Building America Building Science Advisor

OUTWARD VAPOR DRIVE

Water vapor moves from a higher concentration to a lower. This phenomenon is referred to as diffusion; a constant mechanism driven by vapor molecules to be in balance. Yet, diffusion by itself will not result in consequences related to moisture, such as condensation or critically high relative humidity levels. This can only happen under the influence of temperature. The amount of vapor air can hold varies with temperature, and since most building materials are filled with small pockets of air (pores), water inside materials is dependent on temperature.

Imagine humid air as hollow spheres, where air temperature will determine the size of the sphere, and thus the capacity to hold water. Figure 1 illustrates two spheres for which the vapor content is the same, but due to differences in temperature, their capacity to hold vapor varies. If the sphere gets completely saturated, any excess vapor will condensate and thus become liquid water.

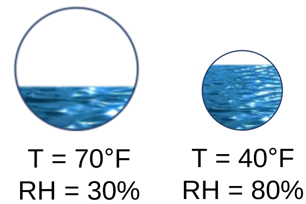
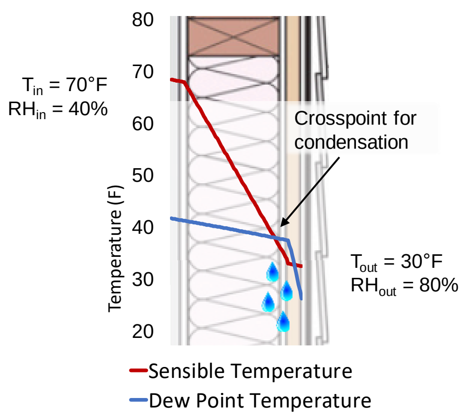


Figure 1: *Humid air seen as spheres. Their size and vapor capacity depend on temperature, but both spheres contain an equal amount of vapor.*

Cause and Effect



In a cold climate, the indoor vapor content is typically higher, and thus vapor moves outwards. Figure 2 depicts a scenario for which condensation occurs inside the wall due to the lack of an interior vapor retarder. The red line represents how temperature is distributed inside the wall. The blue line illustrates the dew-point temperature. As seen in the figure, when the temperature drops below dew-point, condensation occurs.

The fact that the illustrated wall in Figure 2 is missing an interior vapor retarder allows vapor to travel outwards at a relatively high speed. For this specific wall, the exterior sheathing happens to have the lowest permeance for vapor transportation causing moisture to get "trapped" on the interior side of the sheathing.

Figure 2: *Wall with no interior vapor retarder in a cold climate may result in intermediate condensation.*

Preventive Actions

In a cold climate, critical moisture levels and condensation can be avoided in two ways. Either increase the vapor resistance on the interior side, allowing vapor content to drop which will lower dew point temperature. Or raise the temperature of the materials where the problem occurs. Figure 3 illustrates how these two different approaches will eliminate the condensation problem.

The left-hand illustration of Figure 3 depicts how an increase in temperature will avoid condensation (see *Vapor Open Walls*).

For walls with no continuous insulation (right-hand illustration), an interior Class I or II vapor retarder is required in Climate Zones 5, 6, 7, 8 and Marine 4. A wall with an interior vapor retarder requires that materials on the exterior side is vapor permeable enough to allow for outward drying; meaning, high vapor contents are kept on the interior side. See *Trapped Moisture* for further details on what is required to keep the exterior side of the wall vapor permeable.

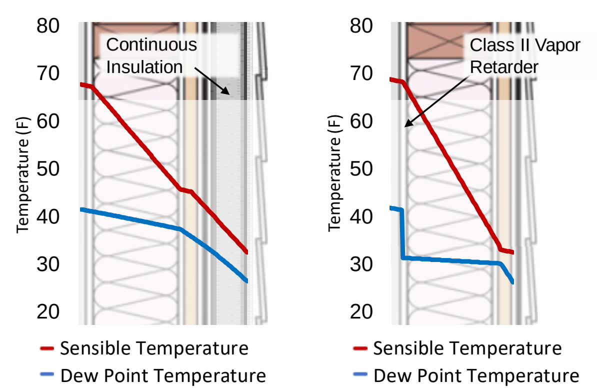


Figure 3: *Intermediate condensation can be avoided for walls in cold climates by either make them warmer (left), or install an interior vapor retarder (right)*

References and Further Reading

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BSI-026: They All Laughed....
BSI-071: Joni Mitchell, Water and Walls
BSI-031: Building in Extreme Cold
BSI-049: Confusion About Diffusion
BSD-106: Understanding Vapor Barrier
Continuous Rigid Insulation Sheathing/Siding

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