Indoor moisture sources can be the cause of many types of building moisture problems. Two solutions need to be addressed with respect to indoor moisture—1) protecting the exterior building envelope and 2) removing excess moisture with ventilation. Part 4 of this series focuses on the first: protecting the building’s exterior envelope.

Where a building is located impacts how to properly protect exterior walls and insulated ceiling assemblies from moisture problems. Different climate zones have been established for the United States as shown in Figure 1. The specific design and construction details vary depending upon where your building is located. The publication entitled “Guide to Determining Climate Regions by County” lists the climate region for each county in the U.S. The appropriate design and construction details depend upon where the building is located and the following three strategies to protect the building components:

- **Vapor migration** – installing a vapor retarder in a proper location
- **Indoor air infiltration** – preventing inside air from leaking into exterior walls and/or insulated ceilings
- **Outside air penetration** – preventing outside air from leaking into exterior building components

**VAPOR MIGRATION**

Moisture that is permitted to migrate at a sufficiently high rate through an insulated building component will often condense inside the insulated building assembly. This condensed moisture will result in a variety of moisture problems. A vapor retarder minimizes the moisture migration rate through an insulated wall or ceiling.

Moisture will migrate through an insulated building component from a high-vapor pressure to a low-vapor pressure. However the climate where the building is located will dictate whether the inside air has a higher-vapor pressure or a lower-vapor pressure.

In climates where the inside is usually warmer than outside, the inside vapor pressure is normally higher than outside. Conversely, climates where the inside is usually cooler than outside, the outside vapor pressure is normally higher than inside.

Buildings located in Climate Zones 5, 6 and 7 should have a vapor barrier, with a perm rating less than 2, located near the inside of an insulated assembly. No more than one-third of the total insulation value of the assembly should be located on the “warm side” of the vapor retarder.

Buildings located in warmer climates should use a vapor retarder with a perm rating of greater than 2. It can be located on either the inside or outside of the insulation.

A more detailed discussion on vapor retarders is located throughout “Moisture Control Guidance for Building Design, Construction and Maintenance” which can be found on the web from the U.S. Environmental Protection Agency.

**INDOOR AIR INFILTRATION**

The exterior building envelope needs to be protected from indoor air infiltrating exterior insulated walls and insulated ceiling assemblies. Buildings located in Climate Zones 4, 5, 6 and 7 are ones which definitely need to minimize inside air infiltration. Typically, the air inside is relatively warm compared to the outside air, especially during cold weather periods.

**FIGURE 1: Climate Zone Map**
The dew point temperature is often defined as the temperature at which moisture will condense from air onto a surface exposed to the air. During cold weather, the inside dew point temperature is normally higher than the outside air temperature even though inside relative humidity levels are acceptable. This is the foundation for indoor air infiltration-based moisture problems.

When warm, moist inside air infiltrates into an insulated exterior wall, the infiltrated air will usually come in contact with a surface or material inside the cavity that is cooler than the dew point temperature of the inside air. Moisture will condense out of the infiltrated air and cause a variety of moisture problems. Exterior insulated walls can be protected from indoor air infiltration-based moisture problems by addressing the following construction details:

- Seal all electrical boxes located on exterior walls. Air can easily infiltrate through unsealed electrical boxes into many types of insulation, resulting in moisture problems inside exterior wall cavities.
- Seal all holes in the top plate of exterior walls. Sealing the top plate reduces any inside air that can leak into an exterior wall cavity because air will not enter into a wall cavity if it cannot escape from the cavity.
- Seal the inside exterior wall surface to the top and bottom plates or use spray foam insulation to create an air barrier at the inside insulation surface. Convection currents can develop when inside air enters into an exterior wall cavity, cools and then exits from the bottom of the same exterior wall cavity. When warm inside air cools inside an exterior wall cavity, moisture problems will typically result.

Insulated ceiling assemblies can be a source of moisture problems in attic spaces. Warm air will naturally infiltrate through any hole or crack. When inside air enters the cold air in the attic, moisture carried by the inside air will typically condense out the infiltrated inside air and cause moisture problems. Adequate attic ventilation is generally not capable of removing the amount of moisture moved into the attic in these cases, but air infiltration can be minimized by addressing the following construction details:

- Seal all attic accesses to minimize any air leakage from the inside into the attic.
- Seal all holes in the top plate of all interior walls. If air cannot escape from an interior wall cavity, air will not leak from the inside into the attic via interior walls.
- Seal all electrical fixtures and any recessed light fixtures located in the ceiling. Unsealed recessed ceiling light fixtures will result in a significant amount of air to leak from inside a building into the attic space.

OUTSIDE AIR PENETRATION

Outside air penetration needs to be minimized for buildings located in all Climate Zones. For buildings located in cold climates, cold air that can penetrate into an exterior building assembly can cause a cold surface to develop on the inside surface. Moisture problems will occur on the cooled inside surfaces when these surfaces are at or below the dew point temperature inside the building.

For buildings located in warm climates and are air conditioned, moisture problems can develop inside insulated assemblies when warm, moist outside air penetrates the assembly. A convection current will carry moisture in the warm outside air and the moisture will condense on the outside surface of the cooled inside building assembly surface. Any air conditioned building that has moisture condense on the outside of a window during hot, humid weather will most likely have moisture problems in insulated exterior building assemblies if outside air can penetrate into the cavity. This air infiltration can be minimized by addressing the following details:

- Seal between windows/exterior doors and rough structural frame prior to installation of exterior flashing
- Ensure an exterior air barrier is installed and is continuous
- Install attic baffles or air chutes to minimize air that enters attic space from penetrating under ceiling insulation.

FOR ADDITIONAL INFORMATION:

The publication “Guide to Determining Climate Regions by County” can be found at http://www1.eere.energy.gov/buildings/publications/pdfs/building_america/ba_climateguide_7_1.pdf from USDOE.

A more detailed discussion on vapor retarders is located in “Moisture Control Guidance for Building Design, Construction and Maintenance” found at https://www.epa.gov/sites/production/files/2014-08/documents/moisture-control.pdf from USEPA.