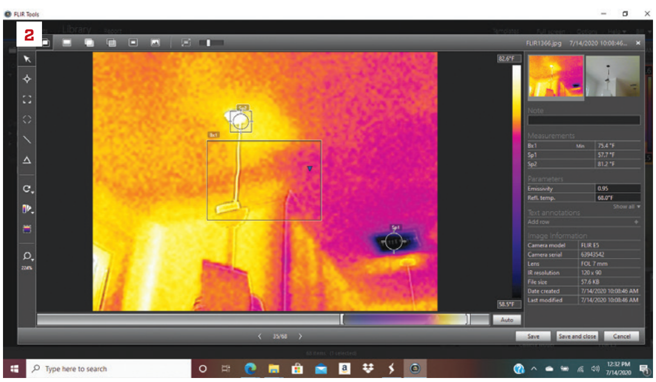
BY BILL ROBINSON

Moisture Detection Tools



Photos by Bill Robinson

The author's inspection case **(1)** contains a range of tools for measuring moisture. Of these, the thermal camera is often the one he pulls out first to scan a site for possible hidden moisture. Dark areas on the image **(2)** indicate cool areas—places that may be wet and need further investigation.

Several years ago, when I was contracting in California, a big part of my business was installing windows. At one point, a manufacturer representative told me that the manufacturer would void the warranty on windows in the 5- to 6-foot range if there were fasteners directly nailed through the mounting flange at the header. This warranty requirement existed because most header stock on the West Coast at that time was full-dimension, green stock. It was so heavy with water, you could be splashed when you cut into it with a saw. Understandably, window makers were concerned about what would happen to the flange fasteners as those big, wet headers dried out and shrank. The solution, the rep told me, was be sure to install fasteners into header stock that measured below 15% moisture content. If I could document that, the installation could be warranted. But at the time, I had no idea how to measure lumber moisture content.

Learning about measuring moisture content started me down a path that led to my acquiring a Pelican case full of diagnostic tools **(1)**, most of which are designed to measure moisture in one form or another within building materials and in the environment inside or outside buildings. These days, I live and work in New Orleans. I was drawn here shortly after Hurricane Katrina devastated large swaths of the city, and I saw how I could be useful in helping to rebuild the 9th Ward, which was particularly devastated by floods from Katrina and subsequent storms. For this work, and for ongoing work here in this hot, humid climate, reading moisture is a big part of defining effective building solutions.

In this article, I will "unpack" my case. Not only do the tools within allow me to derive quantifiable moisture measurements, but just as important, many of them streamline how I document the problems I encounter, which helps me communicate the solutions I come up with to clients and subcontractors. Data is everything. I have learned that to be convincing and to educate clients, it is essential to have tools that will quantify environmental conditions, including, but not limited to, wood and drywall moisture content (MC), relative humidity (RH), temperature, and observable (that is, graphic) conditions.

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The scale on the author's Mini-Ligno **(3)** is set for drywall, for which 1% moisture content (MC) is the trigger point; a higher value would indicate an elevated moisture condition. The author finds that the readings from this relatively inexpensive pin meter from Calculated Industries **(4)** compare favorably to the ones from his other meters. The Delmhorst ProScan **(5)** can read wood moisture content to a depth of 3/4 inch without marring finished surfaces.

FIRST PRINCIPLES

First, I'll run through some key points to keep in mind when evaluating buildings that may be at risk from moisture.

BOG. In my reports, I use the term "microbial growth" or BOG (bio-organic growth) rather than saying outright, "You have mold in your home." This growth exists in homes all the time and becomes a problem only when a certain level is reached. But since I am not a licensed mold inspector, it is not my place to define when that level has been reached. My job is to stay in front of the problem and identify where the weak links are that might result in it becoming a problem over time.

Wood decay, or rot, typically occurs at 28% moisture content. Mold typically begins to grow on wood and other cellulose-containing building materials at 21% MC, and some mold can continue to thrive at 16% MC. This puts those green headers I mentioned earlier into perspective: 19% MC is a dangerous number because it's in a range that can support biological growth. For the work I do in New Orleans, we need to be careful not to cover things up at any time, but particularly after a flood, when the moisture content is high. I shoot for 15% MC on the meter before even considering burying a material in an assembly.

Termites are a big problem here in the South, and they are becoming a bigger problem in many places farther north. Keeping wood below 15% MC is also the threshold we strive for to help reduce termite destruction.

Drywall is not the same as wood. Though 15% MC is a reasonably safe threshold for wood, 1% MC is the threshold for drywall and plaster. It's critical to have a device that can be calibrated to read accurately in that range.

Wood products. Some engineered wood products come from the mill at 4% MC, while others can be as high as 25% MC. The wide range underscores the need to acclimate all these products to the environment where they will be installed. Inside, in conditioned spaces, the equilibrium moisture content (EMC) of building materials can range from 6% to 8% in dry climates to around 10% to 12% in more humid climate zones. On the exterior, wood and other hygroscopic materials will equalize to a moisture content matching the outside temperature and humidity. The range of these conditions varies widely in the U.S. (For more on understanding EMC, see "Managing Wood Movement," Feb/21).

As we build with more precision to meet energy codes, and we increasingly face storms, fires, and flooding, we need to understand environmental conditions with precision. If we can't measure those conditions, we don't have a prayer of a chance of building durable, efficient, healthy, and resilient homes.

THERMAL CAMERAS

A thermal camera reads infrared radiation, and shows surface temperatures. But it can be used to highlight moisture problems as well as thermal losses. When wet materials dry, they become cooler—like what happens to the temperature of skin when you perspire: The skin surface cools. The same thing happens with building materials, provided the air temperature is warm enough to allow evaporation. The cooler surfaces show up on a camera as darker colors. Of course, something showing up on the image at a lower temperature can simply be cooler, not necessarily wet. But if I scan an area, and it shows up with patches that are cooler, that gives me a clue to chase down: It may indicate a wetter, not just a cooler, area, and I know a little analysis is called for.

I always begin a building investigation looking for moisture accumulation using a thermal camera, and work it in tandem with a moisture meter to check for elevated moisture content. The thermal camera simply gives me the best place to "look" further with my moisture meter.

The camera image is especially useful for identifying potential condensing surfaces, where liquid water exists. These are the most likely places for microbial growth to occur. In image **(2)** on page 27, the AC register, shown clearly in dark purple, had been cooled enough by the supply airflow to drop the grille surface below the dew point. This resulted in dripping water and led to biological organic growth on the surface. I will discuss the environmental conditions detected using Kestrel meters later in the article.

Flir thermal camera. Thermal cameras are becoming more available and more affordable. I use a Flir E5, which is relatively inexpensive for a thermal camera. I paid around $1,500 for mine several years ago. There are less expensive models and even devices that will connect to a smartphone to provide some thermal imaging. I like standalone ones that can connect to a computer and provide more-precise images that can be output as records. The camera I use can take two images: a thermal image and a black-and-white image that highlights the dark areas most likely to be moisture. With the Flir tools, temperatures can be pinpointed on the image where there might be an anomaly of interest.

MOISTURE METERS

The one most important diagnostic tool every building contractor should own is a moisture meter. In my work, I use two general types—lower-cost pin meters, which require you to push two small metal pins into the wood surface—and more expensive, contactless meters.

Mini-Ligno S/DC. This pin-type moisture meter runs about $100. It's the first one I bought, and I still use it quite often, particularly for evaluating building materials before I install them or when scoping out a house that has suffered a flood or a leak.

With the Mini-Ligno, I can select from four scales: "Relative" compares different locations; I use this to establish the baseline moisture content in a known dry area to compare with other areas that may be wetter. "Drywall" checks the moisture content of drywall and plaster; in this case, the scale is set to a trigger point around 1% MC. In addition, the meter has two scales for wood, depending on how wet the wood is. In most cases, I do not concern myself with selecting different species of wood. I am more interested in relative readings.

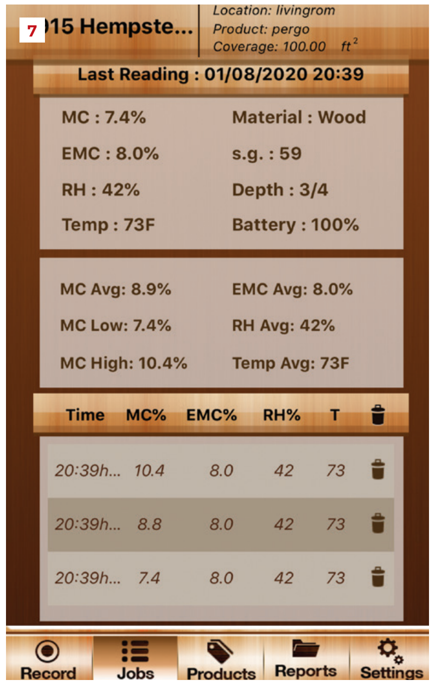
AccuMaster XT. There are lower-cost pin meters available that can provide accurate readings. One stand-out is the AccuMaster XT from Calculated Industries, which costs about $45. Its readings compare favorably to my Mini-Ligno's, and while it might not be as adjustable, it can still be adjusted to low, medium, and high percentage ranges for different types of materials and moisture levels. It would make a great starter meter for someone beginning to develop a habit of checking moisture content. If I succeed at anything with this article, I hope it's to persuade every contractor to use a moisture meter. Cost is not the issue.

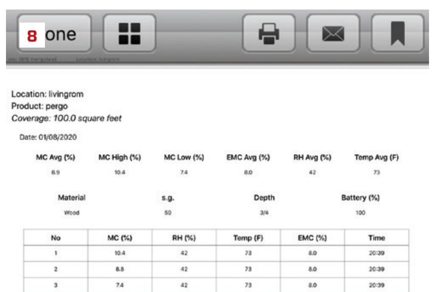
Delmhorst ProScan pinless moisture meter. This meter uses scanning technology to detect moisture below the surface of materials. The two main attractions of pinless meters are:

- Moisture detection to 3/4 inch.
- No marring of surfaces.

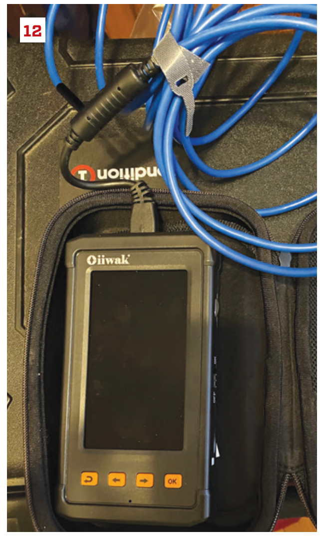
The ProScan can be set to several different species of wood and to a reference scale for nonwood materials. It is the first pinless meter I used, and I have always been satisfied with the reading. But recently, I have been attracted to devices that can also help me document jobs.

Wagner Orion 950 pinless meter. I like this pinless meter primarily for its ability to save and record several readings, including moisture content, equilibrium moisture content (EMC), relative humidity, temperature, time, date, and location. EMC is a particularly good reading for use in acclimating building materials—it's a calculation of the moisture content relative





The Orion 950 **(6)** is a contactless moisture meter that can deliver calculated results on the author's phone **(7)** and can send a report via email **(8)**.



The Kestrel 5200 **(9)** senses a broad range of environmental factors; for evaluating buildings, the author relies most often on the humidity ratio. He can read and record this device via Bluetooth on his phone **(10)** and share the results via email. The author also uses a pair of smaller, Kestrel D2 sensors **(11)** for measuring the humidity ratio at various elevations in a room. For looking into building cavities, he uses an Oiiwak borescope with a digital display **(12)**.

to the temperature and humidity recorded in the surrounding environment. It's the target moisture content, so to speak, for the actual environmental conditions of the space you're in.

DATA RECORDERS

Increasingly, I have become interested in not only measuring moisture in materials, but also tracking and recording environmental conditions on the jobsite. This helps me better understand condensation potentials and predict where problems might occur. There is quite a range of environmental data to measure, but for my purposes, what I find most useful is humidity ratio, or grains. When the humidity ratio is above 100, comfort and moisture problems tend to result.

Kestrel environmental data recorders. I use two types of recorders made by Kestrel: The larger 5200 is useful for more detailed reports, and the smaller D2 (I have two) I like for quick readings in attics, in crawlspaces, and on poles at various elevations in a room. These readings are essential to analyzing why certain things are happening.

For example, when there is water dripping from HVAC registers on high ceilings, I can attach one of the small D2s to a Zip-Wall pole and take temperature, relative humidity, and dew-point readings at the ceiling register to compare with readings at countertop height and floor level. I have discovered that in older homes when new high-SEER HVAC systems replace older, less energy-efficient systems, the newer system puts out colder air. And humid air, much like hot air, is buoyant. This means that the RH and dew point are likely to be higher near tall ceilings. Combine that with cooler air that may be cooling the register grille to below dew point, and you get dripping water. Using the Kestrel recorders, I am better able to document and explain what is happening. Both models allow me to capture a range of conditions and output those in an email to the client.

OTHER USEFUL GADGETS

So far, I have covered the most basic devices for measuring critical environmental conditions. Here are a few others I depend on.

Manometer. Measuring air pressure dynamics deserves its own article. Positive and negative pressures with reference to the outside play a big role in how a building takes in and expels air along with moisture and energy. Here in the hot, humid South, a negative pressure with reference to the exterior can pull hot and humid air into the interior, triggering moisture accumulation, microbial growth, staining, and compromised health. For measuring pressure dynamics, I use a Retrotec manometer (ones from Energy Conservatory are also highly recommended) to develop strategies for air-sealing and duct reconfiguration.

Borescope. For looking inside building assemblies, I use a 5.5mm Oiiwak borescope. The Oiiwak has a nice interface that allows me to capture and output images that I can share with clients.

Not to be left off this list of essential tools are those I use to capture the data: a smartphone, a tablet, and Rite in the Rain note pads (when it's pouring outside, I prefer not to pull out my electronics). These are essential and deserve a place in the case.

Bill Robinson is based in New Orleans, where he focuses on solving building envelope and hot/humid-climate performance issues. Follow him on Instagram: @bandannabil.