Psymplified Psychrometrics
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More items for Environmental Controls

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Psy`chrom´e`try n. The measurement of the humidity content of the air by use of a psychrometer.
Psychrometrics has often been a confusing and misunderstood area of the industrial coating business. Used every day in the HVAC and humidity control industries, the mechanical engineer or refrigeration professional may have a clear understanding of the principles, but the industrial painter is involved with just a small part of this science and may not thoroughly comprehend the concepts that affect his or her job every day. This article will explain conditions to watch for on the job, what causes conditions to deteriorate, and how to correctly predict humidity as closely as possible and measure these parameters.

What Causes Fluctuations in Relative Humidity?
The earth's atmosphere consists of a mixture of gases in various concentrations. Air is commonly the name given to this mixture which includes mainly oxygen, nitrogen and carbon dioxide, as well as water. The ability for any or all of these compounds to be suspended as part of the air mixture is impacted by two things: pressure and temperature.

The impact of pressure on moisture content can be illustrated when the separator on an air compressor is drained. As the air is compressed, it can hold less water and the excess will collect in the bottom of the tank. Barometric pressure of the air around us has a similar impact on the air's ability to hold water. Barometric pressure changes with altitude and weather systems and these differences in barometric pressure are largely insignificant in the industrial coating world.

What is significant however, is the air temperature and its ability to change the air's capacity to "hold" water. As is the case with many things in nature, when cooled, there is less energy; energy to dissolve things when we cook or clean, energy to polymerize when we mix up an epoxy coating or energy required for water to remain in vapor form. When the air is cooled and it loses energy, the water that it contains does not remain in vapor form as easily. When cooling continues, eventually the sum of the water vapor will become liquid in the form of condensation or rain.

When and How Does Condensation Occur?
Condensation, very simply, is the formation of water droplets from air that is cooled to below its dew point temperature.

What we see when condensation occurs is water moving from a gas to a liquid form. When the air is cooled to below its dew point temperature (also called saturation), the water molecules must leave the air and they find something to attach to. In the upper atmosphere, the water droplets form on microscopic specks of dirt or dust to form raindrops and while on earth, the droplets attach to the most convenient surface, forming dew.

To further explain the relationship between water and air, imagine that heat (energy) is like a juggler. The harder he works, the more balls (water molecules) he can keep in the air. When he gets tired (less energy), he can't keep them all moving and some of them fall out of the air, which is a rough conceptual parallel of why the water sticks to surfaces as dew.

Contrary to popular belief, a cold surface does not draw moisture to it. A cold surface cools the air adjacent to it and, if cooled enough, causes the air to give up moisture. That moisture then deposits itself on the surface in the form of dew or, if below freezing, frost.

The heat that a surface loses by radiation is related to its temperature and the net radiation loss depends on the temperature of surrounding surfaces. If you imagine a ball sitting in a room, if the walls are the same temperature as the ball there won't be any net loss by radiation. What it radiates out, it gets back from the surroundings. If the walls are hotter (even if the air is air-conditioned) the ball will get warmer. You would "feel the heat" on your skin from radiation (infrared).

Think of sitting next to a pot belly stove, even if the room is cold, the radiant heat will warm you.

The sky at night is very cold. The effective temperature is about 40 degrees below zero. Surfaces exposed to the sky radiate their heat out and get nothing back, and therefore, cool faster. Horizontal surfaces lose their heat faster because they face the sky. This is why the hood of your car or the roof of a water tank has more dew or frost. These surfaces condense first because as the surface loses its heat to the atmosphere, it cools the air around it to below the dew point and the moisture is forced to find a place to condense.

How Do Air and Surface Temperature Affect Relative Humidity and Condensation?
Relative humidity is defined as the amount of water vapor in the air as a percentage of what it can hold when it is completely saturated. Air at 50 percent relative humidity (RH) holds one half of the water that it can. Air at 100 percent RH is holding as much water as it can. At 100 percent RH, we say the air is saturated … it can hold no more.

As mentioned earlier, when the air is cooled, it cannot hold as much water. So, if the air is at 100 percent RH and we cool it, some of the water will condense. If we heat the air, its capacity to hold water increases; therefore, the RH will drop accordingly.

Moisture and Painting
Controlling moisture during painting and curing, particularly with clean or freshly painted surfaces, is critical. Knowing how moisture interacts with steel surfaces and paint is also helpful.

To keep surfaces clean, particularly blasted surfaces, less moisture is better. Moisture at the surface causes two major problems:

Firstly, if surfaces are exposed to humidity levels above about 50 percent RH, corrosion (flash rusting) can occur in a matter of hours. Absolutely clean steel won't rust in the presence of non-condensing atmospheric conditions for a long while, but no surfaces are absolutely clean.

It is important to remember that the 50 percent RH measured in the center of the tank does not represent the condition at the surface. The air adjacent to the surface of the steel assumes the steel temperature, therefore impacting the RH there at the surface.

Some contaminants, like those found in industrial environments and smog, sulfur dioxide (SO2) for example, create conditions for flash rusting to start at around 65 percent RH. A more common contaminant, particularly in marine environments, is sodium chloride (table salt – NaCl) which will cause flash rusting at about 55 percent RH. This is why the rule of thumb for dehumidification to hold a blast and postpone flash rusting is to stay below 50 percent RH. Some types of contamination on the surface can make flash rusting occur at even lower humidity levels, but are very rare, and therefore, the most common contaminants will not cause flash rusting below 50 percent RH.

The second problem is that moisture at the surface can cause direct condensation. If there is liquid (water) on the surface, most coatings will not successfully adhere. Water on the surface as a liquid is generally a contaminant, preventing most types of paint from a successful application.

In cold weather, frost is of particular concern. Ice may not always be visible, especially if it is a thin film, but it will prevent adhesion and proper curing. This issue is why almost all coatings recommend a difference of 5 degrees F (or 3 degrees C) between the atmosphere dew point and the temperature of the surface to be coated.

Even after application, condensing conditions can cause serious problems. Many coatings are not water resistant until fully cured. Condensation can interfere with initial curing and permanently degrade acrylic, vinyl and other coatings that form films primarily by evaporation and consolidation. Epoxies in particular are sensitive to liquid water during cure and can develop an amine blush where surface moisture has preferentially reacted with some of the active sites in the resin, creating an oily residue on the surface, rather than the cross-linked polymer desired. Similarly, isocyanate groups in polyurethanes will preferentially react with water rather than the intended polyols if the surfaces of fresh films get wet. Other types of coatings may be discolored and have final cure delayed by exposure to liquid water on the surface. This is undesirable, even if the problems are temporary or cosmetic. One needs to be particularly concerned about outdoor locations where the coating is exposed to clear night skies and the temperatures drop significantly overnight. If there is frequently dew on steel surfaces when the sun rises, expect that condensation can occur overnight after paint is applied.

The moisture in the air can transfer to opened paint and solvents as well. As one example, due to the sensitivity of polyurethanes to water in the mixed paint, use of thinners that have not been certified for use with urethanes (anhydrous) or even solvent containers that have been left open for a period of time, may have enough water in them to cause problems such as reducing pot life or interfering with proper cure.

Too little moisture can also be a problem, although a less common one. Low humidity, particularly in cooler temperatures, will retard or prevent the proper cure of ethyl silicate inorganic zincs. They will remain soft and not fully cured until enough moisture is present, sometimes requiring misting with water to achieve a full cure. Moisture-cured urethanes, as the name implies, also require a reaction with atmospheric water to cure and may not be a good choice in very dry climates.

Knowing the details about atmospheric moisture, or more broadly, psychrometrics, will help control surface cleaning and the application and curing of protective coatings, leading to more successful and profitable projects.