

tips & tricks

BY JOSEPH M. ZULOVICH, PH.D., P.E.

Moisture problems and solutions

Moisture problems can be one of the most destructive elements a building faces, leading to the quick deterioration of building materials, building contents, and possibly your reputation as a builder. At the time of their purchase, your customers probably won't worry as much over the long-term health of their new building as they will about what they want that building to protect. It is something Chris Davis, Filc USA, makers of DripStop sees firsthand all the time. A case in point: "When a farmer spends a half million dollars on a new piece of equipment, the first thing they want to do is go out and put a building up to protect it," he said. Because addressing present or potential moisture problems is so critical, *Rural Builder* has teamed up with Joseph M. Zulovich, Ph.D, P.E., in a series of five articles that will look at the primary causes and cures.

An overview and strategy [Part 1]



Moisture problems are relatively easy to identify—liquid water or damp, wet materials exists where it shouldn't. However, determining the best solution for a particular moisture problem is not straight forward because one solution does not fit all situations.

The strategy to understand and address moisture problems is common, but the details to address any one problem are more complicated.

There are four steps to undertake:

- First, identify all the sources of moisture affecting a building envelope or a building system.
- Second, determine if any of the moisture sources can be eliminated. Sometimes a source can be eliminated or at least minimized. However, many moisture sources cannot be eliminated and then must be addressed.
- Third, the building envelope must be constructed and maintained to protect from moisture exposure.
- Fourth, remove any accumulated moisture from the building system.

The first two steps of identification and elimination can be considered fairly straight forward. The third and fourth steps of protection and removal are dependent upon the moisture source, location of a potential moisture problem and specific building system details. The complexity of these last two steps dictates why one solution does not fit all situations.

Moisture sources can be categorized into three main groups:

- Surface water,
- Subsurface water, and
- Indoor sources.

The primary **surface water source** is due to precipitation from rain or melting snow. Surface water will almost always exist so it can't be eliminated as a source; therefore, the building system must be protected from exposure to surface water.

Any building with a portion of the building volume below the outside finished grade soil surface may be exposed to **subsurface water and soil moisture**. Any building with a basement, partial basement, or walkout basement needs to be protected from potential subsurface water and soil moisture exposure.

A building that uses a slab-on-grade construction can have moisture challenges due to subsurface soil moisture with certain soil conditions. Regardless of building design, the building foundation must be able to cope with any soil moisture or subsurface water issues.

Indoor moisture sources causing moisture problems have increased as more buildings are built with heating systems and sometimes air conditioning systems. Buildings without climate control (heating and air conditioning) tend to have indoor temperatures very similar to outdoor temperatures and often have sufficient air exchange capability incorporated into the building system to adequately address indoor moisture sources.

When building envelopes are built to be more

+ ABOUT THE AUTHOR

Joseph M. Zulovich, PhD, PE, is extension agricultural engineer at the University of Missouri, Columbia, Missouri. He can be reached at zulovichj@missouri.edu.

airtight to reduce heating and cooling costs, adequate air exchange to address indoor moisture generation may not exist. The lack of air exchange or user-space ventilation can often result in indoor moisture problems.

The activity and use of an indoor building space has the potential to generate moisture that then must be removed from the indoor space. Indoor moisture sources include but are not limited to wet vehicles stored in buildings, people, plants and/ or animals inside the conditioned space.

Indoor moisture problems can be reduced or eliminated if some or all the indoor moisture generation sources are removed or stopped within the conditioned building space. However, the intended use will dictate whether moisture will be generated inside that building space. A change in activities or uses can impact whether indoor moisture problems occur. One user who generated little moisture may leave and the new user who generates considerably more moisture moves in and the result can be a building that now has indoor moisture problems. Therefore, the solution to a particular indoor moisture problem is closely tied to the use of the building space.

To solve moisture problems, the moisture source must first be identified. Then based on the moisture source and location of the problem, a solution can be developed.

A LOOK AHEAD

Future articles in this series will look at solutions to prevent or address moisture problems based on the moisture source.

Article two will address protecting the building system from surface water and how some below-grade water problems are really caused by uncontrolled surface water.

Article three will focus on subsurface moisture and foundation protection.

Articles four and five will focus on controlling problems caused by indoor moisture generation. The fourth article will focus on protecting the exterior building envelope from indoor moisture by using airtight construction practices and vapor retarders. The fifth article will focus on indoor space ventilation to remove moisture from within the conditioned space and to enhance indoor air quality. RB



This series of articles will be made available online at www.ruralbuilder.com

CERAMIC INSULATING TECHNOLOGY

SPACE AGE CERAMICS

COOL ROOFS COOL WALLS

INSULATES, REDUCES HEAT & SAVES ENERGY

ELASTOMERIC WATERPROOFING INSULATING CERAMIC COATINGS FOR ROOFS, WALLS & MORE

Warranties up to 20 Years!

KEEP YOUR LIVESTOCK & BUILDINGS COOLER

GREEN SAFE LOW VOC ZERO VOC

PERMAKOTE WATERPROOFING CERAMIC ROOF COATING

ULTRA SEAL ELASTOMERIC WATERPROOFING INSULATING CERAMIC PROTECTIVE WALL COATING

OVER 100 QUALITY PAINT & COATING PRODUCTS; CALL FOR A PRODUCT CATALOG!

ENERGY STAR PARTNER Partner Since 1999

NATIONWIDE PROTECTIVE COATING MANUFACTURERS, INC. SARASOTA - FLORIDA - USA

BBB ACCREDITED BUSINESS A+ RATING Member Since 1997

The PERMANENT Coating Solution™

1.800.423.7264 941.753.7500

Circle Reader Service #463

WWW.RURALBUILDER.COM

13

tips & tricks

BY JOSEPH M. ZULOVICH, PH.D., P.E.

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 2 addresses the first main moisture source—surface water. The series will continue in subsequent issues of *Rural Builder* and made available online at RuralBuilder.com.

Protection from surface water [Part 2]



Undesired surface water that can effect a building's integrity are most commonly caused by rainwater, surface water runoff and snow/ice melt.

These precipitation-based sources cannot be eliminated so they must be controlled in order not to cause adverse impacts on a building system.

Several phases need to be followed to control surface water from impacting a building system. These phases include the following:

- 1. Site Selection** – where the building will be located determines much of what needs to be done to control surface water
- 2. Site Preparation** – proper site preparation has a significant impact on effectiveness of surface water control

3. Site Drainage – details need to be addressed so surface water drains off and away from the building on the finished site

4. Exterior wall and roof system selection – the selected roof and wall system, along with flashing transitions must be selected to ensure precipitation does not penetrate the exterior of the building

5. Construction process – attention to detail during the construction process must be done to ensure a well-designed wall and roof system is effective

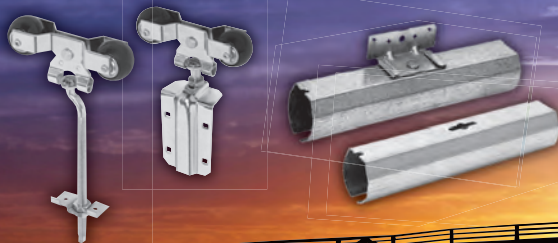
The proposed site of a new building needs to be evaluated to determine not only how surface water will drain away from the site but also how much water potentially will drain onto the site.

+ ABOUT THE AUTHOR

Joseph M. Zulovich, PhD, PE, is extension agricultural engineer at the University of Missouri, Columbia, Missouri. He can be reached at zulovichj@missouri.edu.

ROUND TRACK

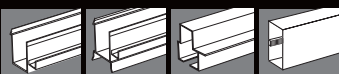
YOU'RE ON THE RIGHT TRACK WITH WESTERN™



600-lb. capacity, smooth, easy gliding round track. Self-cleaning design, corrosive resistant 14 gauge galvanized construction.

(800) 553-5142 www.westernproductsinc.com

ALSO FROM WESTERN: 1 1/2" + 3 1/2" SLIDING ALUMINUM DOOR FRAMES



WESTERN™
PRODUCTS OF INDIANA

Circle Reader Service #374

For example, there may be excellent drainage away from the proposed site but is located where a lot of surface water from up the hill will drain will down to it. In this example, the proposed building site may be located in a drainage path for a large watershed area. If so, can the proposed site be moved to some degree so that it is no longer located in the significant drainage path?

A second example of a potentially poor site selection is one that is located in a hole or depressed area where the surface water collects rather than drains away. Surface water should be able to drain away from the site at a sufficient rate so that it does not flood a building during rainfall events.

Site preparation is the phase to address any problems identified during the building site selection process. Sometimes, a new building site needs to be elevated to increase a surface water diversion capacity or to get the finished building elevation high enough so surface water can drain away. During site preparation is the time to ensure that surface water will adequately drain away from the building when construction is complete.

A building site located near the bottom of a hill will

require the construction of a surface water diversion with sufficient capacity so that surface water flowing to the site will flow around the new building site. Sometimes the building site elevation needs to be increased to ensure enough diversion capacity can be constructed. A site with naturally slow or poorly draining soils needs to use a similar clay type soil fill to increase the elevation under the building. This will prevent surface water from infiltrating into the fill and collecting under the building. A granular material like gravel or sand can be used to elevate the building base to a higher finished elevation. **Figure 1** graphically shows how low permeability fill should be placed to ensure infiltrated surface water does not collect under the new building base.

If the building fill base was all granular material, surface water in the diversion will infiltrate the fill base under the building, which can result in significant subsurface water problems. In this case, the source of the water is infiltrated surface water rather than a subsurface water source.

If the building example shown in Figure 1 had a basement with the floor below the elevation of the bottom of the surface water diversion, and the fill material was all

The Heartland NFBA Chapter presents

the 6th Annual
**HEARTLAND
CONFERENCE**

Oct. 5 - Oct. 6, 2016
Branson, Missouri



Learn how to

- Increase your revenue
- Survive an OSHA Inspection
- Monitor Risk Management
- Increase worker safety



**Register Online
by 9/5/16
to avoid late fee
Pay by credit card
or PayPal**

Free Dinner
Reception at
6 pm on 10/5/16



www.heartlandnfba.org
nfbaheartland@gmail.com

STAY AT THE LUXURIOUS STONEBRIDGE RESORT!
866-332-1373 - Book Now - Limited Availability

Circle Reader Service #597

tips & tricks

BY JOSEPH M. ZULOVICH, PH.D., P.E

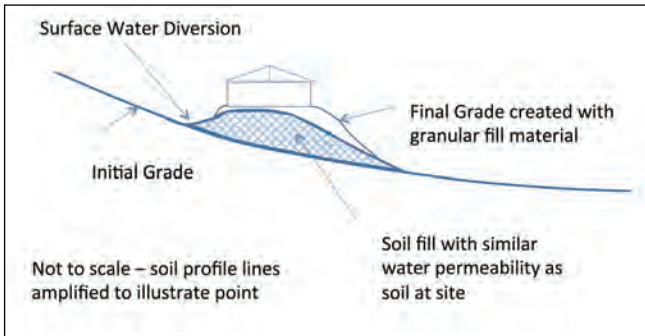


Figure 1: This illustrates how low permeability fill should be placed to ensure that infiltrated surface water does not collect under the new building base.

granular, a good chance exists that the basement could have moisture problems during wet weather periods.

The roof and exterior wall materials protect a building from precipitation of all kinds and types. Proper selection of materials, and the design of transitions between different roof and exterior wall surface components are critical to ensure the building is protected from liquid water throughout all temperatures the building is likely to experience.

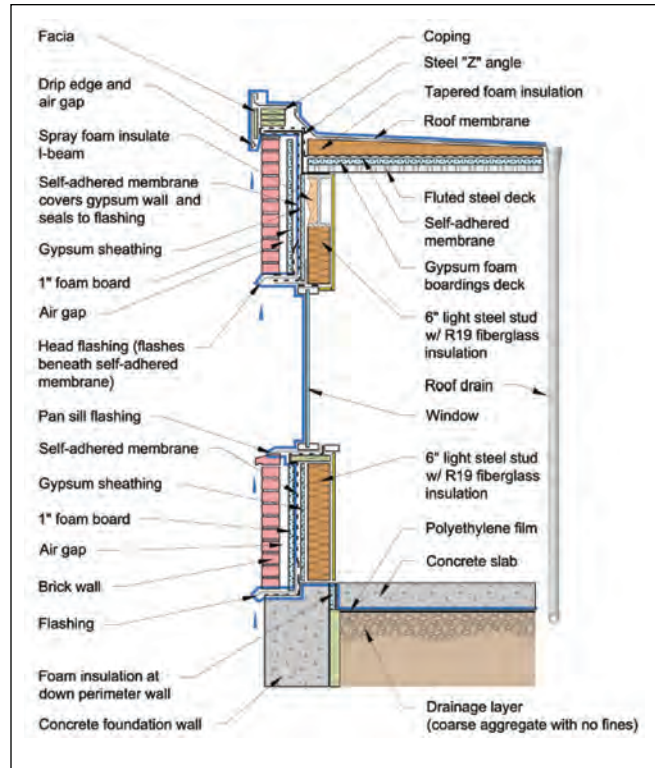


Figure 2: A “Pen Test” can help determine if the chosen design will protect the building from rainwater moisture penetration. This example is taken from “Moisture Control Guidance for Building Design, Construction and Maintenance” found at <https://www.epa.gov/sites/production/files/2014-08/documents/moisture-control.pdf>.

The building owner may be most concerned about esthetics and maintenance; however, the reliability of the chosen system over time also needs to be considered. A capillary break, which minimizes the movement of moisture from outside into the building structure, must be incorporated into the building system. A “Pen Test” can help determine if the chosen design will protect the building from rainwater moisture penetration. An example of this pen test is shown in **Figure 2**. This illustration has been taken from “Moisture Control Guidance for Building Design, Construction and Maintenance” which can be found on the U.S. Environmental Protection Agency website. This document is an excellent resource to understand and address moisture problems in buildings.

The construction process for a new building is the implementation of the material selection and transition design phase. Attention to detail is critical. The success from selecting best materials and developing sound transition designs will occur only if the building is built according to the design. **RB**



This series of articles will be made available online at

www.ruralbuilder.com

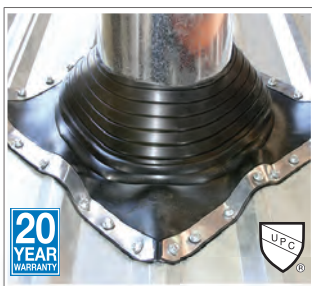
SEAL IT RIGHT, SEAL IT TIGHT!

Fix-A-Flash Master Flash®

Specifically designed for the Metal Roofing Industry

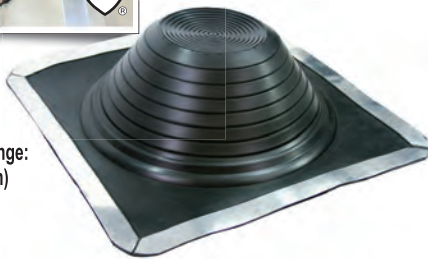
OVERSIZED HOLE IN YOUR ROOF?

Aztec has the answer...



Extra Large Base:
19-1/2" (495mm)

Closed Top Pipe Range:
0" - 15" (0-381mm)



aztec washer company
when reliability counts

1-800-WASHER 5 (927-4375)

To see our complete product line go to www.aztecwasher.com

Circle Reader Service #441

tips & tricks

BY JOSEPH M. ZULOVICH, PH.D., P.E.

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 3 addresses the second main moisture source—subsurface water and soil moisture. The series will continue in subsequent issues of *Rural Builder* and made available online at RuralBuilder.com.

Protecting from subsurface water [Part 3]



Any building has the potential to have challenges from subsurface water and soil moisture simply because the building has direct contact with the soil. However, the building practices to protect a given building depend upon the site soil characteristics and seasonal and permanent water table depths, along with the building foundation type. Types of building foundations to be addressed include concrete wall and foundations for shallow crawl spaces, deep basements, partial or walkout basements as well as slab-on-grade and post-frame construction foundations.

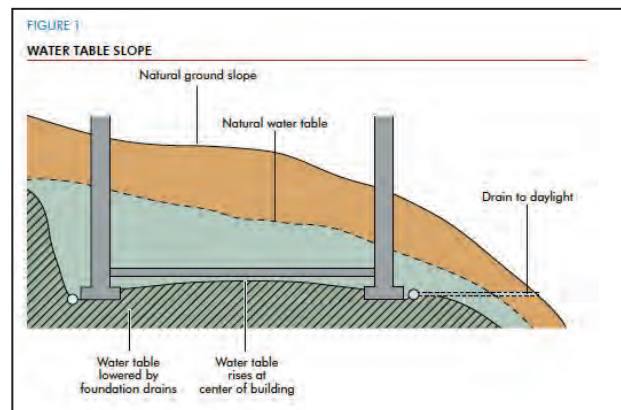
Three different strategies are typically implemented to control subsurface water and soil moisture. These strategies include the following:

1. **Control or Minimize Subsurface Water** – Use foundation or footing drainage to remove subsurface water from contacting the building foundation and footings.

Foundation and footing drainage provides the base control of subsurface water by removing the water from the soil next to the building. Keeping water away from a building foundation protects the building from frost-heave problems and minimizes any unwanted water leakage into a building's basement. Two publications provide detailed discussions about foundation drain systems for slab-on-grade construction, crawl space foundation construction and basement wall foundation construction. The first one is "Moisture Control Guidance for Building Design, Construction and Maintenance" (available from the U.S. Environmental Protection Agency at www.epa.gov/sites/production/files/2014-08/documents/moisture-control.pdf). The second one is "Build a Better Home: Foundations" (available from APA – The Engineered Wood Association at www.apawood.org). The APA publication focuses on home construction but the foundation information is applicable for any building that uses wood frame construction on top of a concrete foundation system.

Either a seasonal or permanent high water table can adversely impact a building's foundation. A properly designed and installed foundation drainage system can lower the elevation

of a water table. The water table can be lowered because the foundation drains allow subsurface water to drain out of the soil around the building foundation. The resulting subsurface water-free zone provides a place for a building foundation to exist without being impacted by subsurface water in contact with the building foundation. The ability of a foundation drainage system to lower a water table is discussed in more detail and shown in **Figure 1** from the APA "Build a Better Home: Foundations" publication.



A post-frame building foundation can be protected from subsurface water using a foundation drainage system if a high water table is found on a post-frame building site. The drainage system must be placed outside (typically two feet or more) of the post foundations and at a lower elevation than the bottom of the post foundation pads. The installation of a foundation drainage system must not impact the post foundations, which must be free of subsurface water to minimize frost-heave issues.

2. **Minimize Surface Water Infiltration** – Implement building foundation construction practices and surface water drainage practices to minimize surface water infiltrating close to building

tips & tricks

BY JOSEPH M. ZULOVICH, PH.D., P.E

Surface water that infiltrates into the soil becomes subsurface water. The key is to minimize surface water infiltration near a building. As discussed in part two of this series, good site drainage must be established so surface water drains

away from building. However, foundation drain systems need to be protected from surface water infiltration flooding. Many foundation resources will show the need for granular backfill or gravel to be placed against a basement founda-

tion wall, especially on building sites with clay and/or highly expansive soils. The granular or gravel backfill helps protect the foundation wall from high soil pressures when soils expand during wet periods. A low permeability soil needs to be placed at least six to eight inches thick to minimize surface water infiltration directly into the granular or gravel backfill. If the granular backfill is installed from the drainage system to the top of the finish grade around a building, rainwater is likely to drain directly into the gravel backfill especially during heavy and extended rainfall events. When rainfall directly enters a foundation drainage system, the drainage system typically becomes flooded because the typical 4-inch perforated drainage pipe is not nearly large enough to serve as a storm water drainage system. If a building basement with a basement foundation often becomes wet during heavy or extended rainfall periods, check to see if rainwater can easily enter the foundation drainage system.

Fight Condensation Without Insulation



A Necessity for Any Steel Roofed Building That is Not Climate Controlled.

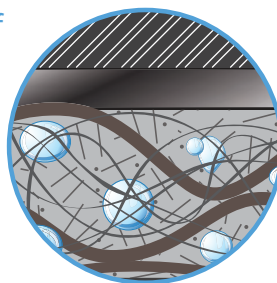
- Post Frame/agricultural buildings
- Steel buildings
- Self-storage
- Workshops/unattached garages
- Open-walled structures
- Carports, truck ports & RV storage

DripStop Stops the Dripping from Condensation.

When condensation occurs, moisture gets stored in the specially designed pockets of the DripStop membrane.

DripStop is applied at the time of roll forming

- Arrives on-site already on roof panels
- Helps fight corrosion in livestock confinement
- Significantly reduces construction time
- Saves money



Ask for it from your preferred steel panel supplier

Visit our website at www.dripstop.com or call us at: 1-(937) 660-6646

Circle Reader Service #384

3. **Protect from Soil Moisture**
 - Install vapor barriers and capillary breaks to protect the building from soil moisture penetration

Soil moisture exists in soil even when all subsurface water has been drained out of the soil. Capillary water in the soil can often cause moisture problems inside building spaces that are in contact with the soil when building foundation components are not protected from soil moisture. The specific details for protecting a building foundation from soil moisture varies depending upon the building foundation construction system. The two publications mentioned earlier provide detailed discussions and diagrams on how to protect different foundations from soil moisture. In general, gravel (often 3/4 inch diameter) or damp proofing methods provide a capillary break protecting the foundation from capillary moisture movement. A vapor barrier, often polyethylene film, minimizes moisture vapor movement from the soil into the building space. **RB**

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 4 addresses how to protect the exterior building envelope.

Protecting the exterior building envelope [Part 4]

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:

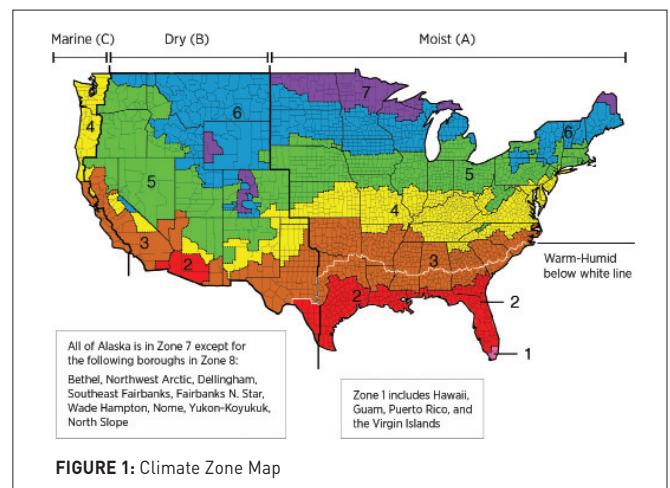
- **Vapor migration** – installing a vapor retarder in a proper location
- **Indoor air infiltration** – preventing inside air from leaking into exterior walls and/or insulated ceilings
- **Outside air penetration** – preventing outside air from leaking into exterior building components

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.

BY JOSEPH M. ZULOVICH, PH.D., P.E.

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. **RB**



LAM-PLY TRUSS

The Truss That Will Carry The Load

- Spans up to 72 ft.
- Spacings up to 12 ft. on center, depending on the load you desire
- Bird Nesting Control
- Better Ventilation & Visibility
- No Feed Alley Post Obstruction
- Additional Ceiling Height

Starwood Rafter Usage

- Pole Sheds
- Free Stalls
- Pavilion Shelters
- Machinery Storage
- Riding Arenas
- Solar Barns



Starwood Rafters, Inc.
 W24141 Starwood Lane
 Independence, WI 54747
 (715) 985-3117 • 888-525-5878
www.starwoodrafters.com

► 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.

tips & tricks

BY JOSEPH M. ZULOVICH, PH.D., P.E.

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.

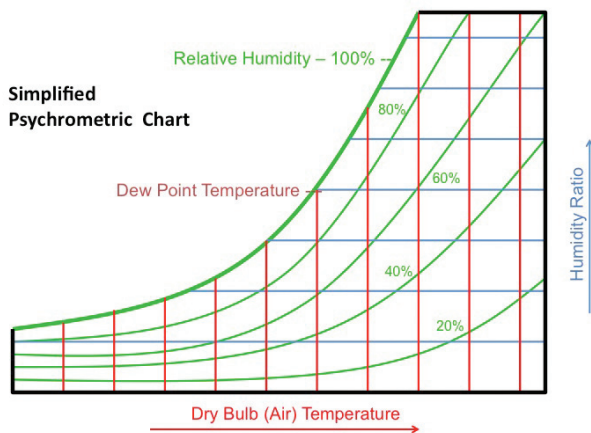


Figure 1. The Difference Between Room Air Temperature and the Dew Point as a Function of RH. This example is taken from "Moisture Control Guidance for Building Design, Construction and Maintenance" found at <https://www.epa.gov/sites/production/files/2014-08/documents/moisture-control.pdf>.

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 horizon-

tips & tricks

BY JOSEPH M. ZULOVICH, PH.D., P.E

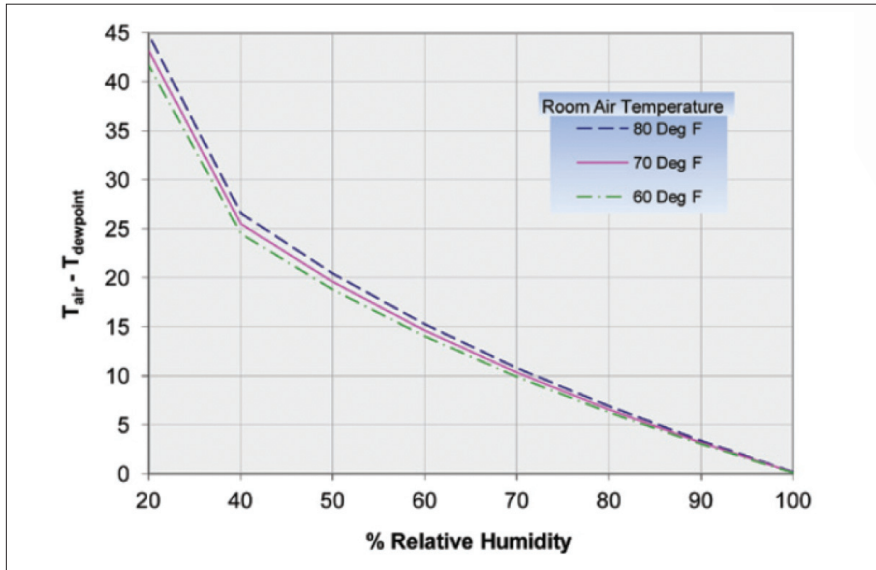


Figure 2. Source: <https://www.epa.gov/sites/production/files/2014-08/documents/moisture-control.pdf>.

tally 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

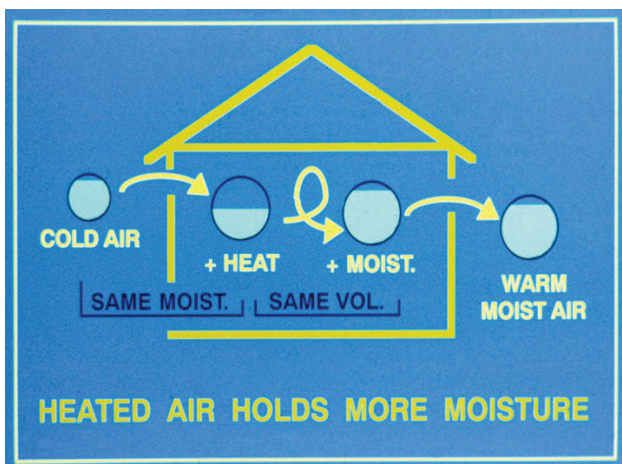
To minimize condensation on inside surfaces of exterior building components, one wants to operate a building such that the inside dew point temperature is lower than the inside surface temperature of any exterior building com-

ponent. 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

Figure 3. Source: <https://www.epa.gov/sites/production/files/2014-08/documents/moisture-control.pdf>.



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