

# **How to Avoid Moisture Damage to Walls from Condensation**

## **Background Information**

Exterior building walls are barriers between the atmospheric conditions on the outside and the atmospheric conditions on the inside. Certainly the temperatures on the inside will be different than that on the outside, but when we talk about atmospheric conditions, we must also include the humidity, which is the water vapor present in the atmosphere.

The proper design of an exterior wall must take in to account the subtle differences in atmospheric conditions, along with the walls ability to do its' main job of resisting wind, rain, snow, sleet, hail and the sun.

There are consensus standards available (ASTM, ANSI, etc.) that by examining various exposures in the laboratory, can measure the ability of an exterior wall to perform the job of protecting the inside of a building from the weather conditions on the outside. These test standards may even help to provide an answer to the question on how long an exterior wall will be able perform its main function.

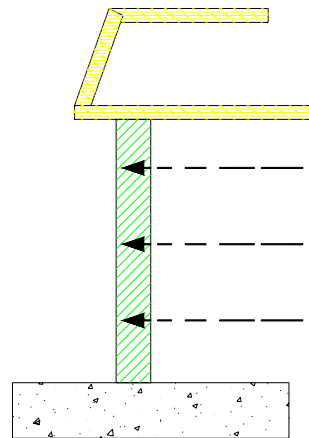
However, methods that are available to measure the effects that the unseen atmospheric conditions (temperature and humidity) can have on the performance of an exterior wall, generally use extensive calculations in addition to lab data. A potentially damaging result of the differences in temperature and humidity is condensation that may occur within an exterior wall. The only readily available and practical method of determining this possibility is by means of computer programs that calculate dew points in walls. The calculations follow methods given in the "Handbook of Fundamentals" published by ASHRAE (American Society of Heating Refrigeration and Air-conditioning Engineers). Although these programs are not perfect and leave a lot to be desired, they do provide some information to the design professional to avoid long term damage.

## **Water Vapor Migration**

There is always some amount of water vapor in the atmosphere, and this amount of water vapor will typically be different on the inside of a building from that on the outside. As is always the case, nature will try to equalize this imbalance, which means that the water vapor will try to migrate from a location of higher concentrations to a location of lower concentrations. This results in a water vapor drive across the boundary between the two locations.

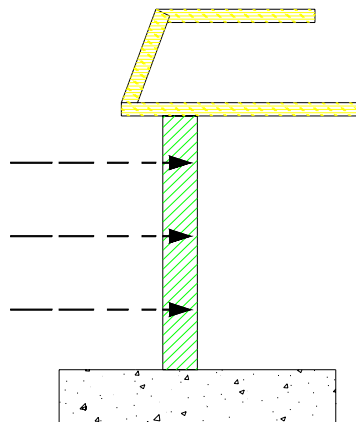
The usual water vapor migration direction is from higher temperatures towards lower temperatures, so in colder northern climates, where buildings are heated

more than cooled, the primary vapor drive is from the interior towards the exterior (Figure A).



**Cold Climate - Figure A**

For warm southern climates, buildings are air-conditioned more than heated, so the primary vapor drive across the wall is from the exterior towards the interior (Figure B).

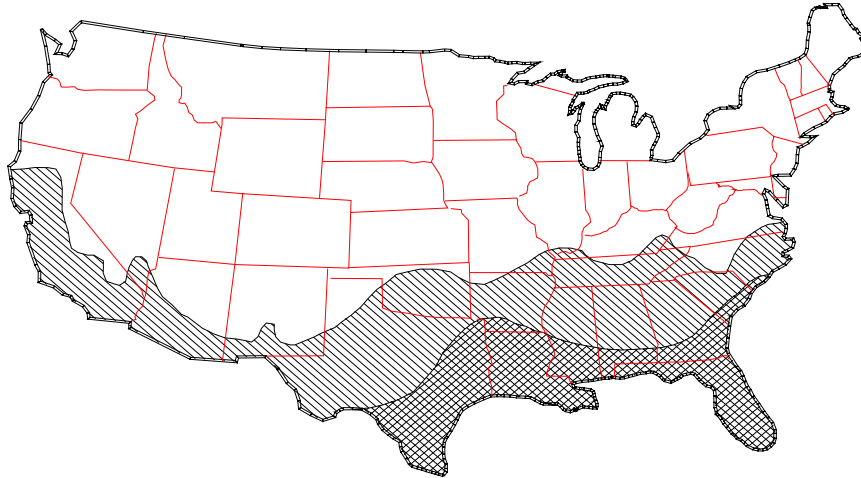


**Hot/Humid Climate - Figure B**

During summertime in northern climates, the interior to exterior vapor drive is minimized, and winter in the southern climates minimizes the exterior to interior vapor drive.

Looking at a map of the United States, we've defined three areas in which the water vapor drive is predominant. First, the northern or cold climate is established as the area of the country north of the 4000 heating degree day line (For explanation of Heating Degree Days, see Definition of Terms). The second line is the border of the hot/humid climate, which is defined in the ASHRAE Handbook, and this runs from the Texas Gulf Coast across the southeast to the

North Carolina Atlantic coast. The area between these two climate extremes is considered a moderate climate where the vapor drive is essentially equal in both directions.



- Northern Cold Climate - Vapor Drive Interior to Exterior**
- Moderate Climate - Vapor Drive Equal Both Directions**
- Hot/Humid Climate - Vapor Drive Exterior to Interior**

## Definition of Terms

The definitions below are simplified descriptions of the terms used in the program so that the results generated by the computer program can be easily understood and interpreted.

**Saturated Vapor Pressure** – This is a measure of the total amount of water vapor that the atmosphere can hold at a given temperature. The higher the temperature, the more water vapor the atmosphere can hold, and conversely at lower temperatures, the atmosphere can hold less amounts of water vapor.

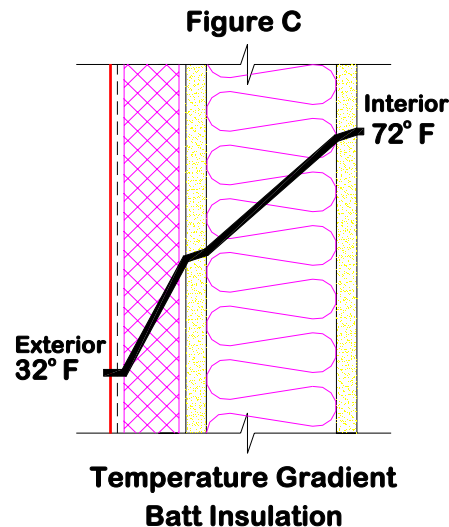
**Partial Vapor Pressure** – The actual amount of water vapor that is in the atmosphere at a given time, and it is usually given in terms of percentage of the saturated vapor pressure. In weather terms, it is called the relative humidity. So when the weather report states the “Relative humidity is 80%” it means that the amount of water vapor in the atmosphere is 80% of what the atmosphere could actually hold.

**Dew Point** – The point at which the partial vapor pressure equals the saturated vapor pressure and condensation occurs. In weather terms, the relative humidity is 100%, and there is precipitation falling from the sky.

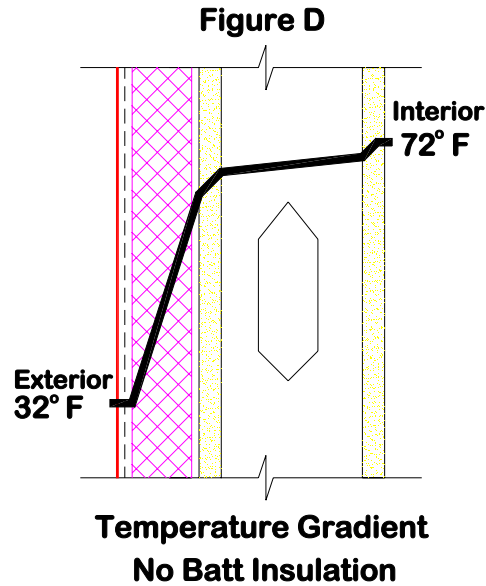
**Heating Degree Days (HDD)** – This is an indication of what period of time a building must be heated to maintain a temperature of 65 degrees Fahrenheit. As an example, take a building that only has to be heated for two days, and the temperature one day is 35 degrees Fahrenheit and 25 degrees Fahrenheit the second. The total is 70 heating degree days (35 degrees to 65 degrees is 30 degrees and 25 degrees to 65 degrees is 40 degrees, so for the two days of heating, you have 30 plus 40 for the 70 HDD). Thus, as one travels north, the number of heating degree days increases (e.g. Nashville, TN is 3696 HDD and Chicago, IL is 6127 HDD).

## What's Happening in a Wall?

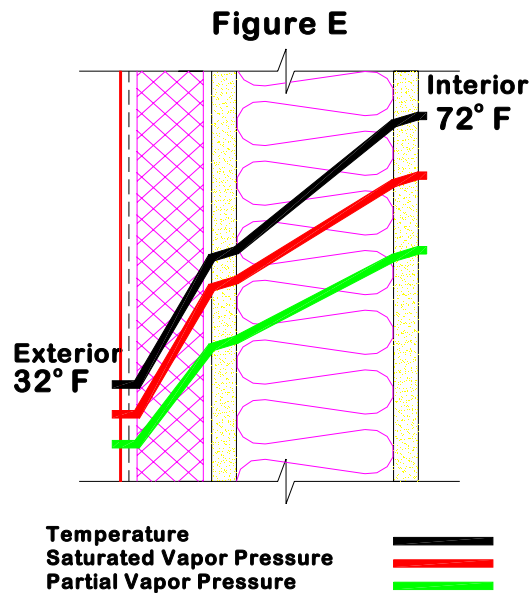
As noted earlier, the conditions on the interior of a building are typically different from the exterior conditions, and this means that there are gradients across the wall from the interior to the exterior. One gradient across the wall is the temperature gradient as shown in Figure C below:



The greatest temperature drop across the wall is at the wall components that exhibit good insulating properties. In the example above, the greatest temperature drops are at the batt insulation and the Expanded Polystyrene (EPS) board in the Exterior Insulation and Finish System (EIFS). Removing the batt insulation from the wall cavity, the temperature gradient would be similar to that shown in Figure D.



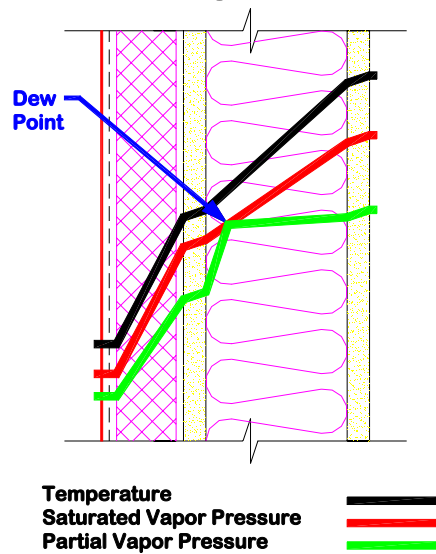
Along with the temperature gradients across the wall, there are also the vapor pressure gradients for both the saturated and partial pressures. Since the vapor pressures are directly related to the temperature, these gradients will reflect the changes in temperature across the wall. Figure E shows how these gradients may appear across the wall assembly.



Note that in Figure E, the partial vapor pressure gradient never meets the saturated vapor pressure gradient, so there is no dew point or condensation occurring in this example.



**Figure G**



Here the partial vapor pressure equals the saturated vapor pressure in the batt insulation. Prolonged exposure to the conditions that result in a dew point in this location will lead to accumulation of moisture. Too much accumulation for too long a duration could eventually damage the surrounding wall components. This is not a good location for the dew point to occur.

Keep in mind that as exterior and interior conditions change, the dew point within the wall can move. Conditions that may cause the dew point to fall in the batt insulation may occur very infrequently, and if that is the case, the likelihood of moisture accumulation and possibility of damage is reduced.

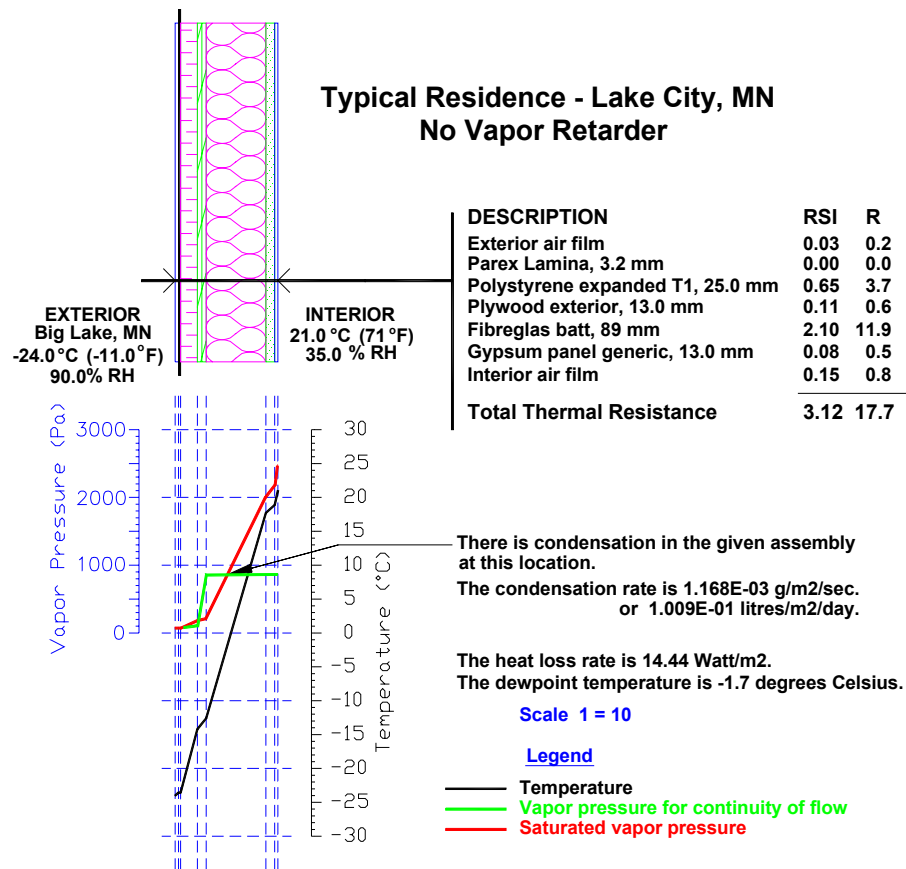
## **Computer Wall Analysis**

There are several computer programs available to analyze a wall assembly to determine the location of the dew point (if there is a dew point), and in some cases, the amount of condensation over a period of time. Typically these programs evaluate the temperature drop across each of the components of the wall assembly based on the “R-value” and thickness of the component.

Included in the data base of building materials in the computer program is the ability of each of the components to allow water vapor to pass through it. This ability for water vapor transmission is given a value as measured by a consensus standard and generally has units of US perms, permeance, permeability, water vapor transmission rate, etc. Based on these values, the partial vapor pressure on each side of a wall component can be calculated, so along with the temperature, the partial vapor pressure is known at the interface of each wall component.

Information that must be entered into these computer programs include a list of all the components and the thickness of each component that make up the wall assembly from the exterior to the interior. Also needed by the programs are the interior and exterior design temperatures and humidities to which the wall assembly will be exposed. These temperature and humidity values can be average conditions, as found in nationally published weather volumes, or extreme values as may be encountered in a worst case scenario.

Below is an example of the results of a computer wall analysis. The components and thickness of each are listed, along with the exterior and interior conditions used in the analysis, the three gradients across the wall are defined, and the location of the dew point with an estimate of the volume of condensation expected. The information contained in here will enable the design professional to assess the potential long term effects, and take the necessary precautions to reduce or eliminate any possible damage.



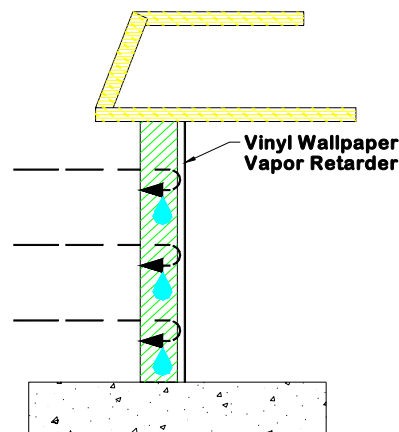
Note: Above program was developed in Canada, which uses metric units and Celsius temperature.



## Vapor Retarders and Proper Location

A building component that is resistant to the migration of water vapor is frequently called a “vapor barrier”, but the more appropriate term would be “vapor retarder” as there are very few building materials that do not allow any transmission of water vapor. Vapor retarders are frequently employed in wall construction, especially in the northern climates, to reduce the amount of water vapor that can enter the wall assembly. By reducing the amount of water vapor in the wall, the partial vapor pressure in the wall is far less than it would normally be, and thus the likelihood of the partial pressure equaling the saturated pressure and forming condensation is all but eliminated.

Thus vapor retarders serve a very useful purpose in wall construction, but they must be placed in the proper location in the assembly. Placement of a vapor retarder in the wrong place in a wall assembly, by a well-intentioned design professional, can actually create more damage to the wall than if it had been omitted. A common occurrence of an improperly located vapor retarder is the use of a vinyl wallpaper inside of a building in a hot, humid climate like Florida. In this case, the vinyl wallpaper, acting as a vapor retarder, is on the inside of the wall. The predominate vapor flow through a wall in Florida is from the outside towards the interior (hot outside to air-conditioned inside), so the water vapor travels through the wall until it meets the vinyl wallpaper and can travel no further. Moisture starts to build-up behind the vinyl until the concentration is high enough to form condensation, and, without a means to escape, there will be damage to the gypsum wallboard and possible formation of mold and mildew. Figure H demonstrates this problem.



**Hot/Humid Climate - Figure H**

## Design Options

In the event that a computer analysis of a wall assembly indicates a possible condensation problem within the system based on the variables entered into the program, there are optional courses of action that the design professional can utilize to correct any deficiencies. One or more of these design considerations may be incorporated in the wall construction, and some of these methods are obvious, and others may seem a bit obscure.

- A. The most frequently used method of preventing condensation is the installation of a vapor retarder on the warm side of the wall. This is an effective means of solving the problem, but as discussed above, the location of the vapor retarder is critical, and the vapor retarder must be able to function properly (i.e. must have a low water vapor transmission rate, and must not be breached by penetrations or breaks). Although this is the first choice, there are instances where this solution cannot be used effectively, so other options have to be reviewed.
- B. If the analysis indicates that most of the time the dew point is going to be located in one of the wall components that is unaffected by moisture, or accumulation cannot occur, then it may be possible to omit the vapor retarder.
- C. A technique used in colder climates is to add more insulation to the exterior of the wall. This has the effect of moving a dew point towards the exterior of the wall and perhaps into a component that does not allow moisture to accumulate and cause damage. There may be some restrictions on how much insulation can be added to the exterior, and it does take a considerable amount of insulation to move the dew point a short distance.
- D. Consider the conditions that were used in the computer analysis, and if a worst case scenario was chosen, then perhaps the period of time that condensation is likely to occur is very short. Damage to most wall components occurs only when moisture is allowed to accumulate and contact is prolonged. Given an adequate time for drying, then intermittent periods of condensation may not pose a problem.
- E. Allowing the wall to drain by means of weeps is one method of preventing moisture accumulation, especially in cavity wall designs. Venting the wall to allow evaporation is employed in curtain wall systems. These options are typically not done in an EIFS clad construction.
- F. Finally, the removal of all insulation in the wall cavity may have to be considered. Dew points occur most commonly where the temperature drop is the greatest, and this happens across materials that have good insulating properties. Removal of the cavity insulation will alter the temperature gradient across the wall and effectively move the dew point to a location that

may be more acceptable. The down side to this approach is the reduction of the overall "R-value" of the wall system.

Parex offers the wall analysis service to design professionals so that they can obtain basic data on water vapor migration through the wall assembly being designed using reasonable techniques to avoid potential long term condensation problems. If you have any questions regarding this service or the resulting analysis, please call us at

**800-537-2739**