Moisture Intrusion and High Ambient Humidity Causation Analysis

An Online Continuing Education Course for Engineers

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Moisture Intrusion and High Ambient Humidity Causation Analysis

Randy Down, P.E.

Despite modern buildings being more "tightly" constructed to prevent unwanted moisture intrusion and to make them more energy efficient, it is still possible to have undesirable moisture conditions that potentially pose a risk of adverse health conditions and damage to the building structure if such conditions persist.

Desired Humidity Range and Mold in Occupied Buildings

What is considered to be an undesirable moisture or humidity condition within an occupied building? Typically, the "ideal" range of ambient relative humidity (RH) to prevent the growth of mold is considered to be *between 30 and 60 percent*. Below 30%RH there are other issues to contend with, such as static electricity. Above 60%RH there is sufficient moisture in the air to be conducive to the active growth of mold or mildew colonies. Mold and mildew colonies are fungal growths that originate as airborne spores that are present under normal conditions indoors or outdoors. It is a natural occurrence of nature that can be observed on rotting tree stumps. A mold spore will drift through the air flowing air currents until it comes into contact with a moisture surface, allowing it to adhere to the surface. If a food source is present, in addition to an ongoing moisture source, the initiation of a colony capable of producing thousands of mold spores will evolve until such time as the moisture source or food source is interrupted or removed; or the mold is destroyed by another means, such as chemical treatment using a chlorine-based solution.

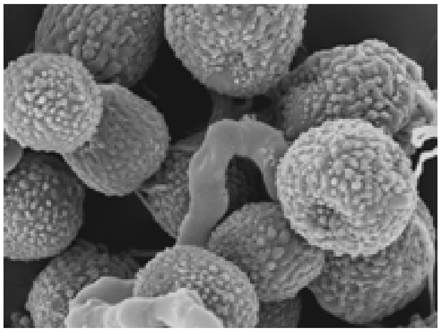

Figure No. 1 - Mold Spores

Indoors, the mold or mildew is very unwelcome; as it results in a musty smell, can release thousands of spores as the colonies mature and die off, and has been linked to cold and flu-like symptoms - particularly in the case of occupants who have allergies or suffer from other respiratory ailments. Since mold spores are microscopic in size, once disturbed and airborne they tend to follow air movement and will spread through a building by way of heating and air conditioning ductwork and vents. Remediation of mold from a home can be quite expensive and disruptive. Mold and mildew will potentially occur wherever there is adequate temperature, moisture and a food source such as wood, cellulose, leather, carpeting and drywall. Such materials are common in most buildings. The onset of mold growth can begin within three days of prolonged moisture, with visible colonies developing within weeks. Of further concern, excessive moisture can also be associated with the attraction of termite colonies and result in wood rot and corrosion that can, over time, severely damage building materials, including structural support members. According to the Western Wood Products Association (WWPA) wood products will no longer support mold growth when their moisture content is below 20%.

Humidity Measurement

Analytical instruments used to measure the relative percentage of moisture in the air are called *hygrometers*. Modern hygrometers are digital, and use solid state technology to detect moisture absorption in a sensory material and determine its level of saturation by measuring a change in electrical conductivity.

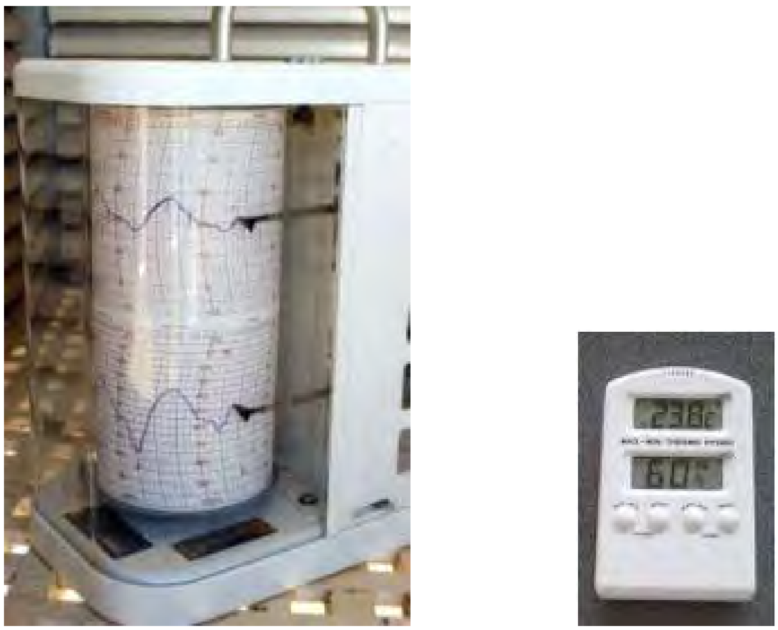

Figure No. 2 - Chart Style Humidity Recorder and Modern Digital Hygrometer

Early hygrometers employed animal or human hair to measure changes in relative humidity. The length of the strands of hair would shrink or expand based on the amount of moisture they absorbed from the air to which they came into contact. Such devices were relatively accurate; but slow in responding to sudden changes in humidity. The dew point temperature of the air can also be determined indirectly and is accomplished by measuring the reflectivity of a chilled mirror surface. The temperature of the mirror is gradually lowered until dew begins to form on its surface, which reduces its ability to reflect light.

Moisture Meter Technology

The relative amount of moisture that has been absorbed into wood, wallboard, concrete block, and other types of building construction materials can be analyzed using an intrusive or non-intrusive type of *moisture meter*.

Intrusive and *non-intrusive* moisture meters use different sensing technology and generally have unique advantages and disadvantages. The intrusive style meter (see Figure No. 3) typically uses two needle-like steel probes that are inserted or placed into direct contact with the wood, wallboard, or other material to be sampled. The conductivity of the measured material increases in direct relation to the level of saturation with moisture that has occurred. The drier the material is, the lower its conductivity. This approach is “intrusive” because it results in two small holes in the material being measured. The advantage of this style of measurement is that some of the meters have optional long probes that can be inserted deeply into a material or wall cavity to detect a subsurface moisture condition.

Figure No. 3 – Intrusive Style Moisture Meter

Non-intrusive moisture meters are simply passed over the surface of the material being measured and most rely on a capacitance or induction-style signal to detect moisture. One advantage of this style of meter is that it allows you to more easily “sweep” an area and identify an area of high moisture. Doing so with an insertion or intrusive style meter would take numerous individual measurements involving more time and result in numerous small holes in the material. The disadvantage of such meters is that most do not detect moisture more than a fraction of an inch below the surface of the material. A moisture problem within a wall cavity that has not resulted in an elevated moisture condition at the measured surface may go undetected. The ideal approach is to purchase both instruments, which can be costly for a high quality moisture meter. At least two manufacturers of these instruments now offer a combination intrusive and non-intrusive meter. While still rather expensive, they are less costly and more convenient than using two separate instruments.

It should be noted that most moisture meters on the market are calibrated for certain types of wood materials and that their use on masonry and other building materials only serves to provide relative or comparative levels of moisture and not an accurate percentage of moisture content.

Psychrometrics

The direct relationship between changes in ambient temperature, relative humidity, dew point, and grains of moisture, referred to as *psychrometrics*, was reportedly first discovered by Dr. Willis Carrier, who is also credited with inventing modern mechanical air conditioning and was the founder of the Carrier Air Conditioning Company. Dr. Carrier brilliantly developed what is referred to as a *psychrometric chart* (See Figure No. 4) which graphically illustrates the direct correlations between temperature and various measurements of moisture in air.

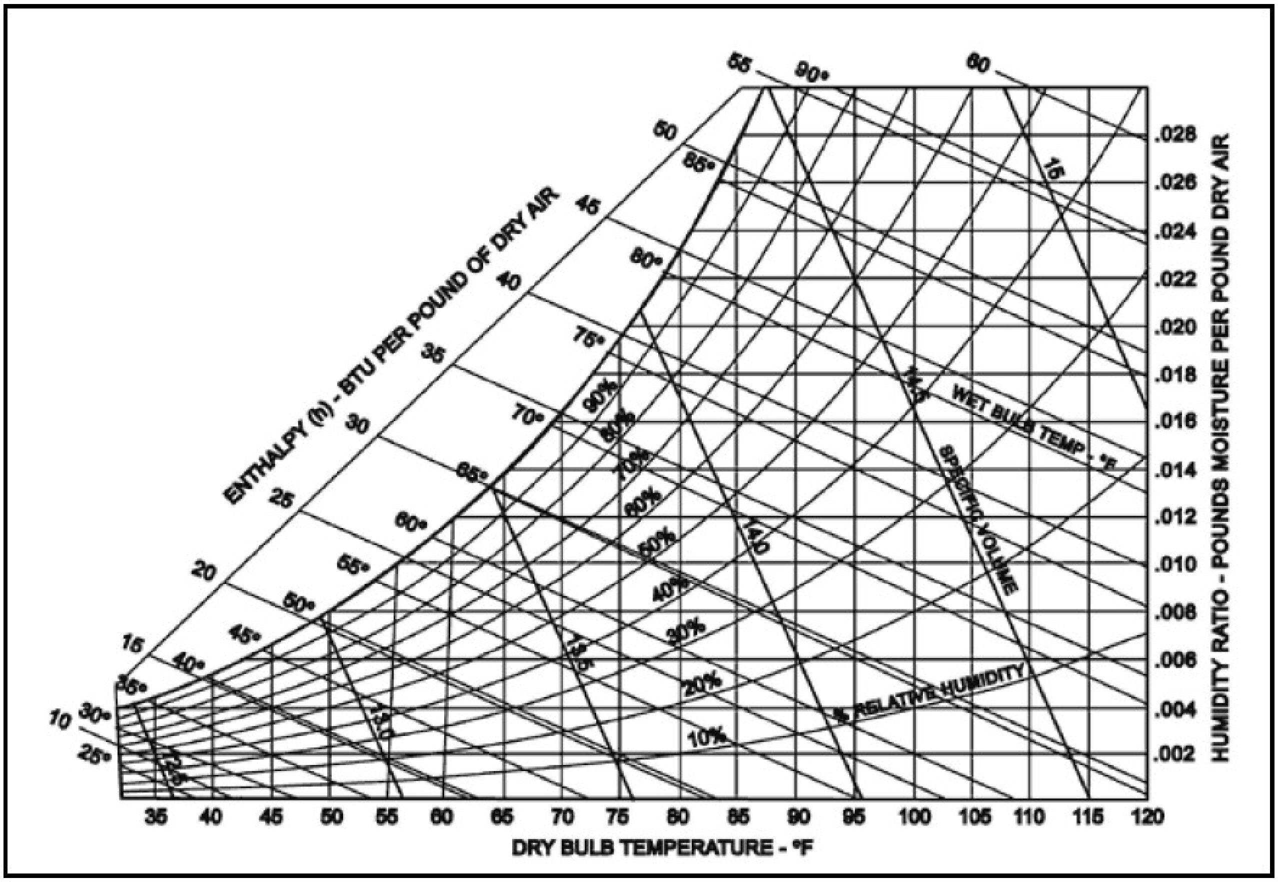

Figure No. 4 – Basic Psychrometric Chart

What psychrometrics reveals is that as air temperature decreases, its density and its propensity to contain moisture decreases. If air containing moisture is cooled to a temperature that is below its *dew point temperature* (the temperature at which dew forms) it will no longer be able to contain the moisture and the moisture will condense out of it. A simple example of this is the removal of a cold can of soda from a refrigerator. Upon coming into contact with air that is at room temperature, moisture will be observed quickly forming on (condensing onto) the exterior surfaces of the can. As the ambient air temperature increases, so does its ability to absorb and hold moisture – thus the humid days of summer; and vice-versa. Outdoor relative humidity levels are quite low during cold winter days. Moisture content of the air can be measured in direct terms as *grains of moisture*; or indirectly in terms of relative humidity the dew point temperature. A less common term, *specific humidity*, refers to the ratio of the mass of water vapor in the air to the total mass of the mixture of air and water vapor.

Why is psychrometrics important in the analysis of high humidity conditions within a building? Because the analysis of a mechanical heating and air conditioning system is important in determining if the mechanical system is properly dehumidifying (removing moisture from the air) when an air conditioning system is in operation during summer climate conditions, and this task requires a good understanding of psychrometrics. It is also necessary to understand and determine the dew point temperature, since dew (condensation) forming on surfaces can provide sufficient moisture for mold growth on building surfaces, furniture, clothing, and other items.

Air Conditioning System Operation

It is also important to realize that when an air conditioning (A/C) system is in operation, some surfaces of the unit's cooling coil, whether it is a chilled water or direct expansion (DX) coil, if operating properly will have moisture condensing onto it from the warmer and moisture laden air passing through it, and that moisture (condensate) will collect by gravity in a catch pan located directly beneath the cooling coil. That condensate will then either drain out through a condensate line pitched out and away from the A/C unit and ultimately pitched such that it drains out of the house and onto the ground; or it will be mechanically pumped (lifted) to a discharge point outside of the building when there is insufficient space to properly pitch the condensate line and rely on gravity to drain the condensate. If the condensate line plugs or the condensate pump fails for whatever reason, the condensate that has collected in the drain pan will either overflow into the ductwork or remain in the pan until it evaporates (re-enters the conditioned air stream). This condition results in a loss of dehumidification of the air and the potential for a high humidity condition to exist within the air conditioning unit, its ductwork and the building.

Use of high efficiency (HEPA) filters in central heating and air conditioning systems is important. Inside heating and air conditioning systems, dust that collects on surfaces and in crevices is a sufficient food source to support fungal growth in the presence of moisture from condensation.

Of further importance is the fact that when air is cooled and moisture is condensed out of it, some drying of the air takes place regardless of the fact that there is no humidistat or other means of humidity controls. By maintaining a space or room thermostat setting at 78 degrees F or lower, a central A/C system should inherently remove some of the moisture; and if properly sized should prevent the moisture level or relative humidity in the conditioned space from exceeding 60%.

A/C systems that are oversized can indirectly result in excessive relative humidity and mold growth due to a combination of factors:

- When an A/C unit is oversized, it tends to lower the space temperature rapidly and cycle back off quickly enough that it does not allow adequate time for moisture to be condensed out of the air at the cooling coil.
- To compound matters, if the unit produces too low of a discharge air temperature at the supply grills, the grill temperature, and sometimes the wall surface around it, will be cooled below the dew point temperature, resulting in condensation and mold growth at and around the supply grills. Often, the onset of mold growth around the supply grills is mistaken for dust or soot because of its sometimes grayish appearance.

Figure No. 5 – Mold at Supp… r

Other Potential So…

Another potential sour… n the exterior of the structure that allow hu… migrates toward areas where the air is less de… ility to wick moisture more readily than one t… *equalize itself throughout an open spa…* o diffuse toward a lower vapor pressure.

Moisture diffusion allow… ity region toward a lower relative humidity r… ature differential to counter the effect. Vapor… sure, but is of differing temperatures, w… ower temperature area.

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