;
- estimates, invoices, bills, and certificates of completion;
- detailed work or activity logs;
- equipment, materials and supplies logs;
- documentation reflecting customer approval for the use of antimicrobials (biocides);
- documentation of project safety and health elements;
- records of pressure readings in and out of containment (if negative pressure is being utilized);
- inspection observations and building evaluations, including photo documentation.

### Excellent Documentation Is Excellent Marketing

Everything done in a business says something about that business. Clean, clear paperwork and excellent documentation says good things. Incomplete documentation, unclear readings, loose ends and a lack of explanation says bad things. Consider the documentation prepared for customers to be a part of the marketing effort. Building owners and managers value a well-done documentation packet because it gives them confidence that their structure was remediated effectively.



RSA Example — Record of Moisture Content (v-3.1)

Job Name: Mrs. Wethead
Street: 555 Rainy Day Lane
City/State: Sedro Wooly, WA 99999
Phone #: 555-555-1212

Area Description: Livingroom
Area Details: Length: 20; Width: 18; Height: 8; Square Feet Total: 360; Class: 2; Inset %: ; Offsets: 2; Cubic Feet Total: 2880; DH Min: 58; DH Max: 116; AM Min: 4; AM Max: 10
* Note: Dehumidifiers for LGR only

Monitoring on this form: Wall Assemby Type: Wallboard; Floor Assemby Type: Cut Pile over Plywood; Framing Type: Wood

| Date and Time | A North East | B North | C North West | D Center West | E Center | F Center East | G South East | H South Center | I South West | J Bay 1 | K Bay 2 | L | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6/10/11 - 11:00 AM | 99 | 99 | 99 | 99 | 99 | 99 | 99 | 99 | 99 | 99 | 99 | | 99 |
| | 25 | 62 | 87 | 56 | 89 | 24 | 88 | 53 | 99 | 52 | 63 | | 63 |
| | 99 | 99 | 99 | 99 | | 99 | 99 | 99 | 99 | 99 | 99 | | 99 |
| | 74 | 87 | 95 | 85 | 94 | 74 | 95 | 84 | 99 | 83 | 87 | | 87 |
| 6/11/11 - 12:00 PM | 89 | 80 | 88 | 99 | 56 | 58 | 74 | 56 | 52 | 65 | 66 | | 71 |
| | 22 | 25 | 34 | 21 | 22 | 19 | 31 | 41 | 52 | 25 | 31 | | 29 |
| | 35 | 31 | 25 | 24 | | 21 | 34 | 33 | 29 | 25 | 21 | | 28 |
| | 49 | 45 | 49 | 48 | 39 | 33 | 46 | 43 | 44 | 38 | 39 | | 43 |
| 6/12/11 - 2:00 PM | 52 | 61 | 52 | 55 | 41 | 34 | 33 | 31 | 50 | 19 | 22 | | 41 |
| | 19 | 12 | 11 | 11 | 19 | 12 | 17 | 23 | 22 | 15 | 14 | | 16 |
| | 22 | 29 | 21 | 22 | | 13 | 24 | 20 | 19 | 19 | 17 | | 21 |
| | 31 | 34 | 28 | 29 | 30 | 20 | 25 | 25 | 30 | 18 | 18 | | 26 |
| 6/13/11 - 1:30 PM | 21 | 26 | 32 | 33 | 29 | 19 | 20 | 19 | 28 | 14 | 19 | | 24 |
| | 12 | 11 | 10 | 10 | 12 | 12 | 12 | 18 | 13 | 10 | 11 | | 12 |
| | 19 | 18 | 17 | 18 | | 11 | 15 | 18 | 17 | 11 | 14 | | 16 |
| | 17 | 18 | 20 | 20 | 21 | 14 | 16 | 18 | 19 | 12 | 15 | | 17 |
| 6/14/11 - 10:00 AM | 12 | 18 | 20 | 18 | 12 | 18 | 17 | 12 | 16 | 9 | 12 | | 15 |
| | 12 | 11 | 9 | 10 | 12 | 12 | 12 | 11 | 9 | 10 | 10 | | 11 |
| | 12 | 11 | 12 | 13 | | 10 | 12 | 14 | 12 | 10 | 11 | | 12 |
| | 12 | 13 | 14 | 14 | 12 | 13 | 14 | 12 | 12 | 9.7 | 11 | | 12 |

Meter Application Notes

| Meter Used | Setting | Goal | Material / Notes |
|---|---|---|---|
| Survey Master, Hammer | Invasive | 12 | Plywood Surface |
| Survey Master, Hammer | Invasive | 12 | Plywood Core |
| Survey Master, 3" Screw | Invasive | 12 | Wall Plate |
| Survey Master | Non-Invasive | 90 | Wallboard, at top of Base Board |

Area Drawing / Moisture Map



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A few simple things can be implemented to improve the professionalism of a company's paperwork:

- Provide a key for moisture readings which explains what all the readings mean. Then the customer will not have to decipher their meaning.
- Be sure that all different paperwork items are clearly labeled for their purpose.
- For paperwork with multiple pages, number pages clearly (e.g., "p. 3 of 5").
- Supply technicians with digital cameras and train them how to take good pictures.
- Moisture maps should not look hastily drawn, but should have crisp lines and meaningful representations of moisture migration, inspection points, material types, and equipment placement.

Clear notes are another part of excellent documentation. Legible handwriting is a must for the technicians in the field. Notes are useless if they cannot be read. Clear notes contain at least the following elements:

- Be sure the date and time is indicated for each note.
- Indicate who wrote the note.
- Document names of people involved, if it was a conversation, and the topic of conversation.
- If the note is about an observed condition, add details about what was observed.

  For example, "Upon arrival at the residence, the dehumidifiers were not running." Indicate, if known, what caused the problem: was a breaker tripped, was the unit malfunctioning, or was it simply turned off?


All documentation needs to be double-checked before it goes out. An office employee who is detail oriented should check all documentation provided to customers and clients. Develop a check sheet ensuring that all relevant forms, documents, notes, etc., are included in the file.

### Importance of Clear Communication

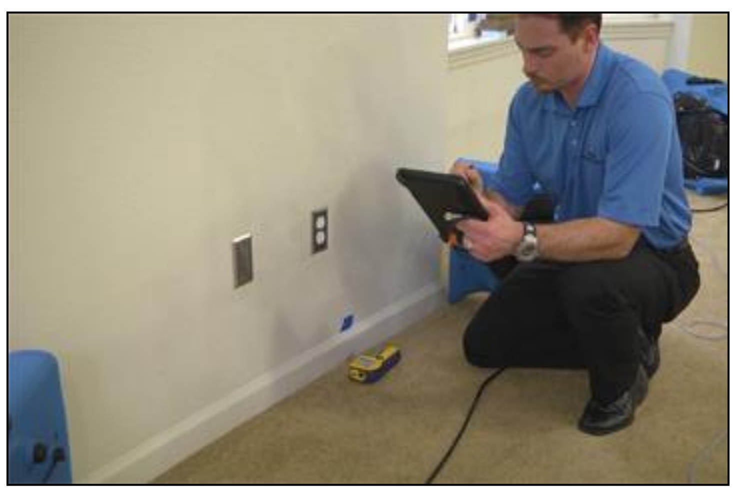
Restorers should give significant attention to improving documentation on restoration projects. They need to respond to changes that have occurred in the water damage restoration industry. Insurance companies are carefully reviewing documentation to verify whether it supports the work performed and the associated costs of the restoration project. Further, the litigious trend among interested parties is forcing restorers to defend themselves with proof that they were competent in their restoration strategy.

Restorers may be losing money on some restoration projects simply because they lack proper documentation of the work performed. How many restoration companies have had adjusters call and say they are only going to pay a portion of the invoice? Most of the adjusters who do this are looking for one thing — justification of the invoice.

Job project documentation needs to communicate clearly what was done and why each procedure was necessary. Do the documents, forms, and reports accomplish this? Several new technologies help restorers produce professional-looking documentation. Types of information to cover include:

- Description of the conditions encountered.
- The restoration procedures employed to return the property to a pre-loss condition.


- The manner in which the initial inspection was conducted:
  - What materials were tested?
  - Where is the test site located in the structure? (Include photo and thermal image if available).
  - What would a person expect the moisture content to be in that geographic area in that season, and what supports that conclusion?
  - What kind of meter was used on each inspection site?
  - How was the meter checked to verify its correct function (i.e., correct settings, mode and application)?
- The results of daily monitoring of drying progress.
  - How close to Dry Standard does a material have to be to be considered “dry enough”? Is enough moisture still present to support mold growth?
  - Does the inspection site meet the criteria for being considered “done”?
  - What is the influence of the present environment on the hygroscopic materials?
  - How does one inspection site compare to others monitored on the project?
  - If multiple meters were used on an inspection site, are they in agreement or do they conflict? If so, what does this mean?

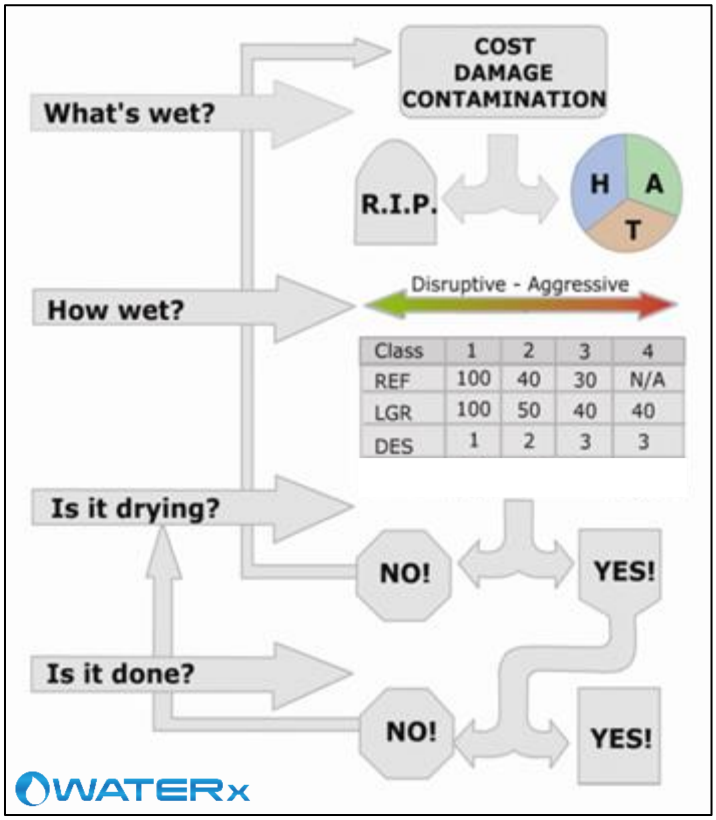


At some point, most restorers will likely have their procedures challenged by the homeowner or insurance representative. Usually the individual who is asking the questions does not understand the science behind the drying efforts, nor the meaning of the moisture measurements in materials. These interested parties are seeking written justification for the process, not a reiteration of the line items on the invoice.

The restoration company must excel at performing water restoration, but also at documenting their performance. Job project documentation should show how the restorer inspected the situation, established the best course of action, and decided what equipment would address the problem effectively, as well as record the results of procedures used to return the structure to a pre-loss condition.

## Adjusting the Drying Method

After a thorough initial inspection, restorers install equipment according to accepted equipment formulas. After 24 hours (or less) of drying, materials are re-inspected (monitored) to determine if progress was made. As each material's progress is documented, equipment and processes are adjusted as follows:




*Material Is Drying* — If the material is drying, continue with the current drying approach. It is working properly and progress is being made.

*Material Has Dried* — If the material has achieved its drying goal, reposition equipment to focus on other areas, or remove it from the structure.

*Material Is Not Drying* — If the material is not making progress, modify the approach. It is not working. Modification may be made to the equipment or the material, depending upon which is most economical.

The absolute constant in a wet structure is change. Change, when controlled closely, is a positive change: a change toward pre-loss condition. If the desired change is not evident (e.g., drying progress), the technician must control the change by other means. At this point, it is critical to re-evaluate the material:

*Contamination* — Now that materials have been wet for another 24 hours, is there a concern for contamination? Can this contamination, if present, be treated properly? Should the material be removed to ensure complete removal of the contaminant, if present?

*Damage* — Now that materials have been wet for another 24 hours, has permanent secondary damage become evident, such as warping, swelling, splitting or staining? Can the damage be restored, cost effectively?

*Cost* — The current system is not working and must be changed. What will result in the lowest cost — removal and replacement or more aggressive drying (e.g., more equipment)?

Using this approach of assessment and ongoing re-evaluation ensures that the structure is being thoroughly and properly dried for the lowest possible cost. Restoration will be maximized, reducing the amount of time necessary for repairs and reconstruction.

## Adjusting Equipment

In a restorative drying environment, conditions are constantly changing. As a result, the type and amount of equipment needed also changes. Just a few examples of what can be done to maximize effectiveness through frequent monitoring are:

- Repositioning air movement to the wettest areas:
    - Begin wall and flooring inspections in front of air movers, and reposition as needed.
- Removing equipment as materials return to their dry standard:
    - Restorers should establish drying goals that return materials to an acceptable dry condition. Drying goals may be set equal to the dry standard or within 10 percent of dry standard or normal Equilibrium Moisture Content (EMC).
- Changing equipment technology to meet drying challenges.
- Dealing with limitations and complications.

## Evaluating Dehumidifier Performance with Grain Depression


Monitor drying equipment to ensure that expected results are being delivered. Dehumidifiers are monitored using a calculation called grain (gram) depression. Grain depression is calculated by comparing the humidity ratio (GPP) of the air entering the dehumidifier to the humidity ratio (GPP) of the air processed by the dehumidifier. Air processed by a dehumidifier should always be lower humidity ratio than the affected air. Minimal grain depression indicates that a dehumidifier may be performing poorly.

When used alone, grain depression does not accurately reflect the unit's performance compared to other dehumidification systems. This is true because the amount of air processed by each dehumidifier (typically CFM, or cubic feet per minute, or CMH, cubic meters per hour) will vary.

The influence that CFM (CMH) has on actual water removal is important. It is best understood when the grain depression and CFM are used to estimate water removal in a more common measurement, such as pints of water in a 24-hour period. When these measurements are converted to pints (liters) per day, the result can be compared to the unit's rated performance. The water removal can also be compared to other dehumidifiers in the drying environment to establish performance differences.

The calculation for converting grain depression to pints of water removal per day is:

CFM × 60 (minutes in an hour) = CFH

CFH × 24 (hours in a day) = CFD

CFD ÷ 14 (cubic feet per pound of dry air) = lbs/air

lbs/air × grain depression = grains/day

grains/day ÷ 7,000 (grains per pound) = lbs/water/day

lbs/water/day ÷ 8.34 (lbs water per gallon) = gallons

gallons/day × 8 (pints per gallon) = pints

This calculation can be dramatically simplified. Because several of the factors are constant, they can be consolidated. The result is the following abbreviated formula:

P = CFM × GD ÷ 71

Where:

- P is Pints of Water Removal per 24 hours
- CFM is Cubic Feet per Minute processed by a mechanical system
- GD is Grain Depression
- 71 represents the abbreviation of all other constants in the original formula.

The Metric Calculation to convert gram depression to liters of water removal per day:

CMH × 24 (hours in a day) = CMD

CMD × 1.25 (kilograms of air per liter)

Kg air × gram depression = grams per day

Grams per day ÷ 1,000 = liters per day

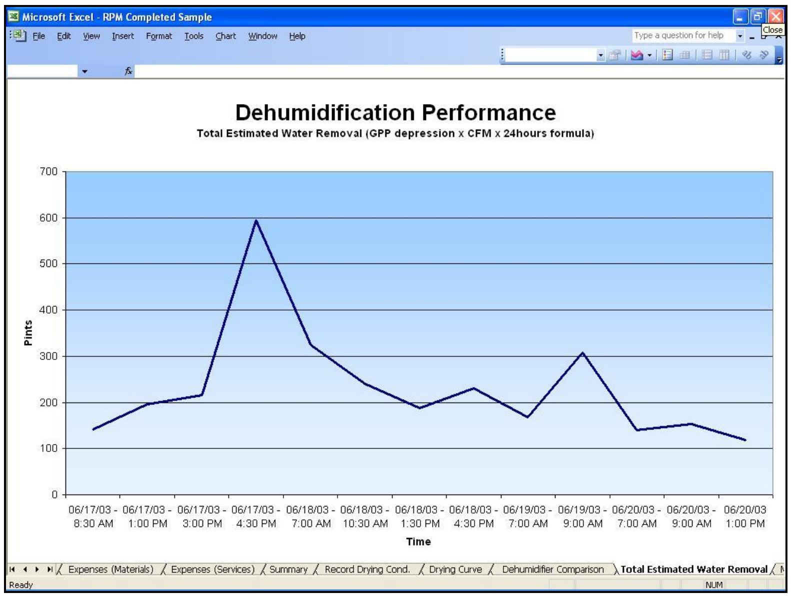
This calculation can be simplified because several factors in the calculation are constant. The result is the following abbreviated formula:

Liters per day = CMH × GD ÷ 33

## Interpreting Grain Depression in Context

Grain depression is a useful measurement for the restoration contractor to use when evaluating the effectiveness of the equipment in use. However, other readings, especially the measurement of material moisture content, are far more significant in judging the effectiveness and efficiency of the drying effort. Grain depression calculations should always be considered in light of other measurements, including:

1. Moisture in materials being dried.
2. Humidity and temperature of the air being used to dry affected materials.
3. Capacities of mechanical systems used to control temperature and humidity.




Best practices for monitoring a drying project require that restoration vendors understand the accuracy of the various types of data collected and not place unrealistic importance on grain depression numbers.

**1. Moisture in materials** — Drying structural materials is the ultimate goal for any drying project. Therefore, this data should be evaluated first, and should always receive the most attention. When evaluating the effectiveness of drying equipment, give first priority to material moisture content readings. If materials are drying, the system as a whole is performing, including the dehumidification.

If materials are not drying, priorities #2 and #3 now become critical:

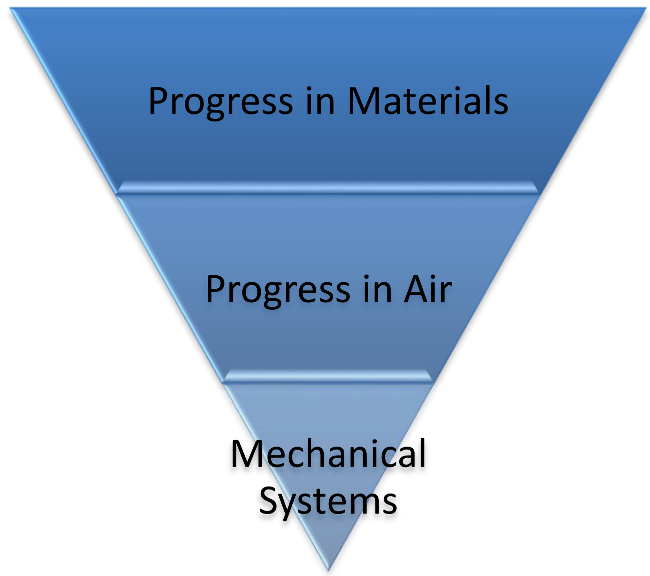
**2. Humidity and temperature of the air** — Monitoring the air being used to dry affected materials is the second priority. In evaluating this measurement, the restorer should ask:

- Is the air in the affected area drier than previous readings?
- Is the Relative Humidity of the air low enough to avoid secondary damage from high humidity?

If the answers are "Yes", then the drying system is appropriately balanced in terms of humidity control. If the answers are "No", then the drying system is not appropriately balanced and a new approach to dehumidification should be considered.

**3. Mechanical systems capacity.** Where available, a building's heating and air conditioning system can be used to control heat and, to a limited extent, humidity. Existing HVAC systems rarely have the capacity to provide the humidity control required in a water-damaged building, so portable dehumidifiers are needed. If the existing HVAC system and the installed dehumidifiers together are maintaining effective drying conditions, no change in dehumidification may be necessary.




Basing decisions about equipment performance solely on grain depression will lead to false determinations. To best understand the progress, performance and efficiencies of a drying project, restorers should first focus on material drying progress. Next, they should evaluate temperature and humidity readings for what could be changed to speed material drying and ensure additional damages are not caused by high humidity. Last, they should consider the combined effectiveness of the existing HVAC and portable dehumidifiers.

## Metering and Monitoring Techniques

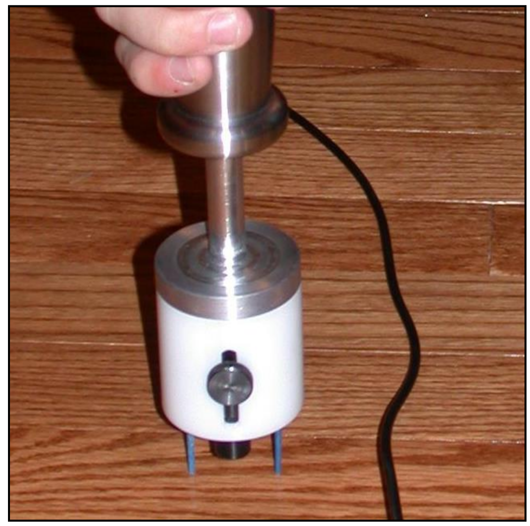
Restorers monitor a project to track the condition of affected building materials and their change in status from day to day. Using a couple of simple techniques and adding a few tools to your inspection kit will greatly increase your ability to determine accurately how wet building materials are, and whether or not they are drying. Some of these procedures will use fixed inspection point locations that are created by mounting semi-permanent monitoring probes in and on target materials. This greatly increases accuracy and validity by providing consistent location for daily monitoring.

### Measuring Moisture in Hardwood Flooring

In order to effectively monitor strip hardwood flooring, a combination of invasive and non-invasive moisture meters is required.

Non-invasive moisture meters allow the restorer to map out the areas of greatest moisture and to identify the extent of water migration. Non-invasive moisture meters are used only to map the extent of migration through the wood flooring. Moisture meters can also be used to monitor the subflooring beneath the hardwood if the subfloor is accessible from below. This is the preferred method of determining whether the subfloor is drying.

If it is not possible to measure the moisture from below, the invasive meter can be used to measure the moisture content inside the strip hardwood and in the subfloor beneath. Focus on the areas of greatest moisture already identified by the non-invasive moisture meter. When using a hammer probe to monitor strip hardwood flooring, the pins are inserted into the darker "winter" portion of the grain which is more easily repaired. The dark winter wood is also known as the "grain" but is more properly called "late wood." To minimize damage to the wood, insert the probes near the center of the target board to avoid splitting the strip flooring.

Once it has been determined that the floor can be salvaged by in-place drying, the first step is to determine a drying goal for the hardwood and subfloor. Directing warm dry air under and between the boards is the most effective way to dry the hardwood.

The wood is considered dry when:

- Hardwood and subsurfaces are within 10 percent of the dry standard or normal moisture content (EMC).
- Subsurfaces below hardwood are dried to within 2–4 percentage points of the hardwood.

After the wood flooring has been dried to an acceptable moisture content, remind the customer to allow sufficient acclimation time before the floor is refinished.

### Monitoring a Wall Assembly and Wall Plate Behind Cabinets

Monitoring behind built-in cabinetry can be a challenge.

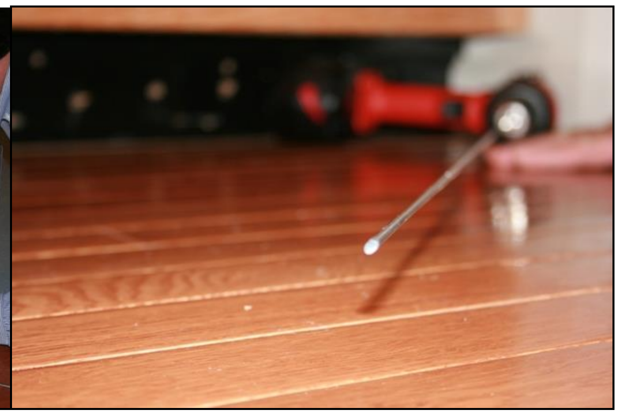
Required tools and equipment:

- *Cordless driver*
- *Alligator Clips (2) wired to connector*
- *Penetrating moisture meter*
- *30" or longer metal rods (brazing rod or similar) cut at tip*

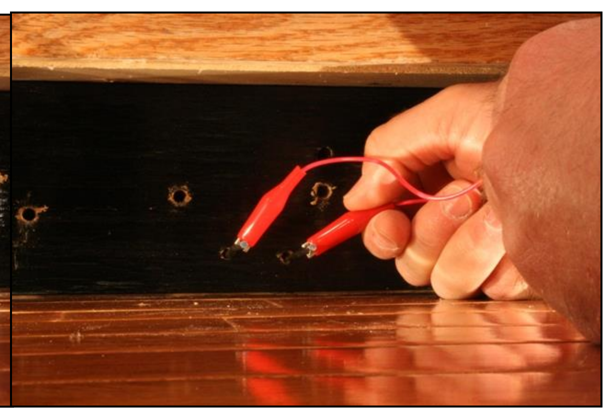
Often, monitoring the wall assembly and wall plate behind cabinets required destructive processes from inside the cabinet. Creating holes in the cabinet often leaves behind visible evidence of the monitoring process. The process outlined below will eliminate the visible damage and increase the accuracy and consistency of the monitoring process.

Begin by removing the baseboard or other trim from the toe kick on the cabinet assembly. In the photo (left), the trim has been removed from the toe kick. Next, prepare two long metal rods for insertion into the exposed wood structural member (which may or may not be present). Ensure metal rods are long enough to pass completely beneath the cabinets and into the assembly behind. Usually 30″ will suffice. The metal rod can be a brazing rod or any other conductive steel / metal rod. Many such materials can be found at the local hardware store.



Using a cordless driver, drill the metal rod into and through the cavity beneath the cabinets. This process will be much easier if the tip of the metal rod is cut at a sharp point to allow it to bore its way through the assembly. Cutting or shaping the rod to give it a sharp point can be accomplished using a grinding wheel or with steel wire cutters, snips or other hand tools capable of cutting through the material selected.



Attach clips to the end of the exposed rods once the rods are inserted. The alligator clips can be wired to the same connector used on penetrating moisture meters.

## Monitoring the Wall Plate without Removing Base Trim

The 2 × 4 wall plate at the base of the interior and exterior wall assembly is commonly affected by migrating water. Monitoring this material is critical to ensure complete and total drying of the affected structure. Accessing this plate can be a challenge, unless the appropriate tools are available.

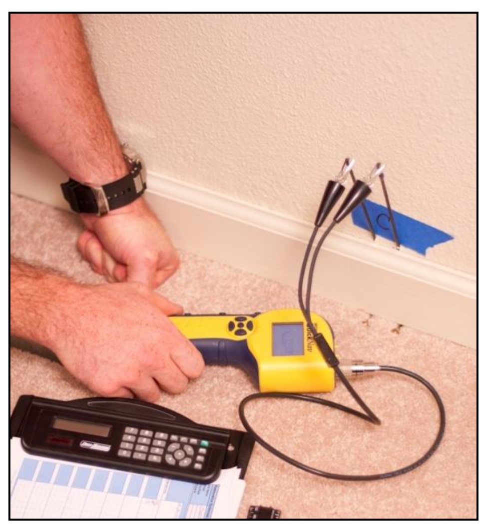
Required tools and materials:

- Penetrating moisture meter
- 3″ or longer wood screws
- Alligator Clips wired to connector

Using the 3″ wood screws, as opposed to the standard deep wall cavity probes, will yield a much more accurate reading of the plate and substrate. The wood screws are driven into the wall plate just beneath the base trim assembly. Ensure the screws are driven at least 1.5″ into the wall plate. The wood screws allow for penetration into and through the assembly, accessing moisture that the deep wall cavity probes will not be able to reach.

## Monitoring through Extensions

Monitoring procedures using screws or rods can be applied to many building assemblies where the depth of penetration required exceeds the depth commonly provided by deep wall cavity probes. Commonly, the manufactured deep cavity probes are 6″ – 12″ in length.

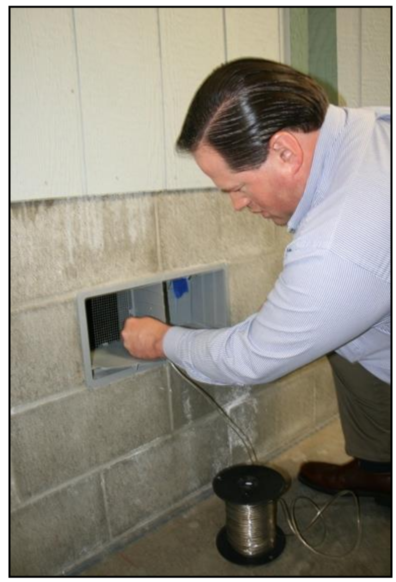


### Substructure Monitoring: Setting Points Beneath Inaccessible Areas

Commonly, the only way to access certain areas of the structure is by entering areas such as crawlspaces or deep into relatively inaccessible areas such as plumbing access holes and other hard-to-reach areas.

These areas can be accessed *once* to set semi-permanent inspection points using wood screws, wire and ring terminals. The wire can be run to a more accessible area for daily monitoring of this fixed location, preventing the need to continue to enter the relatively inaccessible area. The fixed location increases accuracy, while the wire extension speeds daily monitoring.



Required tools and materials:

- 18 gauge speaker wire
- Wire strippers / cutters
- 18 gauge ring terminals
- Appropriate length wood screws

Prep the wire assembly by crimping on 18-gauge ring terminals to the end of each wire. Insert wires into the space where the inspection point will be set.

Mount the wire assembly with ring terminals to the material to be monitored. Use wood screws that are the appropriate length for the material (e.g., ¾″ wood screws when monitoring ¾″ plywood subflooring).


Attach the meter to the other end of the speaker wire using alligator clips. If several inspection points will be set using this method, avoid confusing the points by "flagging" each wire coming out of the space with an identification.

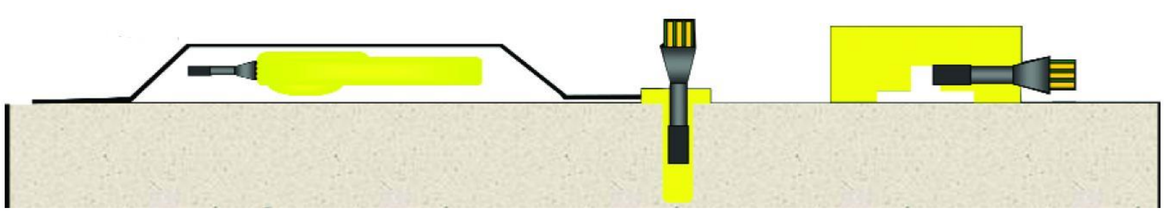
### Testing for Moisture in Concrete

Floor covering manufacturers specify that concrete should not exceed a maximum moisture or vapor emission level before the installation of flooring in order for a warranty to be valid. Flooring manufacturers have generally agreed that a vapor emission level of 3 pounds or less of water per 1,000 SF per 24 hours is acceptably dry for installation (Schnell). In addition, the manufacturer may specify the method of testing for this moisture level. The following are descriptions of the most common concrete moisture testing methods specified by the flooring industry:

**Plastic Sheet Test (ASTM Standard D4263):** This is a qualitative test which involves taping an 18" square of 4-mil polyethylene sheet onto the concrete surface and allowing the sheet to remain attached and undisturbed for at least 16 hours. The underside of the sheet and the concrete surface are then observed. If moisture has condensed under the sheet, or if the concrete has darkened noticeably, then excessive moisture is present and the concrete is not ready for installation of a moisture-sensitive covering. This is the least accurate method of testing, but is inexpensive and non-destructive.


**Electrical Impedance Test:** The electrical impedance test is a qualitative test using a non-invasive (non-penetrating) meter. These meters can provide useful information on relative differences in moisture conditions of the concrete. Meters that are specifically designed for use on concrete are available. Flooring manufacturers do not generally recognize this method as valid for warranty purposes, but for the restorer this may be the most practical test to perform as it does not require significant time or special expertise.

**Moisture Vapor Emission Rate (MVER) (ASTM Standard F1869):** This is a quantitative test commonly referred to as the Calcium Chloride Test. Most flooring manufacturers give specifications for this test in terms of pounds of moisture emitted from 1,000 sq. ft. in 24 hours. The ASTM standard requires that the room and floor be at normal service conditions for 48 hours before performing the test. The calcium chloride is weighed, placed on the floor and the dome is secured to form a tight seal. After 60 to 72 hours, the dish is removed and re-weighed. The difference in weight is the moisture that was emitted from the concrete.



Plastic Sheet Test ASTM 2170 ASTM 2420

**Surface RH Insulated Hood (ASTM Standard F2420):** This test seals an insulated hood to the surface of the concrete and, once it is acclimated, determines the RH by placing a thermo-hygrometer under the hood. Although not as accurate as the ASTM Standard F2170 test, the insulated hood method is more feasible for restoration-related activities. It retains the accuracy of temperature by using an insulated dome. It loses accuracy in relative humidity because the test is limited to the surface of the concrete. Longer acclimation times will yield more accurate results.

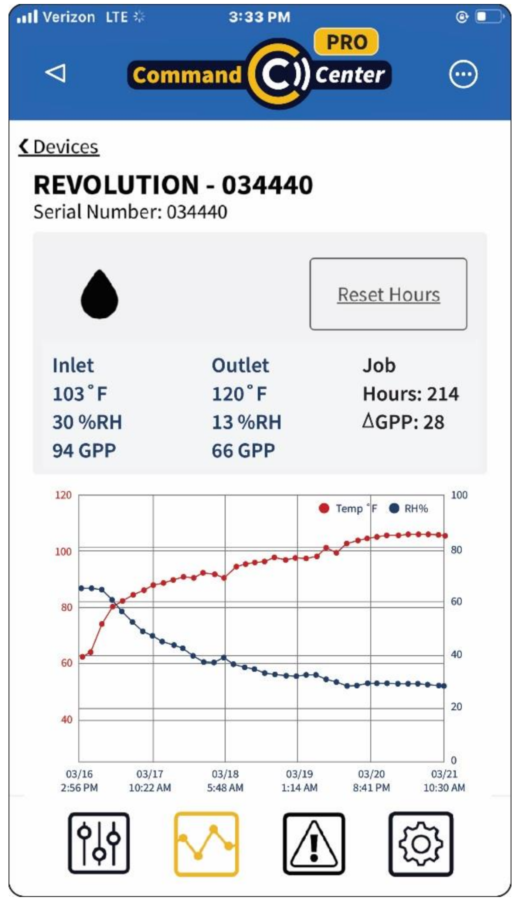
**Relative Humidity Probe (ASTM Standard F2170):** This is a quantitative test that has been common in Europe for many years but only recently has begun to receive acceptance in the U.S. It is performed by measuring the relative humidity in concrete. In a slab drying from top only, a hole is drilled and probe is inserted to 40% of the slab depth.

Acceptable maximum equilibrium relative humidity levels have been established by many flooring manufacturers to meet their warranty standards. There are specific requirements for placement, quantity of test points and calibration of the probes. The ASTM standard requires that the room and floor be at normal service conditions for 48 hours before performing the test.

| Flooring Standards for RH Probe (ASTM F2170) Test | |
|---|---|
| **Max. %RH** | **Cover Material** |
| 90% | • Plastic tiles<br>• Plastic carpet with no felt or cellular plastic base |
| 85% | • Vinyl flooring<br>• Textile carpet made of natural fibers<br>• Textile carpet with latex, rubber or PVC backing<br>• Cork tiles with a vinyl layer on the underside<br>• Plastic carpet with felt or cellular plastic base<br>• Rubberized carpet |
| 80% | • Wood and wood-based materials<br>• Vinyl floor coverings with a paper backing<br>• Cork tiles without vinyl layer on the underside<br>• Mosaic parquet on concrete |
| 60% | • Parquet board with no plastic film between wood and concrete |

*Source: The Finnish SisaRYL 2000 Code of Building Practice and Swedish HusAMA83*

## Systems to Measure and Document Job Site Conditions




Restorers can install systems on a job site to record and even transmit temperature, humidity, and moisture level measurements. These systems are capable of recording restoration measurements at pre-determined time intervals, allowing the restorer to evaluate not only the current job site status, but also conditions present between each monitoring visit. Some systems even provide historical data from the beginning of the project or allow the restorer to modify the operation of drying equipment, including powering equipment on or off from a remote location, such as the company office or warehouse.

Systems used currently in the restoration industry include:

- Handheld instruments commonly called "Data Loggers" — These devices log temperature, humidity, and moisture content data. They record measurements on demand or at pre-set or customizable intervals. The data is downloadable, and some systems can report data via a Wi-Fi connection at the job site.
- Wireless data transmission — Wi-Fi and Bluetooth-connected restoration equipment offer systems that report to apps and/or websites via the Cloud. Project atmospheric conditions, dehumidifier performance, and even material moisture data can be viewed in real time, with some historic data available. Additional features are remote monitoring, control, and tracking of wireless enabled dehumidifiers and HEPA air scrubbers.


- Remote monitoring systems — A high capacity dedicated data acquisition device frequently "pings" multiple wireless sensors placed in its range. The sensors collect measurements of temperature, relative humidity, or wood moisture content on the job site. Data is pushed out to servers for long-term storage, and detailed customized reports can be produced.

Systems that provide remote access to job site data offer certain advantages to the restorer:

- Restorers gain an ability to know if the drying atmosphere has become unfavorable or when equipment has been turned off, finding out well ahead of their planned monitoring visit.
- These systems transmit temperature, humidity, and even moisture content readings that represent job site conditions accurately. Daily decision-making and job documentation are not hindered by inconsistencies of measurements using handheld instruments.
- Restorers can generate reports in professional-looking formats.

## Successful Ongoing Daily Decisions

The most successful restorer will apply the tools and techniques that are best suited to each unique structural drying project. This requires an array of tools to control humidity, temperature and airflow in a variety of circumstances and the knowledge to apply each tool properly. It is critical to diligently and thoroughly evaluate the change in materials over time, and adjust the drying system as progress dictates.

A drying job site is a dynamic environment where change is constant. The change desired in drying is movement toward a pre-loss condition — by first creating a clean, safe environment and then assessing potential damage. Because the job is not complete until materials are clean, dry, and equal or better in appearance and function than when the loss occurred, the impact of each decision must be evaluated closely. Ultimately, decisions must direct the work toward the most cost effective process available to achieve this end.

## Microbiology

When structures are allowed to remain wet for extended periods of time, microbial growth begins nature's recycling process. Microorganisms begin to feed on the organic materials in the structure, breaking them down into simpler compounds. As this occurs, the levels of mycotoxins, endotoxins, exotoxins, volatile organic compounds and organic debris begin to escalate. At the same time, structural components begin to lose integrity and visible damage occurs in the form of staining.

Plain water has no odor. When odors are present, this means that water has contacted a material or organism that can release volatile compounds. These volatile compounds are readily released into the air and detected as odors. Strong musty or bitter odors are the clearest indication of microbial contamination and signal the need for further inspection to find the source. The best way to prevent odors and retard microbial growth in a wet structure is to ensure that all materials are dried thoroughly and rapidly. No other procedure is as effective in the prevention of microbial growth.

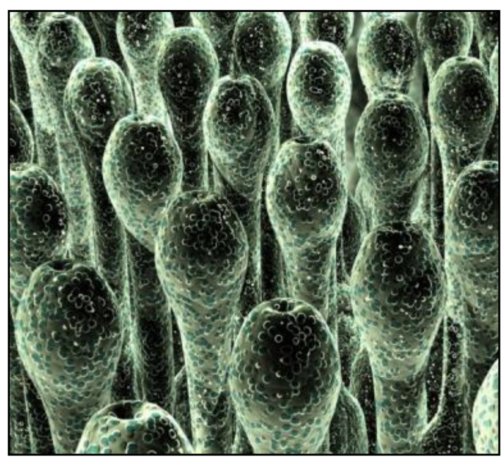
## Microorganisms

Living creatures that are too small to see with the naked eye, called microorganisms, include fungi, bacteria, protozoa, parasites and algae. Viruses too may be included in this list, though they live and propagate by other mechanisms.

In the restoration context, the two types of microorganisms usually encountered are fungi and bacteria. Some important modifications to standard restoration practices must take place when dealing with these organisms.

### *Fungi*

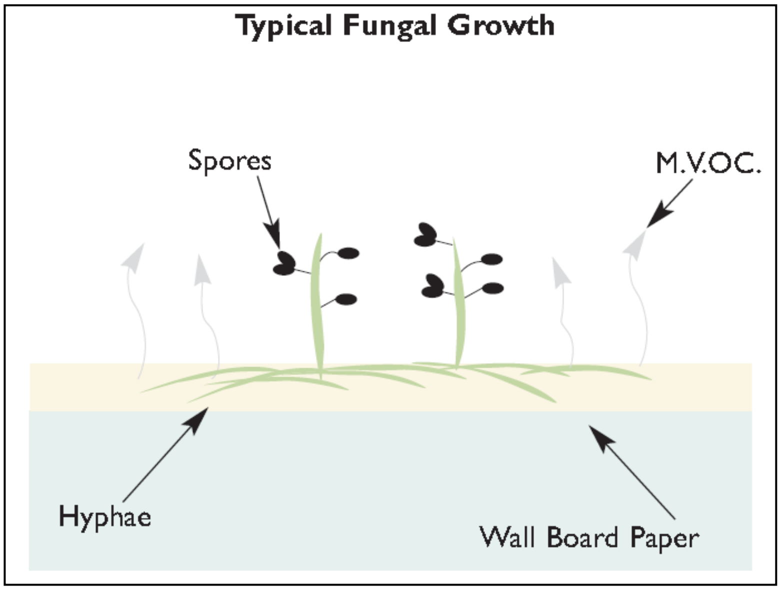
The microorganism most apparent in structures that have had prolonged contact with relatively sanitary water is fungus. When moisture levels are sufficient (about 16% moisture content in wood), mold can germinate and grow on the surface of virtually any material. Surface molds can feed on the dusts and soils present across every interior surface, in carpets, etc. They can also grow on cellulose materials like paper and wood.



When mold forms a colony, several significant processes are taking place. First, the process of digestion occurs as mold breaks down organic material. This creates a by-product known as a Microbiological Volatile Organic Compound (MVOC). Because they are volatile, MVOCs are readily released into the surrounding air. They are responsible for the odor associated with mold growth, typically an earthy, musty odor. These odors when present indicate that active microbial growth is occurring. MVOCs have not been shown to be toxic to humans.

A second process is defensive. Growing mold under certain conditions produces chemical substances called mycotoxins. These toxins give mold a competitive advantage over neighboring microorganisms competing for food. Unlike MVOCs, some mycotoxins have been shown to be toxic to humans.

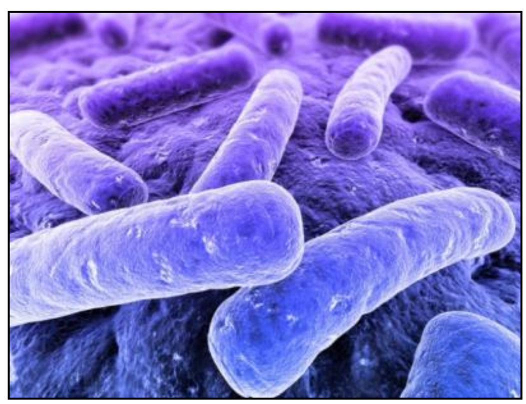



When the presence of mold is suspected, restorers should communicate with all parties and use appropriate protective measures. Remediation costs and safety considerations should be agreed upon. Also, consider the impact of drying equipment when mold is present. As with any contaminant, mold should be removed or contained before any air movers are placed in the structure. Remediation of microbial growth must be conducted in a manner that avoids cross-contamination of unaffected areas. Blowing air can spread mold spores and hyphae fragments from the contaminated area to previously unaffected rooms. Antimicrobials and biocides can help manage growth, but they are not sufficient in themselves to eliminate the contaminant. Antimicrobial treatments must be followed by proper removal of the mold growth.

Mold can also germinate within wood and begin to break down the material. This type of fungi is commonly referred to as rot, but is actually a member of the mold family. Rot can occur in wood that is visibly wet, or above fiber saturation point (30% MC in many wood species). When this occurs, the rot is referred to as a wet rot. Rot can also occur when wood is visibly dry, below its fiber saturation point, yet wetter than 20% moisture content. This occurrence is referred to as dry rot.

### *Bacteria*

Like fungi, bacteria grow and feed on organic materials. But unlike fungi, which can grow whenever excessive moisture is present, bacterial growth is most likely to appear in structures affected by unsanitary water from outdoor flooding, sewage systems and septic systems. Under the right conditions, the number of bacteria could double every 15 minutes.



Bacteria produce MVOCs and toxins, just like fungi do. Odors from bacterial activity are typically much more pungent and bitter than fungi odors. Bacteria obtain energy from digestion, and their digestion occurs outside of the organism. One of the by-products of the digestive process is off-gassing, which creates the musty odor that we smell at a water loss. The toxins created by bacteria are referred to as endotoxins when they are produced inside the bacterium itself and exotoxins when they are secreted by the bacterium into the surrounding environment. The ways to minimize, reduce or eliminate bacteria are by proper cleaning, drying wet materials and applying EPA-registered antimicrobials or biocides.

### Odors and Growing Organisms

Water damage responders often adopt the generally accepted time frame that mold begins to grow within 24 to 48 hours. The U.S. Environmental Protection Agency (EPA) recommends responding to clean water damages within the time line of 24 to 48 hours to prevent mold growth and states: “Even if materials are dried within 48 hours, mold growth may have occurred” (see the EPA publication *Mold Remediation in Schools and Commercial Buildings,* page 11, Table 1). If in connection with the 24–48 hour time frame, restorers also detect musty odors, they normally associate the odors with microbiological volatile organic compounds (MVOCs) as indicating mold is growing.

On some losses mold seems to grow, and on other losses mold does not seem to grow. Water damage restoration technicians experience some projects that have been wet for two or three days where microbial growth is still not evident when they arrive. On other jobs, they observe visible growth immediately upon arrival, assume it is mold, and see other signs that the building has more issues than just being flooded. So does mold really begin to germinate and grow (the technical term is “colonize”) in 24 to 48 hours?

How long does it take mold to grow? A realistic answer should consider both *mold spores* and *mold colonies*. Indoor Environmental Professionals (IEP) report that, in the lab, spores begin to germinate and form microscopic structures in a few hours. The first tiny visible colonies of fast-growing mold types may arise in about three days (72 hours). However, colonies large enough to visibly identify and count may not appear until about four days (96 hours). Some slow growing types of mold may not grow colonies fast enough even within this time frame. (Personal communication with Payam Fallah, a PhD mycologist with the Indoor Environmental Hygiene Laboratory).

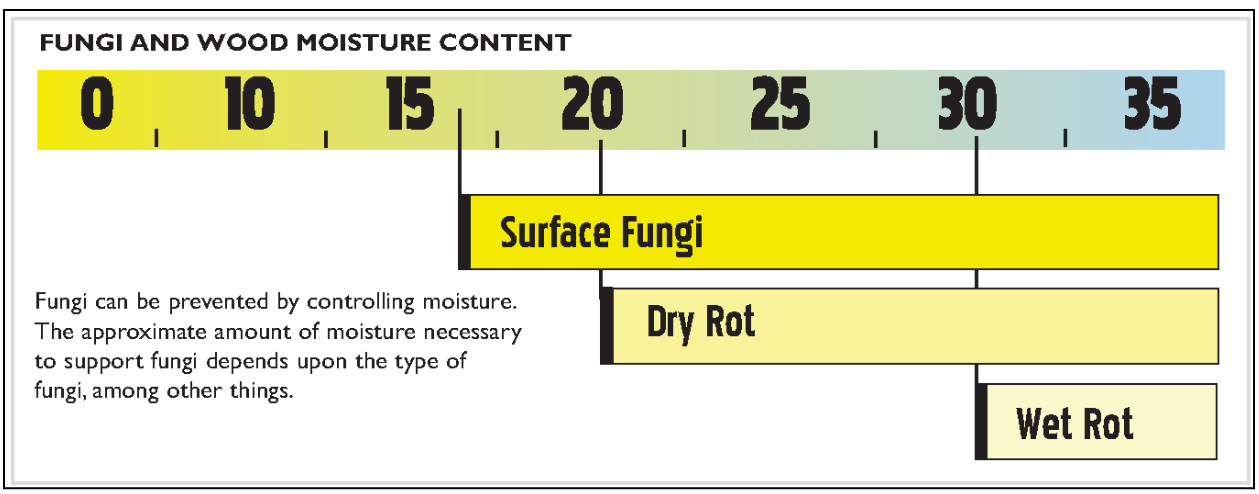
While mold spores may germinate within 24 to 48 hours, much more time is often required for mold colonies to grow and potentially produce musty odors. This point was demonstrated in a test led by Michael Krause, CIH, with Veritox Inc. Krause and his associates performed a test with a number of untreated and treated wallboard sheets under very controlled scientific conditions.

Their paper entitled "Controlled Study of Mold Growth and Cleaning Procedure on Treated and Untreated Wet Gypsum Wallboard in an Indoor Environment" reports the results. At least a week passed before they could confirm that invisible microscopic growth structures (hyphae) had formed on wet untreated wallboard in a closed office. Mold growth colonies were not visible on untreated drywall until three weeks into their eight-week experiment.

Restorers should always make note of musty odors during a water damage response. They should not, however, immediately assume that mold is growing whenever 48 hours have passed since the water intrusion. Keep in mind that different mold species colonize at different rates and the time required for colonization is affected by different climates and different food sources.

### Surface Water Activity and Organism Growth

The restoration industry commonly refers to 16% or 20% *moisture content* (MC) as reflecting moisture levels required for microbial growth. Those measurements provide a general indication of whether wood is wet enough for microbial growth. A more exact measurement for microbial growth potential is known as *water activity*.




Moisture content measurements do not indicate how much moisture exists for microbial growth to start or to be sustained. The moisture measured by MC is not spread uniformly throughout the material. Technicians take numerous MC measurements, finding readings such as 16, 20, 26 percent, etc., indicating some locations are wetter or drier than other locations. The MC reading for the location at which the reading is taken does not describe the wetness of the entire board.

Microbial growth occurs at the surface level of a material. Microbiologists have learned that the moisture at the surface level has to be at a certain minimum level for microbial growth to begin and continue. Different materials require different levels of surface wetness to sustain microbial growth. The measurement that best describes the amount of water at the surface is *water activity*. Water activity (abbreviated as $a_w$) is the amount of water at the material's surface from which microbial life can draw sufficient water for germination and growth.

Water activity ($a_w$) can be measured by using a thermo-hygrometer. Place a thermo-hygrometer under a small sheet of plastic wrap. Tape the edges shut, trapping the meter inside the plastic envelope. The meter is now trapped inside an envelope of air — one side is the affected material and the other side is the plastic bag (non-permeable).

The air in this envelope will reach what is known as equilibrium, meaning that the moisture in the material will evaporate into the air space of the envelope, and as this air becomes more humid, the moisture will be absorbed back into the material. Thus the air in the envelope space and the moisture at the surface of the material will have reached equilibrium.

The relative humidity reading inside the envelope space indicates what is known as Equilibrium Relative Humidity (ERH). The reading is the relative humidity of the air at the surface of the material which is available to support microbial growth. The time required to measure this ERH varies with the material, porosity, surface coating and amount of moisture in the material.

The ERH reading is easily converted to water activity ($a_w$):

$$ERH / 100 = a_w$$

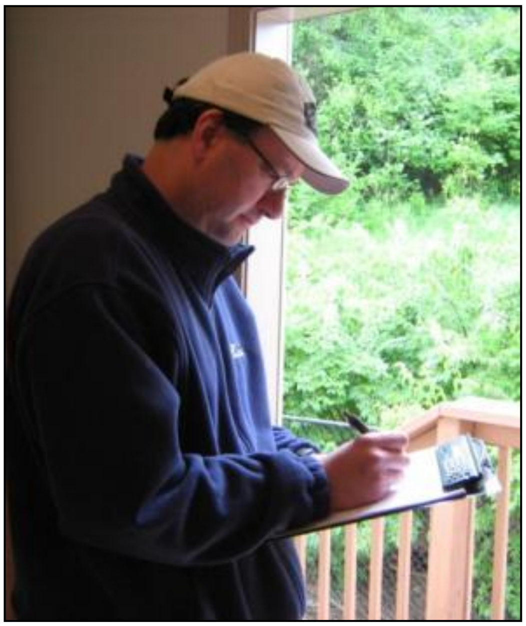
An ERH reading (inside the space of the envelope) of 60% would equate to an $a_w$ reading of 0.60.

The minimum $a_w$ required for microbial organisms to germinate and grow is 0.66, which is equal to an ERH of 66%. Virtually no microbial growth can occur if the $a_w$ is below 0.65. Students in water damage restoration classes are taught to lower indoor relative humidity (RH) below 60% as quickly as possible. If the indoor humidity stayed above 66% RH for an extended period of time, the wood could reach 0.66 $a_w$, which would support microbial growth. Hygroscopic materials would suffer rapid microbial growth when relative humidity rises above 70% RH ($a_w$ of 0.70).

Both moisture content (MC) and water activity ($a_w$) are measurements that tell us about the amount of water in a material and on the surface of a material. Moisture content reflects the amount of moisture at a specific location on a material. Water activity reflects the amount of moisture at the surface of a material for sustaining microbial growth.

### Third Parties

Situations involving extensive microbiological contamination may involve an independent, third party evaluator or other professional to assess structural damage, microbial problems and other potential health and safety risks. Third party professionals may provide a pre-remediation assessment of contamination, a protocol of recommended cleaning procedures, and/or a post-remediation test to verify the effectiveness of remediation activities. Restorers should use a third party in situations that involve severe public health issues, high risk occupants living or working in the structure, or extensive microbial contamination that can affect worker or occupant health.



A number of third party experts and specialists are available when needed, including industrial hygienists, physicians, microbiologists, indoor environmental professionals (IEPs) and attorneys. Seek expert advice and guidance when you have concerns about the risk and liability associated with the impact of restoration-related decisions.

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