JS HELD

PERSPECTIVES

Water Damage Restoration: A Guide to Advanced Structural Drying

Our perspectives feature the viewpoints of our subject matter experts on current topics and emerging trends.

OVERVIEW

Advanced Structural Drying (ASD) is the effective, efficient drying of water-damaged buildings and dwellings, using comprehensive knowledge and tools. The process includes the collection of appropriate data for utilization and application of scientific and technical principles. Psychrometry - the science of drying, helps to track moisture content, drying progress, and the verification of project completion. In many cases, ASD uses more equipment to accelerate drying, thus reducing costs, time, and the inconvenience related to replacement and repairs.

Specialized training in ASD helps in understanding the science of water damage and best practices on water losses. Psychrometric science includes atmospheric air mixtures, their evaluation, control and effect on material, and the comfort level of occupants. With a reasonable understanding of psychometrics, restorers can often dry and restore materials, which in the past were demolished and rebuilt. Science and best practices to dry building materials using airflow, amplified dehumidification, and controlling temperature/energy provide exceptional results to dry structures.

WATER DAMAGE RESTORATION

Water damage restoration is best identified within the Institute of Inspection, Cleaning and Restoration Certification (IICRC) Standard and Reference Guide or Professional Water Damage Restoration (IICRC S500 -2015 Fourth Edition). The document outlines the principles behind safe water restoration and includes steps a vendor should consider with reference material behind the standards. It is important to note that while the IICRC S500 provides the foundation for basic principles, it does not teach complex water damage processes.

Determining the category and class of water related to a disaster are important components in the beginning of a water damage restoration. This information allows the restorer to formulate a drying strategy to meet initial needs of the water project.

"Category of Water" identifies the initial condition of the water affecting materials and potential range of contamination in water and water quality once it comes into contact with materials. In other words, how clean or how dirty is the water source?

IICRC S500 references the use of an Indoor Environmental Professional (IEP) in its definitions to determine the Category of water. It defines an IEP as, "An individual with the education, training and experience to perform an assessment of the microbial ecology of structure, systems and contents at a job site, create a sampling strategy, sample the indoor environment and submit to an appropriate laboratory, interpret laboratory data and determine Category of water or Condition 1, 2, and 3 for the purpose of establishing a scope of work and verifying the return to a normal microbial ecology (e.g. Condition 1)." Section 10.6.7 of IICRC's S-500 also confirms that an IEP should be used to assess the levels of contamination for the preliminary determination.[1] Thus, the determination of the Category of water should be performed by a person that meets the appropriate standard, especially when certain conditions or "risk situations" are present.

> [1] *ANSI/IICRC S500-2015 Standard and Reference Guide for Professional Water Damage Restoration – Fourth Edition*

Section 10.6.7 of IICRC's S500 indicates, "If the inspection shows that one or more of the following elevated risk situations are present, then an IEP should be retained...... considerations can include, but are not limited to:

- Occupants are high risk individuals;
- A public health issue exists (e.g., elderly care or child care facility, public buildings, hospitals);
- A likelihood of adverse health effects on workers or occupants;
- Occupants express a need to identify a suspected contaminant;
- Contaminants are believed to have been aerosolized;or
- There is a need to determine that the water actually contains contamination."

In states where mold regulations for consultants and assessors are enacted, consumer protection laws exist to require that the IEP or mold assessor/consultant not have any financial connection to the company performing the restoration work. This allows the mold assessor/consultant to provide an independent opinion as to the presence or absence of contamination and determine the scope of remediation work to be performed. IICRC's S500 also uses the word "independent" to describe the IEP. Devoid of regulation and the IICRC's S500, it is commonly recognized that it is important to avoid any conflict of interest with the mold assessor/consultant and restoration contractor.

CATEGORY OF WATER

- **Category 1** – Category 1 water originates from a sanitary water source and does not pose substantial risk from dermal, ingestion, or inhalation exposure. Examples of Category 1 water sources can include, but are not limited to: broken water supply lines; tub or sink overflows with no contaminants; appliance malfunctions involving water-supply lines; melting ice or snow; falling rainwater; broken toilet tanks; and toilet bowls that do not contain contaminants or additives. However, once clean water leaves the exit point, it may not remain clean once it contacts other surfaces or materials.

- **Category 2** – Category 2 water contains significant contamination and has the potential to cause discomfort or sickness if contacted or consumed by humans. Category 2 water can contain potentially unsafe levels of microorganisms or nutrients for microorganisms, as well as other organic or inorganic matter (chemical or biological). Examples of Category 2 water can include, but are not limited to: discharge from dishwashers or washing machines; overflows from washing machines; overflows from toilet bowls on the room side of the trap with some urine but no feces; seepage due to hydrostatic pressure; broken aquariums; and punctured water beds.

- **Category 3** – Category 3 water is grossly contaminated and can contain pathogenic, toxigenic, or other harmful agents. Examples of Category 3 water can include, but are not limited to: sewage; toilet backflows that originate from beyond the toilet trap regardless of visible content or color; all forms of flooding from seawater; ground surface water and rising water from rivers or streams; and other contaminated water entering or affecting the indoor environment, such as wind-driven rain from hurricanes, tropical storms, or other weather related events. Such water sources may carry silt, organic matter, pesticides, heavy metals, regulated materials, or toxic organic substances.

- **Regulated Hazardous Materials & Mold** – If a regulated or hazardous material is part of a water damage restoration project, then a specialized expert may be necessary to assist in damage assessment, and government regulations apply. Regulated materials posing potential or recognized health risks may include, but are not limited to: arsenic, mercury, lead, asbestos, polychlorinated biphenyls (PCBs), pesticides, fuels, solvents, caustic chemicals, and radiological residues.

Specialized experts include IEPs, as indicated by IICRC, but also should meet definitions from other science-based organizations such as the American Industrial Hygiene Association (AIHA).[2] The most basic standard for an Industrial Hygienist is "…a person possessing either a baccalaureate degree in engineering, chemistry, or physics or a baccalaureate degree in a closely related biological or physical science from an accredited college or university, who also has a minimum of three years of industrial hygiene experience." Professionals that meet these standards are those that can be qualified to perform this sampling. In some cases, such as with asbestos and lead, individual federal or state certifications may be required to sample these materials.

[2] *American Industrial Hygiene Associations (AIHA)*

In order to begin the drying process, the estimated or probable rate of evaporation is required. A component of the humidity control requirements is the Class of water. According to IICRC's S500, the Class of water intrusion is defined as a classification of the estimated evaporation load and is used in calculating the initial humidity control. It is based on the type of materials affected (porosity and permeance) and the amount of wet surface area in the room or space that was flooded. The classes are divided into four separate descriptions, Class 1, 2, 3 & 4:

- **Class 1** – least amount of water, absorption, and evaporation load. Water intrusion where wet, porous materials (e.g., carpet, gypsum board, fiber-fill insulation, concrete masonry unit (CMU), textiles) represent less than ~5% of the combined floor, wall, and ceiling surface area in the space; and where materials described as low evaporation materials (e.g., plaster, wood, concrete, masonry) or low evaporation assemblies (e.g., multilayer wallboard, multilayer subfloors, gym floors, or other complex, built-up assemblies) have absorbed minimal moisture.

- **Class 2** – significant amount of water, absorption, and evaporation load. Water intrusion where wet, porous materials (e.g., carpet, gypsum board, fiber-fill insulation, concrete masonry unit (CMU), textiles) represent l ~5% to ~40% of the combined floor, wall, and ceiling surface area in the space; and where materials described as low evaporation materials (e.g., plaster, wood, concrete, masonry) or low evaporation assemblies (e.g., multilayer wallboard, multilayer subfloors, gym floors, or other complex, built-up assemblies) have absorbed minimal moisture.

- **Class 3** – greatest amount of water, absorption, and evaporation. Water intrusion where wet, porous materials (e.g., carpet, gypsum board, fiber-fill insulation, concrete masonry unit (CMU), textiles) represent more than ~40% of the combined floor, wall, and ceiling surface area in the space; and where materials described as low evaporation materials (e.g., plaster, wood, concrete, masonry) or low evaporation assemblies (e.g., multilayer wallboard, multilayer subfloors, gym floors, or other complex, built-up assemblies) have absorbed minimal moisture.

- **Class 4** – deeply held or bound water. Water intrusion that involves a significant amount of water absorption into low evaporation materials (e.g., plaster, wood, concrete, masonry) or low evaporation assemblies (e.g., multilayer wallboard, multilayer subfloors, gym floors, or other complex, built up assemblies). Drying may require special methods, longer drying times, or substantial water vapor pressure differentials.

DRYING METHODS FOR MITIGATION

Restorers use the information obtained during evaluation of materials to help select the best drying method for the job. Generally, there are two primary approaches to promote drying an affected structure:

1. Disruptive drying methods involve removing wet items, injecting air to speed up drying, or perforating surfaces to allow water to evaporate. Disruptive methods are used when contamination, damage, cost, or customer concerns require removal or manipulation of the affected material.

2. 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.

The IICRC sets industry standards for water damage and mold remediation. Through research, laboratory testing, and field experience, the IICRC has identified four principle components for successfully drying a structure.

1. Remove the Excess Water: Extraction - The Water Removal Phase

There are three ways of removing water from a structure; physical extraction, dehumidification, and evaporation. Removal of liquid water is at least 500 times more efficient than just going straight to using dehumidifiers and air movers. The more water that can be extracted, the quicker the structure will dry. The density of materials will all affect extraction and dry time.[3]

[3] Disaster Academy – Study Guide – Applied Structural Drying and Water Damage Restoration

Different types of extraction tools:

- Light wand – Primarily used around the perimeter of the water loss and to extract glue-down carpets

- Stationary tool (e.g., water claw) – A subsurface extraction tool used to extract carpet and cushion (pad)

- Self-propelled tools (e.g., Rover; Xtreme Xtractor) – A riding extraction tool, some with multi-speeds, used to extract carpet and cushion

- Vacuum squeegee – Squeegees are used to move large volumes of water, mud, debris, waste, and snow on concrete; hardwood; vinyl; and laminate

2. Enhanced Airflow: The Evaportaion Phase

Following the removal of as much water as possible, the remaining moisture is evaporated by use of high velocity air movers.

Most objects, when exposed to water or high levels of humidity, will absorb some of the water or moisture, making them damp or wet. By drying the material object, we are providing an escape for the water molecules from the material and into the surrounding air.

Air also has a level of saturation, the point to where it can't hold any more moisture. The higher the humidity, the closer the air is to its level of saturation. If the humidity is too high or has a high vapor pressure, it won't be able to accept the water molecules from the object to be dried.

Different types of evaporation tools:

- Air movers – centrifugal (laminar); axial (high-amperage; low amperage; focus ability)
  - Placement – 1 for every 10-16 linear ft. of wall area; 15-45-degree focus; almost touching wall
  - Safety screens – intake and output areas; clean with compressed air; do not block intake
  - Electrical safety – lightweight extension cords; three-prong plugs; maintain electrical cord safety

- Structural Cavity Drying Systems (SCDS)
  - Vented (e.g., Turbovents 18"-48" widths; Octi-dry; Omni-dry; Air Wolf)
  - Injected (e.g., Injectidry; Dri-Force; Direct-it In)

- Floor Drying Systems
  - Vented (e.g., Air Wolf)
  - Injected – negative air mats (e.g., Dri-Force; Injectidry)

- Air Filtration Devices – AFDs (negative air machines - NAM; air scrubbers; HEPA filters)

3. Dehumidification: The Balanced Evaporation Phase

As the moisture is forced into the air, it evaporates and becomes water vapor in the air. Dehumidifiers are used to absorb moisture from the air. It is essential to use dehumidification; otherwise, absorbent materials in the room could soak up the moisture and become damaged.

The four most common dehumidifiers used in restoration are desiccants, refrigerant dehumidifiers, low-grain refrigerant dehumidifiers, and conventional refrigerant dehumidifiers.

Desiccant dehumidifiers – This kind of dehumidifier creates the lowest humidity ratio. Desiccant dehumidifiers absorb moisture through chemical attraction instead of condensation to remove water from the air. A desiccant is a material that attracts and holds moisture. This material acts like a sponge drawing moisture from the air (sorption). When the wheel rotates through heated exhaust air, the moisture evaporates (desorption) and is carried outside. Then the cycle repeats.

The air to be dried, or processed, is ducted through the rotor in one air stream. The rotor brings the moist desiccant to the reactivation air stream to heat it up. Desiccant dehumidifiers work when moist incoming air flows over a wheel filled with a silica gel desiccant. This process absorbs moisture without ice build-up and is not limited by low temperatures. Desiccants can easily operate below freezing temperatures.

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

Desiccant dehumidifiers range in size from small electric units to very large diesel fired units. The size is measured in CFM's or Cubic Feet per Minute, this is the speed in which it will perform an air exchange.

Refrigerant dehumidifiers – There are two types of refrigerant dehumidifiers, standard and conventional. The only difference between the two is that a conventional refrigerant dehumidifier uses a heat pipe or defrost cycle to defer frost from forming on the coils.

The refrigerant dehumidifier fan draws warm moist air into the dehumidifier and the moist air then crosses over the dehumidifiers refrigerant cooled coils, causing the moisture in the air to condense on the coils within the machine. This kind of dehumidifier is the most energy efficient type of dehumidifier. Refrigerants perform most efficiently in operating conditions 70° - 90° F. It is usually the most efficient dehumidifier to use in warm, wet environments.

LGR - Low-grain refrigerant dehumidifiers – This kind of dehumidifier removes water vapor from the air using a process called condensation. LGR dehumidifiers continue to remove a significant amount of water vapor below 40 grains per pound. LGRs are a unique form of residential and commercial grade refrigerant dehumidifiers because they are much more energy efficient and they can pull the grains down much lower. LGR dehumidifiers use a double cooling or enhanced step to lower the moisture-laden air temperature once inside the dehumidifier so more condensation can form on the internal cooling coils.

As condensation builds up on the coils, the water droplets drip into a collector and are discharged from the dehumidifier through pumps or into a floor drain.

LGR units provide the best moisture removal for refrigerant dehumidifiers and produce air that is drier, heated, and with less moisture than commercial grade refrigerant units.

Conventional refrigerant dehumidifiers – This kind of dehumidifier loses efficiency as the air dries below 55 grains per pound. It removes water vapor from the air using a process called condensation.

4. Temperature Control: The Maintenance Phase

The secret to drying is knowing how to manipulate the environment to create a vapor pressure differential between wet materials and dry air great enough to create a transfer, and heat the wet materials to a point where the moisture will vaporize and move into the air. Vapor pressure is the force exerted by water vapor (gas/liquid) on the surrounding environment.

Warm air between about 70 and 90 degrees Fahrenheit is ideal, especially for the first 36 to 48 hours of drying and is the optimal temperature for the operation of low grain dehumidifiers. Cooler air slows evaporation, so being warmer than 70 degrees Fahrenheit aids in the evaporation process. Overly hot air above 90 degrees Fahrenheit impedes the dehumidifiers' effectiveness.

Depending on the season, it's easy to keep the area within the desired temperature range because of the cooling effect of moisture evaporation and the heat generated by the drying equipment balance one another. If needed, drying chambers can be used to contain the warmer temperature in the affected area.

The key to evaporation acceleration is controlling temperature. By controlling temperature to accelerate evaporation, the restorer can dry faster, save money, and provide verifiable documentation and data that helps confirm the drying process.

DOCUMENTATION

Daily moisture readings should be included in the drying record to include air, equipment, and HVAC systems. Moisture content levels for wet structural materials should be recorded in a moisture content spreadsheet to show the progress of drying. These recorded moisture content readings will show that the building is back to an acceptable range of pre-loss condition. It is important to know that air records alone will not prove that a building is dry. After 24 hours the psychrometric conditions will demonstrate if sufficient dehumidification is being used or if adjustments are needed.

The psychrometric chart provides us with the tools to evaluate which drying equipment or methods will be the most effective. It is imperative to determine if conditions are achievable within the drying chamber based on the outside temperature and specific humidity for a refrigerant or desiccant dehumidifier, or a heating unit. These conditions can assist in determining what equipment to use on any loss. Enthalpy and its subcomponents, sensible and latent energy, can be calculated by use of the Enthalpy Evaporation Evaluation Formula (E^3). [4] This formula accurately predicts the energy evaluation of ambient air and its relationship to multiple building materials and how they react to each one and provide the best evaporation results. The higher the number, the faster materials will dry. Using this formula, desiccants are more helpful if the outside grains per pound of moisture are lower.

[4] Chuck Dewald Structural Drying Academy

In order to create the best environment for evaporation there is a need to focus on vapor pressure differential. The bigger the spread of vapor pressure the greater the pull of moisture from the air. Surface temperatures are usually 20° - 25° less than the ambient temperature.

As moisture is released in the air, nature always tries to reach equilibrium. Calculating the dew point is important in drying because when air reaches saturation, water vapor will condense as dew on surfaces. The dew point always happens at 100% relative humidity (RH). The dew point is the temperature the air needs to be cooled to, at constant pressure, in order to achieve an RH if 100%. At this point the air cannot hold more water in gas form. If the air were to be cooled even more, water vapor would have to come out of the atmosphere in a liquid form. The higher the dew point rises, the greater the amount of moisture in the air.

Humidity, airflow, and temperature (HAT) work together, and when managed, enable achieving target time for drying. "HAT" all influence movement toward equilibrium, i.e. wet seeks dry; hot seeks cold; high vapor pressure seeks low vapor pressure.

Vapor pressure is directly related to humidity ratio (specific humidity or grains per pound-gpp and dew point). As heat is applied to a material, energy is added. Raising the temperature of a wet material increases the rate of evaporation, further releasing moisture from the material and changing the internal vapor pressure. The greater the difference between ambient temperature and dew point temperature, the greater the potential for faster and more efficient drying.

INSPECTION EQUIPMENT

These are some of the tools professionals use to measure, monitor, and evaluate during the drying process of a structure:

- Moisture sensor – senses moisture in materials over 17% MC; helps determine perimeter of water damage; unable to determine which layer is wet or when dry;
- Thermo-hygrometer – determines temperature/RH in all required atmospheric areas of inspection; helps determine open or closed drying system; further determines dehumidifier requirements after initial placement;
- Moisture meters – invasive and non-invasive; determines moisture content; establishes, monitors, and determines when dry standards are met; and
- Miscellaneous – infrared camera and thermometer; manometer; borescopes; data loggers

AIR MOVEMENT

As mentioned, rapid air movement across wet surfaces of materials or assemblies is a critical component of effectively and efficiently drying the surface of those materials and assemblies. Conditions conducive to drying at the surface differ from moving excess moisture within the materials or assemblies. Rapid air movement across the surface of material becomes less important relative to vapor pressure as the focus of removing surface moisture gives way to reducing moisture content in low evaporation materials. The constant and falling rates of drying materials require different criteria for changing conditions.

HUMIDITY, TEMPERATURE & AIRFLOW

These factors influence the movement of moisture within a material as well as the evaporation rate from the surface of the material and can greatly impact the overall drying time for a project. It is important to quickly control the moisture in the air and use sufficient airflow to dry the surface of materials to reduce water activity, thus lowering the potential for microbial growth. If the surfaces of hygroscopic materials can be dried and maintained below 0.75, microbial growth can be quickly halted, even though the core of the material may still have elevated moisture content.

As the job progresses and the environment is stabilized, materials can be dried by managing the humidity, airflow, and energy (heat). Further into the drying, air movement should be re-directed and ensure good transfer of energy to the remaining wet areas. The overall need for humidity control and airflow can be lower than at the beginning of the project since there is significantly less moisture in materials being evaporated during the latter stage.

CONCLUSION

Advanced Structural Drying (ASD), based on psychrometry, science, and mathematical formulas, is a proven method to accelerate drying, reducing costs, time, and inconvenience related to replacement and repairs. While this technique may initially involve more equipment than standard drying processes, it can produce results that get homeowners back in homes faster, businesses back open, and salvage materials that would have previously been expected to need removal and replacement.

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MORE ABOUT J.S. HELD'S CONTRIBUTORS

Theresa Chimento is a Project Director and Safety Regional Lead in J.S. Held's Environmental, Health & Safety Practice. She is an experienced environmental consultant in both the field and as a project manager. Her professional experience of environmental consulting services have included all aspects of a project, from initial scope assessment and project development, initial assessments and data gathering, preparation of assessment reports and recommendations, development of remediation protocols and abatement specifications, project oversight and clearances, close-out report and final report documentation, and project management with client and contractor correspondence through the entirety of the project.

Theresa can be reached at tchimento@jsheld.com or
+1 504 420 1978.

Sara Raley is a Senior Vice President in J.S. Held's Building Consulting Practice. She is an expert in large commercial catastrophic losses resulting from hurricanes, flooding, fire, and mold. Her technical consulting emphasis has been in the cleaning, restoration, and construction industries both domestic and abroad and has extensive experience in both private and government sectors for nearly 40 years. Sara's wide ranging background includes but is not limited to building diagnostics, clerk-of-the-works, initial investigations & thermal imaging, development of drying strategies & structural drying, scoping & estimating, moisture mapping, and inventory control & equipment monitoring.

Sara can be reached at sraley@jsheld.com or
+1 407 753 1382.

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