UNDERSTANDING THE USE OF MOISTURE DIAGRAM AND MOISTURE MAPS AND HOW TO APPLY THEM IN WATER DAMAGED BUILDING SITUATIONS

Moisture mapping and moisture diagram are terms commonly used in geology, climate forecasting, meteorology, farming, grain storage and kiln drying to describe the moisture content, movement or changes in moisture. Moisture diagrams and moisture mapping are also commonly used and sometimes are interchangeable terms in the water damage restoration industry. This paper is a discussion of moisture diagramming and moisture mapping. This brief paper is designed to assist restorers, property loss adjusters and property owners to understand the difference in terminology and why it is important for the water damage restoration restorer to follow accepted industry practices.

Soils Example

In the study of soil, a "moisture profile" represents the moisture at a surface and down to the depth of the soil's *available water holding capacity (AWC).* The AWC depends on the pore geometry and type of soil. It also depends on the boundary layer, tension, temperature, humidity, wind and sunlight that directly or indirectly effect soil evaporation. The downward movement of water into soil is usually a result of rain or irrigation while the remaining standing water is a result of the soil reaching its holding capacity.

The rate of water removal out of the soil depends on the energy available for moisture extraction and evaporation. This is expressed in terms of *potential evapotranspiration (PE).* The energy required to remove moisture from the soil depends on the *amount of water (AW)* present and forces exerted by the soil to retain it. Water is removed more readily when the soil water is at low tensions than when the water content in the profile is at a minimum (Newhall Simulation Model, Cornell University 2000). Where these factors come into play in wet building material drying is when the crawlspace or foundation becomes so wet it must be mitigated as part of the building's drying process.

Wet Material Drying Goals

Whether we use the Newhall Simulation Model to describe moisture in crawlspace soil, the Mollier Diagram to describe air temperature, moisture content and enthalpy, or water damage restoration psychrometric charts to describe dry and wet bulb humidity, temperature and dew point, the drying goal is the same. Meaning, what a water damage restorer is attempting to do is change wet and elevated moisture conditions to measurable drying conditions as fast as possible.

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While it is easy for me to make the statement and say: "we must take wet building materials and dry them out as fast as possible," is not an easy task for the restorer to perform. The restorer must rely on air movement and dehumidification processes to achieve a state of material dryness. However, without understanding the wet environment and materials affected by water and moisture, some jobsite drying processes fail to dry wet buildings within a reasonable period of time.

As with soils drying, the restorer must know the types of wet materials they are dealing with, know the porosity of the materials, and how much water they have absorbed. Knowing the answer to these questions sets the framework for engineering a drying process. Some other questions a restorer must answer are: how can I best achieve a drying equilibrium state within a wet environment through the use of air movement and dehumidification; how do I identify wet building materials that are within ceilings, walls and flooring without opening them up; must some of the materials be taken apart in order to dry them completely; can I dry wet building materials before mold growth occurs?

It is important to understand the energy (enthalpy – heat transfer under a constant pressure) required to remove moisture from a material. Meaning, controlled air movement and heat are capable of transferring moisture away from a material faster than air movement alone. Again, the movement of moisture out of material depends on the *(AW)* present and the forces exerted by the material to retain it. Ideally, trapped moisture is removed more easily when a material is at its lowest tension. This requires air flow, ideal temperatures and dehumidification processes to be present at the same time on all sides until drying is achieved.

IICRC Standards: Moisture Mapping and Moisture Diagram Terms

The term "moisture mapping" (moisture maps) are mentioned on page 30, 33, 183, 193, 197, 241 of the IICRC S500 Standard and Reference Guide for Professional Water Damage Restoration, 2006 edition. The terms "moisture diagram or moisture diagramming" is not discussed in the S500 Standard but I believe the principles of moisture diagramming a wet building are taught in water damage restoration and applied structural drying classes.

Page 30 of the S500, 2006 Standard states: "*the recommended documentation includes …observations upon inspection (e.g., diagrams; moisture "mapping";* etc…)." Further down on page 33 "…*the inspection process includes – performing a moisture inspection and mapping its migration*…"

The word *monitoring* is mentioned over 50 times in the S500 Standard and the words *monitor, monitors* and *monitored* are found more than 25 times. While the S500 Standard is the best guidance document we have, it does not provide extensive direction to the restorer on how a water damage drying map should be documented other than describe – the restorer should include the following: "*monitoring reports documenting daily temperature, relative humidity, specific humidity, and dew point of the air; specific and/or relative moisture content readings of representative materials; the drying standards and goals; the monitoring equipment used; the time and date of service and the company representative present during service*."

Moisture Diagram

A moisture diagram is a sketch of the property. On day one of the investigation and water damage restoration process a moisture diagram represents a two dimension drawing of affected and non-water damaged areas. A building's moisture diagram:

- Identifies wet ceiling, wall and floors and wet/damp surface moisture patterns;
- Charts where active moisture migration stops and dry materials begin;
- Shows the perimeter of the water damaged field as compared to dry building areas.

In large or complicated water damaged buildings experiencing migrating water coming through multiple floors or when there is high humidity indoors, the true extent of water damage loss may not become apparent until migrating water and indoor humidity is controlled or surface materials begin to dry. In other words, only when surfaces begin to dry do hidden reservoirs of water become detectible. In these instances the moisture diagram may need to be redefined as new information from testing becomes available.

For example: Migrating water will follow the downward slope of a floor. Migrating water in this instance can travel along walls and in subfloor voids, and reappear a significant distance away from the point of loss. In another instance, migrating water travels to lower floors through electrical and plumbing conduits and HVAC systems. It is not unusual to find the 10^{th} to the 8^{th} floor flooded while the 7^{th} and 6^{th} floors appear to be dry; but the 5^{th} floor has water coming out of ceilings and fixtures. Also, in high humidity conditions the first floor may be the only floor water damaged, but the attic has significant condensation occurring because of the physics of *stack effect*.

Once there is a change in the moisture content of wet building materials through extraction, remediation or evaporation, the moisture diagram is to be redesigned and configured to become a "moisture map."

Moisture Map

A moisture map documents the progression of the buildings' drying process:

- It identifies changes in the migration patterns of standing water, moisture on surfaces, water vapor in air and trapped moisture in building materials, finishes and contents;
- It becomes the chart that maps the daily reduction in moisture;
- It continues to document the building's drying process until such time the restorer determines wet building materials are dry – back to acceptable equilibrium moisture content (EMC) with other materials of like kind.

A moisture map provides valuable information to the restorer. The moisture map (often a series of maps) describes:

- Daily temperature measurements inside water damaged areas, outside in control areas and outdoors;
- Daily relative and specific humidity readings and dew point measurements;
- Daily moisture probe measurements of wet building materials including surface and core moisture content readings; surface and core temperatures.

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A moisture map provides other valuable information:

- The type of tools used to monitor the building's drying process including documenting that the same tools were used in daily monitoring. (This may help to avoid calibration anomalies);
- Time and date of testing and person taking readings;
- Shows the daily location of air movement and dehumidification drying equipment.

In a large or complicated loss, the moisture map:

- Identifies the location of contents affected by water;
- Points out the location of contents that are contaminated with Category 2 or 3 wastewater and their removal;
- Shows the location of detached toilets, cabinets, bookcases, vanities, tubs and shower assemblies;
- Outlines the location of small and large area containments and "do not enter" signage;
- Occupied and non-occupied areas;
- Identifies hallway, stairs, emergency exit and fire escape routes;
- Diagrams ceiling joists, subfloors, HVAC, plumbing and electrical that could be carrying migrating water from one area to another;
- Identifies possible asbestos and lead-base paint damaged areas;
- Records pre-loss conditions;
- Documents wall, floor and ceiling voids where trapped humidity is present and must be eliminated.

Moisture Map Report:

As described above, the moisture map report has the initial moisture diagram sketch and daily moisture maps in it that documents the progression of the drying process to job completion. In some situations the report includes other valuable information related to building drying problems or dealing with contaminated water issues. Some of these issues include:

- Explaining conditions that required further investigation to identify why certain materials did not dry as fast as others or they had to be removed;
- Providing thermal imaging scanning and moisture measurements of surfaces that were identified as wet followed by thermal scans and moisture measurements showing various environmental and building material drying phases;
- Providing photo documentation of the initial water damage conditions, remediation phases, placement of drying equipment and drying chambers;
- Identifying the presence of Category 2 and 3 water contamination;
- Justification (moisture measurements) showing why cabinets and vanities had to be detached;
- Documenting how sheer paneling, double drywall and wall insulation were dried in place, or where they were cut into to allow drying or were removed;
- What was necessary from a plumber, roofer or contractor's point of view to stop and eliminate the source of water?

The moisture map report should have closing language in it that confirms: On a specific date (e.g., June 23, 2009), all building materials and finishes that were wet (name the affected rooms and materials) are dry to pre-loss surrounding-equilibrium conditions. The moisture content of each material (name the materials and finishes) have an average moisture content of ___ and does not exceed ___.

One reason why I recommend a final closing statement be inserted in the moisture map report along with measurements (indoor/outdoor temperature and humidity; material moisture content) is to document for all parties that the materials are dry--just in case another water damage affects the building or ambient humidity levels increase the moisture content of dry materials. There have been instances where restorers were accused of not drying a building properly where reportedly secondary damage and mold growth occurred.

Another reason why I recommend a final closing statement is because all reported water damage claims to insurance companies are put in national databases such as CLUE. The documents of the restorer including their moisture map report may be used as a "certification" the structure was professionally dried. This information may be critical at the time of sale of the property, refinancing or issuing new insurance. Further this information may be used by mortgage companies to sign-off and process insurance drafts.

In Summary

Moisture documentation is required on all professional water damage restoration jobs. It is important to know how to use moisture diagramming and moisture maps to: document the extent of loss; stage various types of air movement and drying equipment; monitor the job's drying process each day; ensure all types of building materials are dry. When billing the completion of work, a final moisture map report should be attached as an appendix to the billing statement.

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