Moisture problems and solutions

Because addressing present or potential moisture problems in a building is so critical, Rural Builder has teamed up with Joseph M. Zulovich, Ph.D, P.E., in a series of five articles that looks at the primary causes and cures of moisture problems and solutions. Part 5 continues the topic of how to protect the exterior building envelope, with this final segment looking at ventilation.

Removing excess moisture with ventilation [Part 5]

As introduced in Part 4 of this 5-part series, removing any accumulated moisture is an important step in addressing potential moisture problems. Proper ventilation—removing inside air and replacing it with outside air—will safely remove excess moisture from inside the building system. But while air infiltration will ventilate a building, the exterior building envelope may be compromised by air escaping into that area (refer to Part 4 of this series for further details).

A ventilation system needs to be operated to remove indoor moisture when moisture is present on the inside of windows or exterior doorframes (see photo at right) during winter (this article focuses on ventilation needs of heated facilities during cold weather). Exterior building components like windows and door frames often have lower R-values compared to exterior insulated wall sections. During winter weather, a building component with a lower R-value will usually have a lower inside surface temperature compared to inside surface temperature on components with higher R-values. This difference in R-values is why condensation will form on windows and door frames before it forms on insulated wall areas.

When the surface temperature of the building component is lower than the dew point temperature of the air inside the building, condensation will form on the inside surface of the component. Psychrometrics provides an understanding of the relationship of air-moisture mixtures and dew point temperature. Basic psychrometrics can be studied using a simplified psychrometric chart shown in Figure 1.

THE SCIENCE OF PSYCHROMETRICS

Air temperature (red lines) increases from left to right, and the amount of moisture that air can hold increases as air temperature increases.

The relative humidity (green lines) indicates how full the air is of moisture at a given air (dry bulb) temperature.

The humidity ratio (blue lines) increases from bottom to top and indicates the actual amount of moisture in the air.

The dew point temperature (purple letters) is found where the humidity ratio line intersects with the 100 percent relative humidity line, with the dew point temperature being the air temperature at the intersection. Dew point temperature is the air-moisture mixture property that indicates when condensation will occur. A surface that is cooler than the dew point temperature of the air in contact with the surface will have condensation form on the surface. Conversely, if a surface is warmer, the surface will remain dry (no condensation).

The air state point is located where the air temperature line intersects with the relative humidity line. A humidity ratio line that intersect with the air state point is followed horizontally to the line to the 100 percent relative humidity line to determine the dew point temperature at the air temperature and relative humidity used to find the air state point.
When the relative humidity is less than 100 percent, the air temperature will be higher than the dew point temperature. The difference between air temperature and dew point temperature as a function of relative humidity is shown in Figure 2.

### THE BOTTOM LINE

To minimize condensation on inside surfaces of exterior building components, one wants to operate a building such that the inside dew point temperature is lower than the inside surface temperature of any exterior building component. The inside air temperature will be similar or somewhat higher than the inside surface temperature of all exterior building components. A large difference between air temperature and dew point temperature exists by maintaining a low indoor relative humidity (Figure 2).

The required difference between dew point temperature and inside air temperature depends on the weather conditions and R-value of the building component. The climate zone map, as introduced in Part 4 of this series, provides some insight into the required minimum R-value of a window or doorframe. Colder zones should have higher window and door minimum R-values. A higher R-value will result in a higher inside surface temperature. This allows indoor air to have a higher dew point temperature before condensation begins to form.

Once a building is constructed, not much can be done about increasing the R-value of a component. If condensation is forming on the inside surface for an unacceptable amount of time, then one must use ventilation to remove moisture from inside the building. A properly operating ventilation system will decrease the inside dew point temperature as moisture is removed. The amount of ventilation needs to be high enough so that condensation no longer forms in the inside surfaces.

The reason a ventilation system can remove moisture from inside a building can be graphically seen in Figure 3. When air is heated (increasing the air temperature), it can hold more moisture. The heated dry air from outside can absorb indoor moisture and will remove moisture from the building when the air is exhausted out of the building.

**Building ventilation is done to:**
- Remove excess moisture
  - And must be continuous when a continuous moisture generation source is present
  - Or can be intermittent to control periodic indoor moisture problems
- Improve and maintain indoor air quality

The amount of ventilation needed depends upon several of the following factors:
- Moisture generation rate
- Moisture generation duration – continuous or intermittent
- Air temperature rise from outside to inside

A properly-sized ventilation system has just enough capacity to remove the excess moisture generated inside the building while maintaining adequate indoor air quality. Keeping the ventilation capacity correct will minimize the amount of supplemental heating required to maintain the inside temperature during winter.

All ventilation systems have the following five functional components:
1. Inlet – location(s) for air to enter the building space
2. Outlet – location(s) for air to leave the building space
3. Driving Force – reason air moves through the building space (the force that moves the air)
4. Distribution – how and where air moves through the building space
5. Path – how and where air moves through the building system

A properly-operating ventilation system will include all five functional components. Experience has shown that most operational ventilation system problems can be traced to the inadequacy of one of more of the functional components.