The Basics of Using IR for Building Moisture Inspections

Using infrared to help locate moisture problems in buildings, while effective in the right conditions, can be a challenging application for a thermographer.

As building professionals know quite well, moisture trapped in a structure creates the potential for trouble. Big trouble in some cases depending on how much is present and where it happens to be affecting the building. Wet insulation in framed walls or ceilings reduces its thermal resistance, resulting in increased energy use or decreased comfort or both. Water can also degrade and rot components contributing to their pre-mature failure while also compromising the structural integrity of the building. Moisture on surfaces provides an environment conducive to mold growth and mildew in the right conditions, which, in turn, can damage the materials themselves and also contribute to significant health issues for building occupants.

Using infrared to help locate moisture problems in buildings, while effective in the right conditions, can be a challenging application for a thermographer. The water could be at the surface or, even more difficult, interstitial, making detection close to impossible in certain situations. Additionally, an infrared camera alone is not able to detect and confirm the presence moisture (or mold for that matter). Instead it is used to locate thermal patterns that may be associated with the presence of moisture.

In the end it is the task of correlating that thermal signature with a moisture meter where infrared imaging brings the greatest benefit to thermographers who are conducting moisture investigations. To do that successfully, though, a thermographer needs to understand what conditions are required and the types of patterns they are likely to encounter.

Conditions

First, thermographers need to be present when these thermal differences are detectable, whether the necessary conditions exist or they can be created though manipulation of the environment or surface. In the real world such conditions are most often transient, meaning the signatures come and go. Without understanding the influences of these situations, locating a water or moisture signature, or missing it entirely, can be a matter of chance in a number of circumstances.

How Moisture Can Present Itself Thermally

Thermal signatures that may be related to moisture can show up thanks to any combination of the following reasons:

Thermal Capacitance

Water has about the highest thermal capacitance of pretty much any naturally occurring material out there, requiring over 62 BTUs of thermal energy per cubic foot to change its temperature by just 1 °F (.55 °C). To put that in perspective, the same volume of air requires only .018 BTUs, a mere fraction of the energy, for it to change the same amount of temperature.

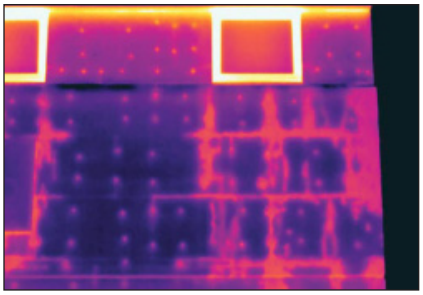

Image 1

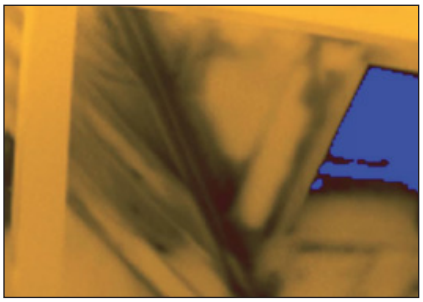

Image 2

What this means is that it takes a lot more energy to warm up something that is wet or saturated than a similar dry material. When it comes to detecting a possible thermal pattern associated with capacitance, a thermographer should know that anything potentially wet can appear colder relative to similar, dry, building materials, as it takes longer (or, said more accurately, requires more energy) for that wet building material to change temperature.

Confusing things somewhat is that the same suspected wet area, after having been influenced by daytime heating (whether from changes in outdoor air temperature, from solar loading or internal heat sources), can also appear to be warmer than a corresponding dry area later in the day, and into the evening, as the wet building materials contain more thermal energy. It has more BTUs to give up for it to cool off, causing it to stay warmer longer, relative to dryer areas. In Image 1, water trapped behind the stucco of this west-facing elevation on a commercial office building appears as irregularly shaped warmer areas late in the afternoon. There were cracks and gaps seen visually around the windows on this particular building which likely allowed water to infiltrate into the wall system.

Conduction

Wet building materials (whether it is insulation, wood, sheetrock, etc.) are better conductors of thermal energy than their dry counterparts. In fact, the thermal conductivity of insulation alone can increase anywhere from 50 to 100 times as it goes from dry to wet to frozen (yes, ice is even more conductive than liquid water). When there is a temperature difference in place (and you understand the direction of heat flow), this can help thermographers try to locate thermal patterns caused by conduction that may reveal areas possibly affected by moisture. The larger the temperature difference the better as you will have a greater amount of heat transfer to help enhance the patterns.

Image 2, taken from the inside during cold-weather conditions, shows a large, relatively, cooler thermal pattern throughout a roof valley adjacent to a skylight which is the blue area of thermal saturation on the right side of the image. It was verified that this section of the roof was in fact affected by moisture thanks to the build up of an ice dam at the edge which allowed water to back up and infiltrate into the roof system. Now, given the situation, and the known issues with the ice dam, it could be said that the thermal pattern detected is likely caused by moisture. If, however, we also take a moment to consider what the root cause of this ice dam is (i.e. heat loss, whether via air leakage or missing/deficient insulation), it might also explain the pattern as also being somewhat related to missing or poorly performing insulation. In truth it is likely a combination of the two in this instance and IR is simply giving us an indication that something is wrong. This re-enforces the point that by the thermal pattern alone we are not able to tell exactly what is happening at this location without additional information.

Evaporation

Evaporation, the process of a liquid converting into a vapor, requires energy to happen. Some of that energy comes from the surrounding air, but some is also supplied by the surface of whatever material the liquid is resting on. As such, when water evaporates, it pulls some of that energy from the surface, so any wet building materials that are exposed to air, or air movement, will be cooled by evaporation and this loss of energy.

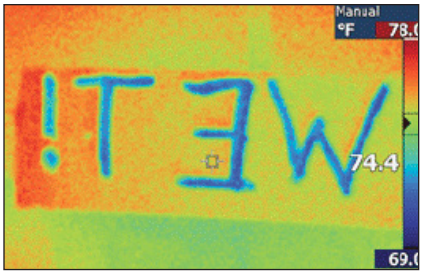

Image 3

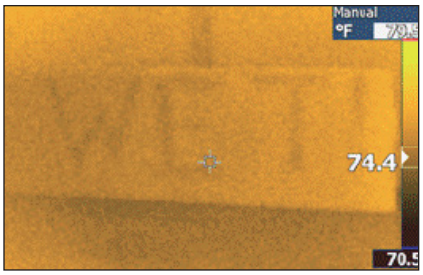

Image 4

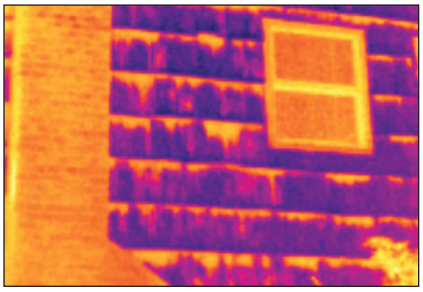

Image 5

How much evaporation occurs is dependent on the air temperature, humidity, and air velocity, making these types of signatures highly dependent on the environmental conditions in place. If the conditions are favorable for evaporation, it does not take much moisture for a pattern to show up.

To demonstrate how little water it takes to create a thermal pattern from evaporation, we took a 1' x 2' piece of 5/8" drywall and wrote the word "Wet!" backwards on the inside surface (Image 3), using about the same amount of water one would need to seal an envelope (i.e. barely any). It was then turned over and monitored with a thermal imager to see if, and how long, it would take a pattern to develop on the opposite side. As the water evaporated on the inside surface, it cooled off the material where the moisture was placed. This created a temperature difference across the piece which then conducted energy from the opposite side, revealing the pattern on the dry side, seen here in the second image (Image 4). Total time for this evaporative effect to show up? Only about 2 ½ minutes!

The effects of evaporation can also last long after a surface has dried. In this next example (Image 5) we see an interesting thermal pattern on the outside of a residential home during the early morning hours in heat loss conditions (warmer inside, cooler outside). At first glance there appears to be a number of warm air leakage spots protruding from these cedar shingles on the outside surface of this house. What is happening is that it rained the previous evening. Even though the siding was now dry to the touch, it had undergone a temperature change where the surface got wet due to the rainfall. Had this data point not been known or considered, it might lead one to the wrong conclusion or at the very least leave the thermographer confused as to what was actually occurring.

A more practical example of evaporation is this infrared image of an irregular thermal pattern detected on a wall beneath a window inside a residential home. A young couple was looking to possibly purchase this house and knew a thermographer friend who brought along a camera to help them evaluate the building. In this one room they noticed walls that had been recently painted. While everything appeared to be fi ne visually, the thermal image told quite a different story (Image 6, next page). The buyers asked the sellers about this and what the camera was seeing. They then conceded that they had just painted over some light water stains on the wall. Doing so might have hid the pattern visually, but it was still very much there thermally thanks to what was likely evaporation of water on the inside surface of the drywall at this location.

Limitations of Thermal Imaging

While these examples demonstrate successful uses of infrared in locating thermal patterns that were confirmed to be associated with moisture, it is not always this simple. First, remember that an infrared camera alone cannot find and confirm the presence moisture (or mold for that matter). Instead it is used to locate thermal patterns that may be associated with the presence of moisture or mold. Those patterns, though, are also many times indistinguishable from the thermal signature of missing insulation or air leakage. Whether or not a water-related signature can even be seen at all, as well as what it might look like, depends on the environmental conditions and the timing of the inspection.

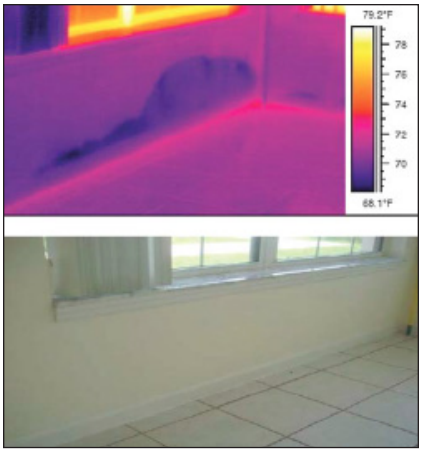

Image 6.

An infrared camera also only sees as far as the surface of the material being inspected. The variables of conduction, capacitance and transient heat flow cycles combined with the amount of water are the main determinants for locating moisture, and that is just for water which may be on, or right at, the surface. Locating interstitial water by its thermal signature is even more challenging, if not impossible, in many situations because it is simply thermally disconnected from the surface that we are inspecting.

Regardless, any suspect thermal pattern you do detect will need to be confirmed with a complementary technology or procedure such as using a moisture meter or perhaps conducting a destructive test if qualified and you have approval. Without these supplementary data points you are making potentially embarrassing assumptions based on a thermal pattern of a surface that may not even be related to moisture in the slightest.

The Importance of Training

Throughout all of this having proper thermography training remains essential. A thermographer needs to understand the physics behind heat transfer and how thermal patterns caused by moisture can appear. It is why we spend as much time as we do in training focusing on the basics of theory, including the concepts of thermal capacitance, conduction and evaporation. It is also why we discuss how environmental influences such as air currents and solar loading can both help, or hinder, a moisture investigation. There are many factors involved in how moisture can, and many times does not, reveal itself thermally.

The mark of any good, qualified, thermographer is that they are always questioning the image, no matter how obvious a thermal pattern may seem. A trained thermographer never accepts at face value what an infrared camera is telling them without giving it critical thought. That is especially true during moisture inspections. As such, take good care if you happen to also be using a "moisture alarm", or similar feature, found on some newer cameras that is designed to highlight areas of the image with an isotherm-like overlay that indicates where moisture may be present on a surface. These tools are not foolproof and are only able to measure and analyze surface radiance (and, thus, apparent surface temperatures) along with select environmental data that has been entered by the thermographer creating the potential for errors or misinterpretation. Subsurface or interstitial moisture may even be missed with this feature.

Further, conditions can change considerably from one area of a building to another and the data entry points you used for the alarm in one room might not be appropriate for the next. It is strongly suggested that if you do utilize this feature to supplement your moisture inspection efforts, that you do so with your mind engaged, remembering to "Think Thermally®", and always use a moisture meter to confirm an anomaly.

In the end know that a number of professional thermographers, home inspectors and IAQ specialists use infrared thermography on a regular basis to complement their moisture investigation efforts. They do so, though, knowing that IR is just one of a number of tools that can be utilized and that the technology, while helpful in identifying potential problems with water, also has its limitations. When used in conjunction with a moisture meter, however, infrared can most certainly help expedite a moisture inspection and provide a valuable data point to pinpoint moisture problems in building systems.