Introduction

When the interior of a building is damaged by water, people often jump to conclusions as to how and why the unwanted water got there in the first place. This article summarizes the “how and why” to water intrusion problems as it relates to buildings.

As simple as it sounds, the basic role of the building is to protect the inside from the outside. Buildings get wet during construction and after construction, but they dry out as well. The three basic design rules with respect to water are as follows:

1. Prevent unwanted water from entering the building.
2. If water enters the building, control how it can get out of the building.
3. Control all wanted or known sources of water within the building.

If the above three rules remain unbroken over the life of the building, there would be no water damage within a building. Water would be controlled. In the real world this does not happen. Water finds a way to go where it is not wanted. Things go wrong and water gets into places where it can cause all sorts of problems.

There is a comfort zone for humans with respect to temperature and humidity. The American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) has identified a zone of human comfort ranging from 30% to 70% relative humidity and 70 to 85 degrees Fahrenheit.

The Scientific Method

As with all engineering problems, the scientific community has developed a method of solving technical problems. The method is known as the Scientific Method. The Scientific Method can be summarized in the following five (5) stages:

Stage 1: Propose or define a non-biased question.

Stage 2: Gather all evidence related to the question needing to be answered. Make site observations of damaged and not damaged conditions. Make observations of the surrounding area. Interview people. Research related storm (or weather) data.

Stage 3: Construct a Hypothesis.

Stage 4: Test the individual hypothesis one by one. Analyze the data and draw conclusions. Accept or reject the individual hypothesis. Return to stage 3 to gather more information if the analysis stage reveals new ideas.

Stage 5: Communicate the results.

There is a comfort zone for unwanted problems as well. If areas are wet, warm, and airflow is constricted these unwanted problems can appear:

- Odors
- Frost and ice on cold surfaces
- Fogging of windows
- Headaches
- Drowsiness
- Unexplainable illnesses
- A damp feeling
- Discoloration and moisture staining
- Rot and decay
- Sweating pipes
- Dripping water on cooler surfaces
- Peeling, blistering, and cracking paint
- Crusty, powdery, and chipping concrete
- Crusty, powdery, and chipping masonry
- Fungal growth
The Water Intrusion Investigation

Per the Scientific Method, the water intrusion investigation must start with an unbiased question. Depending on the specific needs surrounding a water claim, a water intrusion investigation may need certain specific questions answered. A typical water intrusion investigation often includes one or more of the following questions:

1. What was the source of water?
2. What is the extent of damage?
3. What needs to repaired or replaced?
4. What is the ultimate cause?

The image shown below identifies the typical terminology of a simplified water intrusion problem. An actual water intrusion problem is more complicated. In this simplified example the cause is either the person who turned on the water or the person who placed the hose in the window.

Moisture problems can quickly turn into disgusting environments depending on the extent of moisture damage, the air temperature, and the ventilation within the space. Owners often want the mess cleaned up as quickly as possible.

Scope of Repairs

The full scope of repairs must only be determined after the source has been clearly identified. If the source is not identified, the risk of not eliminating future water damage increases. A hasty repair plan might create all sorts of additional problems that include additional cost associated with:

1. Not identifying the extent of damage.
2. Not identifying hidden damage.
3. Not realizing required design changes.
4. Not identifying required material changes.
5. Not identifying code up-grade issues.

The Physics of Water

Water exists in three forms: liquid, gas, and solid. A wet spot in an unwanted area of an interior space is most likely due to one form; not two forms of water. During a moisture intrusion investigation, it may become apparent that a building has numerous water problems, but damage at a specific location normally is the result of just one source. There are only four (4) sources of unwanted water found within a building. They are exterior water, exterior vapor, interior water, and interior vapor.

Timing Concerns

Unfortunately, timing is never ideal in a water damage building. Water damage is never a wanted event. It can be very unsettling for the owners especially if the owners are living or working within the building.

Observations need to be made, and destructive or non-destructive testing may be required. Items need to be documented before removal. Often owners are instructed or encouraged to wait on the clean-up efforts in order to gather this information.
Moisture Intrusion - Water Damage Evaluation
by Rick Abbott, PE SE

Each of the four (4) sources has unique characteristics; however, all movement of the water follows the physical laws of water. Water movement never breaks scientific laws.

Liquid moves by wind, gravity, absorption, and wicking. Within a house, the primary movement is due to gravity.

Gas (or vapor) moves primarily by air movement and is related to the relative humidity, the dew point, and temperature of the air. Condensation is dependent on the temperature of the materials in which the moist air comes in contact with. To fully understand moisture damage caused by movement of water in the vapor phase, the following three terms must be understood:

Relative Humidity is the amount of water vapor present in air expressed as a percentage of the amount needed for saturation at the same temperature.

Dew Point is the temperature at a given relative humidity and temperature where water vapor in the air will condense on a surface.

Condensation is the conversion of a vapor or gas to a liquid.

Relative humidity can easily be measured with handheld devices. If the relative humidity and the temperature are known, the dew point can be found. Relative humidity, temperature, and dew point are related to each other as a property of atmospheric air.

Building Codes

The building codes have requirements on drainage, exterior barriers, drainage paths, ventilation, and numerous other water intrusion topics. In the past, the building code provided guidance for the design of new structures. The building codes have been recognized as the minimum required standard for new building; however, the code requirements have changed throughout the years. Many older buildings were built prior to the enforcement of building code. There are numerous buildings of various ages built to all sorts of level of care that may or may not have followed a standard. Newer sections of building codes are starting to address existing buildings. Considering the fact that building codes have increasingly become better at addressing observed problems of the past, the building code can be a good resource in the evaluation of a water intrusion problem, but simply siting code violation as a cause is not the full story.

Source 1 - Exterior Water

Exterior water can be due to rain, wind driven rain, snow melt, ice dams, flood water, surface drainage issues, or accidental discharges. The path is primarily determined by gravity; therefore, dimensions and elevations play a critical part in the evaluation of the problem.

Source 2 - Exterior Vapor

Exterior vapor is normally not an issue in colder climates. In warmer climates, the outside temperature and humidity are often higher compared to the interior spaces which are often cooled with air conditioning. Outside humidity becomes a problem when the warm humid air comes in contact with the cooler interior materials.

The warm moist air from the outside comes in contact with cooler surfaces. Water condenses on the cooler surfaces that are below the dew point. For this reason, exterior vapor often becomes apparent as fogging on the exterior side of windows in warm climates.

Source 3 - Interior Water

Interior water sources include any and every kind of reservoir or transferring line of water within a building. If water is present in a system, it can leak. The flow of water is due to gravity; therefore, close attention to dimensions and elevations must be made. Water does not flow up hill; yet, it can flow long distances horizontally with the slightest downward slope.

For a moisture intrusion problem to be fully investigated it is prudent to investigate all sources of interior water and to look closely for paths leading from the water source to the point of damage. For this reason, the entire interior of the building should be inspected.
Items of concern on the interior of the building include the following:

1. Plumbing Fixture
2. Supply Lines
3. Exit Lines
4. Sewer back-up
5. Accidental spillage
6. Appliances
7. Condensate pans
8. Cleaning activities
9. Fish tanks
10. Bath tubs
11. Showers
12. Toilets
13. Pools
14. Hot tubs

**Source 4 - Interior Vapor**

Interior vapor is the most misunderstood source of water damage. The general public often ignores interior vapor and the required ventilation. Interior spaces are naturally charged with moisture due to:

1. People
2. Showers
3. Cooking
4. Humidification
5. Washers
6. Dryers
7. Dishwashers

If conditions are right, interior vapor condenses on cooler surfaces. When the interior space is warm and moist, and the exterior atmosphere is cold, any indoor air that comes in contact with cooler materials on the exterior of the building can condense. Water or ice can accumulate causing damage over time. This type of damage can go undetected for years.

Common evidence of an indoor moisture problem is often found within the attic space. If the attic is not adequately vented, warm moist air from the interior can come in contact with the underside of the cold roof sheathing. If the underside of the roof sheathing is below the dew point, moisture will condense on the surface. Over time the wood sheathing can become discolored. For this reason, it is very important to vent exhaust from bathrooms and dryers to the outside.

**Underside of a Roof Sheathing - Note Discoloration**

Thermal tracking or “ghosting” is a common occurrence of indoor air quality problems combined with an indoor moisture problem. Water vapor within a warm moist interior will condense on the cooler exterior walls of a house. When the interior humidity decreases, the moisture on the walls re-absorbs into the air leaving the particles on the wall. Over time the particles accumulate and become visible. The source of particle in the air can come from smoking, candles, fireplaces, or cooking.

**Thermal Tracking or Ghosting**
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Causation

Often the ultimate causation becomes the most important question to answer during a water intrusion investigation. Pointing the finger at the true cause leads to pointing the finger at the party responsible for the damage.

It all begins with design. If a building project, a detail, or a material configuration is not properly designed, it can fail. The failure may not become evident immediately. It can take years to show water damage. Often the initial construction was completed long ago. If the building has functioned acceptably for years, but only recently it become evident that moisture was slowly allowing interior unprotected material to degrade, it still remains a design error.

Many things can alter the initial design which can cause water damage. The following is a list of common causes of water damage:

1. Design error - it was never designed correctly from the start. At the time of construction, it should have been designed differently according to code.
2. Design flaw - it was not designed adequately. At the time of construction, the code or industry standard may not have addressed the issue, but over time it has become apparent that a particular way of construction has not performed well.
3. Installation error - Construction Error - It was designed correctly, but built incorrectly.
5. Alteration mistake. It was designed and constructed adequately, but something altered the function of the system.
6. Weather related damage. Openings or holes were made as the result of a weather event.
7. Deterioration. Some materials such as asphalt roofing shingles have a limited service life. Materials with limited service life that degrade over time must be replaced. Exceeding a service life of a material can lead to water intrusion. Casement windows are often called replacement windows. They can warp and the closing mechanism can fail. Seals become old.
8. Lack of maintenance. Caulk is a material that must be maintained or replaced as it eventually breaks down.
9. Accidental release of water. Over flowing bath tubs or toilets are obvious causes of interior water damage.
10. Accidental exposure to water. Windows can be left open.
11. Improper use of equipment.
12. Improper or inadequate ventilation.
13. The lack of concern for interior moisture.

Summary

A good moisture intrusion investigation includes the following:

1. Practicing the principle of using the scientific method in an inspection and evaluations.
   a. Define a non-biased question.
   b. Gather all evidence.
   c. Construct a Hypothesis.
   d. Test the individual hypothesis one by one. Analyze the data and draw conclusions.
   e. Communicate the results
2. Understanding the physics of water movement.
3. Understanding relative humidity, dew point, and condensation.
4. Understanding the four (4) sources of water.
5. Look closely at all sources of potential water.
6. Understanding building envelope systems.
7. Understanding interior systems that have water.