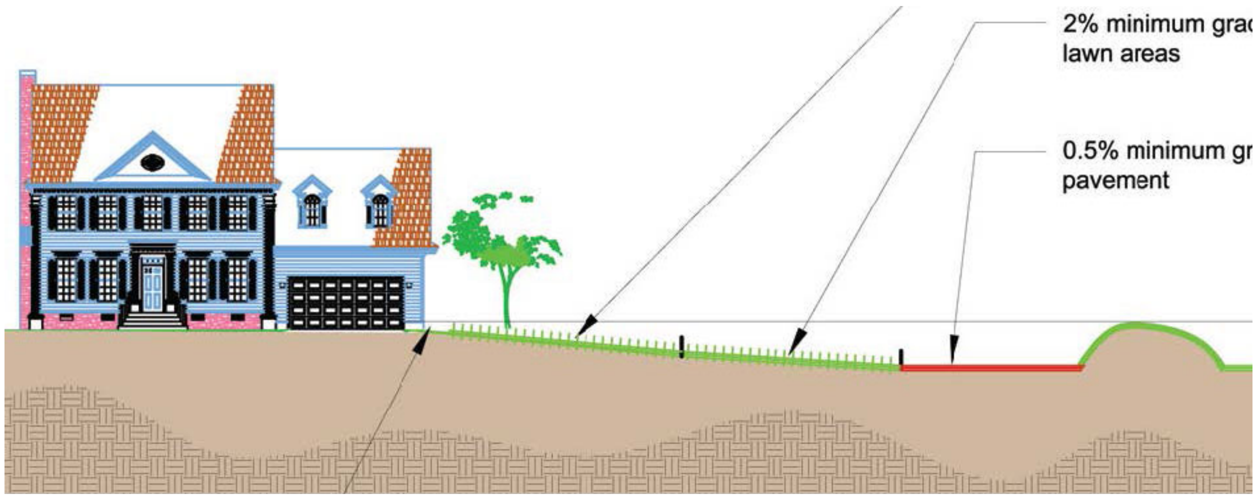
Moisture Management Guide: Three Design Rules

By Daniel Morrison



(image courtesy of US EPA)

Hidden water damage can be a big deal because what you don't see, grows

When plumbing lines burst, people notice. Unfortunately, a lot of the moisture damage in houses has nothing to do with bulk water. Instead, moisture trickles into houses through capillarity, air pressure, and diffusion creating hidden moisture damage.

To be sure, bulk water damage is a huge problem, but **this article is about slow and steady, stealthy damage of water sneaking in the back door.**

And not leaving.

The EPA **Water Management Guide** is a comprehensive resource covering well over 100 pages, and is worth a read. We have edited it into an easier-to-read hit list for you to execute in the field.

The EPA outlines *four key elements* of understanding the sneaky side of water:

1. **Understanding what water damage look like**: bugs, mold, rot, rust, efflorescence, spalling, peeling paint, failed floor adhesive, etc.
2. **Understanding where hidden water comes from**: rain, surface, ground, humidity (inside and outside), plumbing leaks, sewer lines
3. **Understanding how it travels**: capillarity, gravity, surface tension, air currents, diffusion
4. **Understanding which parts of the system break—**based on what has failed in the past: site drainage, gutters, siding, flashing, condensate drainage, humidity controls

This series of articles is meant to bundle those thoughts into a practical handbook for keeping houses dry.

Source: EPA Water Management Guide

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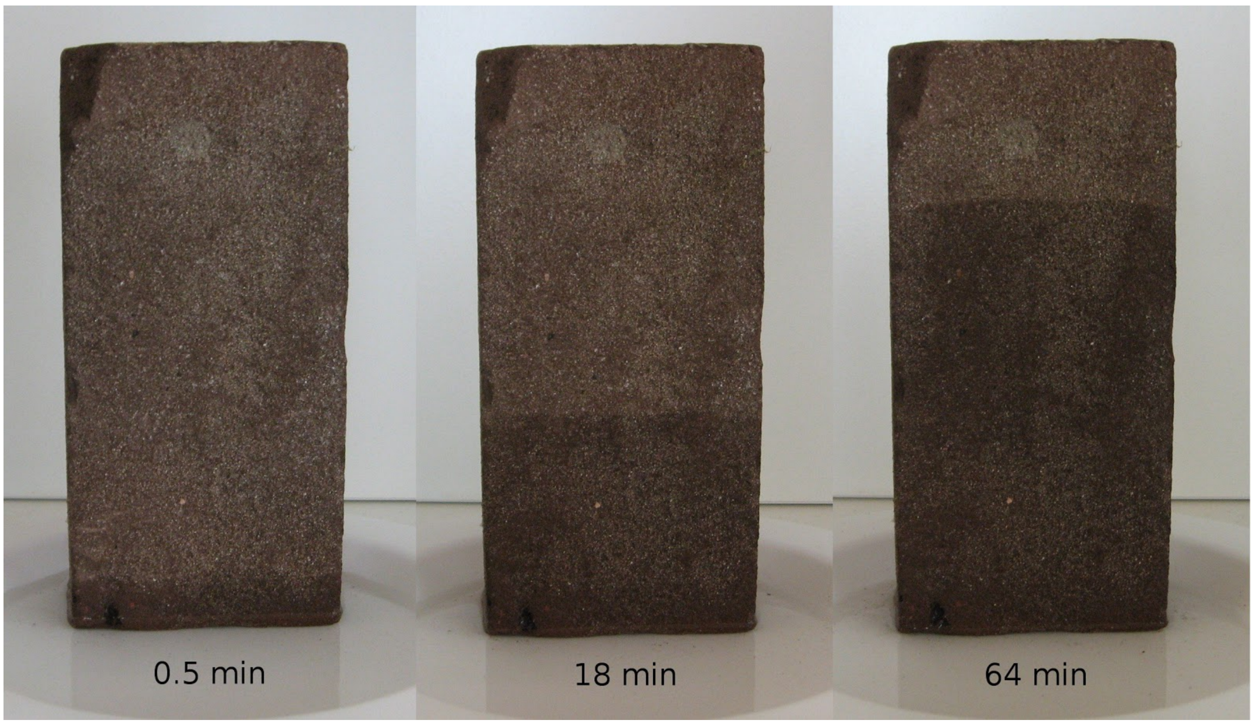
Moisture Management Design Rule 1: Control Liquid Water

Rain is the biggest water threat to house, but there are some slow-and-steady mechanisms that can snowball on you, too



Capillary water flow in a brick that is in contact with water at the bottom. *The time elapsed after first contact with water is indicated. The brick height is 225 mm (about 9 inches). From the weight increase, the estimated porosity is 25%.* Think about how tall a redwood tree is: that's how high water can climb in wood. Photo: Hankwang via wikicommons

In most climates, rain is the largest source of water in buildings, according to EPA. Stop the rain and you stop most of the problems.

Other liquid water sources are surface runoff, groundwater, plumbing leaks, and wet building materials enclosed during construction. Let's start with the rain.

The solution to rain is to drain—gravity works 24/7

Before groundwater becomes groundwater, it is sky water landing on the house. Roofing and siding stop ***most*** of the rain that hits them. After it runs off the building, sky water becomes groundwater.

> *... divert water away from the structure by sloping the grade away from the building. This diverts surface water and keeps subsurface water away from the foundation below grade. — EPA*

In the case of the roof, the water must then be moved to the aforementioned sloping ground by way of gutters, underground flashings, curtain drains, and drywells.

In the case of the walls, create a drainage space behind the siding to let any water that gets past the outer layer to drain away. Traditional brick claddings have a 1-inch air space behind the brick.

(The joke is that the gap is 1 inch because that's how fat the knuckles of the brick masons were. If brick were installed by attorneys, the gap would be a quarter inch.)

Back-ventilated—or rainscreen—siding is becoming more common with other siding types, such as clapboards.

But builders in coastal areas have been using rainscreen siding assemblies for years, as seen in the 19th-century farmhouse in Rhode Island at right. The clapboards stop the majority of the rainwater, and the air gap created by the furring strips allows water to drain down the felt paper behind the siding.

The gap is a capillary break.

> *"A capillary break is either an air gap between adjacent layers or a material such as rubber sheeting that does not absorb or pass liquid water." — EPA*

Speaking of capillarity, let's talk about foundations and concrete.
Concrete is *really* porous.

> *"The theoretical limit of capillary rise in concrete is about 10 kilometers—and folks that is not a typo—it really is about 10 kilometers or about 6 miles. Concrete sucks big time."*
> *— Dr. Joseph Lstiburek*

You said it, Joe.

Wood is less good at sucking water: It can pull water only about 400 feet (the height of the tallest trees). Installing a capillary break between the footing and foundation wall, under the footing and slab, and between the top of foundation and the bottom plate, all prevent ***slippery subterfuge*** in your building assemblies.

As noted earlier, air gaps can break the surface tension of water and therefore act as a capillary break. The same is true of coarse gravel: the air gaps between large stones are big enough to stop capillarity. A good way to figure out if your building assembly is safe from the liquid menace is to take **the pen test**.

Plumbing leaks and wet building materials are the other armies under liquid water's command.

> *"Plumbing must be designed to permit easy maintenance and repair. Plumbing access panels allow critical maintenance over the life of the building.— EPA*

Don't put plumbing in exterior walls—ever

The guide makes another point that is obvious but not really intuitive: "No matter the climate, avoid placing plumbing lines, valves, and drain lines in exterior walls and ceilings that have porous insulation." This rule makes sense in cold climates where pipes can freeze and burst. But why worry about it in a warm place?

Because if the plumbing leaks, **the wet insulation may never dry out**. It can turn into a mold pit before anyone notices, or worse, it can cause structural damage from bugs and rot.

Let wet materials dry

Finally, make sure the materials are dry before closing them into airtight building assemblies. Some moisture comes from materials absorbing water from rain (studs, sheathings), others have water added as part of the finish material (concrete, drywall mud, wet-spray insulation).

Make sure these materials can dry out before installing drywall and flooring.

Moisture Management Design Rule 2: Manage Condensation

Water droplets on cold framing. *When warm moist airleaks into in a wall cavity, it can hit the cool surface of framing, drywall, or exterior sheathing and condense. It is only a matter of time until it runs down the stud and becomes a puddle. Photo: EPA*

con·den·sa·tion | ˌkänˌdenˈsāSH(ə)n | noun

"The conversion of a vapor or gas to a liquid. Synonyms: precipitation, liquefaction, deliquescence" —The Google

Condensation happens when moisture in the air (vapor) hits a cool enough surface to convert the vapor into water. The moisture condenses from a gas to a liquid, and then it drips into a puddle.
The temperature that triggers condensation is the dew point. It's like the opposite of freezing point, only different.

Because the opposite of freezing point is the boiling point, right? (Right.) The other opposite of freezing point is the dew point.

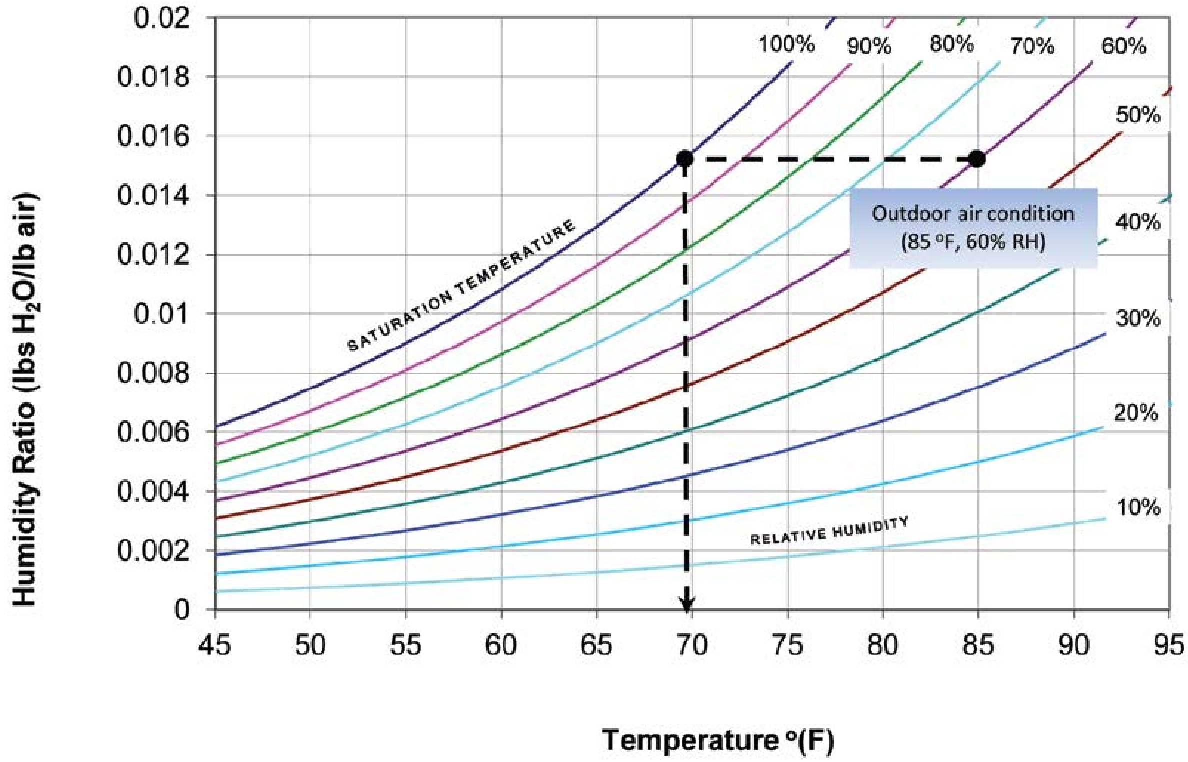
Because of science.

Dew point is directly related to relative humidity (RH), it is the practical application of RH. The temperature at which moisture in the air becomes water on a window. Or a beer glass. Or your supply ducts.

> *Dew Point |ˈd(j)u ˈpɔɪnt| noun*
> *“The **dew point** is the temperature of the air at which condensation occurs.*
>
> ***Relative humidity** is the amount of water vapor in the air compared to the maximum amount the air can hold at its current temperature.” —EPA*

As the air gets warmer, it can hold more moisture. Therefore, if the amount of moisture in the air (say, five gallons) does not go up, then the relative humidity must go down. Because it is all relative, right?

EPA says that to figure out the dew point, you need the temperature of the surfaces which may collect condensation (window, beer glass, supply ducts) and a psychometric chart. 😐



*A psychrometric chart graphs the physical and thermal properties of moist air. Image from EPA Water Management Guide. If charts make you dizzy, you can use this **handy calculator** instead.*

One interesting relationship between RH and dew point: as the RH goes up (the curved lines on the chart), dew point squeezes itself closer to the air temperature. Because the lines are closer together on the chart. So at 90% RH, the dew point is a mere three degrees cooler than air temp.

Humidity is an issue almost everywhere

Three-degree shifts in temperature are pretty common everywhere in the world, so high humidity situations need to be taken seriously. Especially if you couple it with high temperature. Like Houston in July. Or Miami. Or just about anywhere in climate zone one and two and some of climate zone three some of the year. So like, most of North, Central, and South America.

Moisture vapor can come from inside or outside the house, it usually depends on the season which is the main driver. Interior moisture sources are predominantly from people and the stuff they do: cook, wash floors, wash clothes, dry clothes … Exterior sources are predominantly from the water cycle.

Damp basements and crawl spaces can add a lot to the indoor moisture load, too.

You can manage indoor moisture vapor mechanically with dehumidifiers, air conditioners, and bath fans. You can also open a window if the air outside is not more humid than the air inside.

> ***[A note from the 'We Hope This is Obvious' desk:***
> *Damp basements and crawlspaces should be dried with construction before ventilation. Fix the problem, do not ventilate the symptoms and hope for the best.]*

Condensation in winter (usually) starts inside

Because there is usually a temperature gradient inside a stud or rafter cavity (with the outdoor temperature on one side and the indoor temperature on the other), there is a good chance that a dew point exists within.

Also, some parts are cooler than others because of their material properties: like a steel I-beam running through a house. Under the same conditions, the steel beam will be cooler than the wood framing it is hanging around with. (See what we did there? *Hanging around*?)

For dew point to be a problem inside a wall or roof, there needs to be moist air from some sort of pressurization. Pressure can come from wind, stack effect, and mechanical equipment—like supply air HVAC systems.

In winter, condensation usually happens on the upper floors of a house because of stack effect.

Condensation in summer (usually) starts outside

Most condensation problems in summer are caused by air conditioning, which cools the indoor air and dries it in the process. Cool, dry air naturally draws moisture from warm moist air.
Because of science.

EPA Lists six things that contribute to condensation problems in summer:

1. AC cools the indoor air (and the drywall along with it).
2. Some surfaces are even cooler then the drywall, like cold water lines inside walls, refrigerant lines inside walls, and supply ducts inside all kinds of places.
3. Sometimes AC units do not run long enough to dry (dehumidify) the air they cool. This raises dew point.
4. Usually there are more fans blowing air out of a house than fans blowing in (bath fans, clothes dryers, range hoods). This sucks hot humid air into cracks in the envelope.
5. More water gets into walls with brick or masonry sidings from solar driven moisture after a rain.
6. Intentional/accidental vapor barriers (plastic sheeting installed by the insulator, vinyl wallpaper installed by the painter, or a huge mirror installed by the huge mirror guy) trap the moisture flow and can really cause problems.

How to control condensation:

We have already said that to control condensation, you need to control the dew point, so it feels somewhat silly saying it again, but here you go:

To control condensation, you need to control the dew point.

Program the HVAC system to control humidity during both summer and winter, and when you tighten the envelope, take surface temperatures into consideration.

HVAC dews and don'ts

- DO: Equip any residential HVAC system with dehumidification that keeps the home or apartment dry even when cooling is not needed
- DO: Equip any commercial building with a dedicated outdoor air system that ALWAYS keeps the incoming ventilation air dry (below a 55F dew point)
- DON't let the indoor dew point drift above 55F during the summer.
- DON'T let the indoor dew point go above 40F in cold climates in the winter, unless you're prepared to invest LOTS of money in an airtight, indoor-side vapor barrier (as in a swimming pool enclosure or museum, where high winter dew points are a weird fact of life).
- Don't forget to lick the (building) envelope (yuck).

If no moist air is flowing through the walls and roof, then moisture can not condense, right? And if the back of the plywood is warm, moisture will not condense either, right? Right and right. On a new house or addition, airtight construction and exterior insulation are easy additions to make a warm, tight, and dry walls. Retrofitting a house is a different story.

Just the same, EPA suggests meeting 2012 IECC minimum R-values, regardless of what code book your jurisdiction uses (because science is not supposed to follow county lines).

Exterior insulation is great for this because wood framing has a pretty low R-value. Low R value means cooler surface which can cause condensation.

'*Will it Rot?* — a popular new desktop game!

When you are designing a wall or roof assembly, consider the ability of the wall or roof to dry. Are there any impermeable (or semi-impermeable) layers in the assembly? If so, can moisture move away in both directions from that impermeable (or semi impermeable) layer?

If so, it's a go. If not—you've got rot.

Moisture Management Design Rule 3: Use Moisture Tolerant Materials

Tile is a durable and moisture tolerant surface material. *Because grout absorbs water, it is critical to have a waterproof underlayment behind the tile.Cement board is a traditional choice, but it is porous. Paint-on waterproofing can keep the cement, subfloor, and framing dry. Photo: iStock*

> *"The final moisture control principle is to use building materials that can withstand repeated wetting in areas that are expected to get wet." — EPA*

The term 'moisture resistance' includes means both tolerance and intolerance—it means the materials can hack a little water, but they also shed it as quickly as possible. Because drainage = dryage.

Moisture resistant materials are most important in areas that could encompass much of a house:

- Parts of a house that will get wet ***by design***
- Parts of a house that are likely to get wet ***by accident***

Rooms that jump in puddles

Some rooms have 'getting wet' in their job descriptions: bathrooms, laundry rooms, kitchens, mudrooms. In these wet rooms, it is important to use durable, moisture-tolerant surfaces, like stainless steel, copper, stone, tile. These materials contain nothing that mold or bacteria can eat, nowhere for mold and bacteria to live, and they're stable in wet/dry cycles: they don't swell and shrink like wood does.

Wood and drywall both provide free room and board to mold and bacteria. This can lay a path to long-term rot, which can lead to structural failure if things get out of hand. For these reasons, it is good to use less drywall and sheet goods made from ground wood and to look for more durable alternatives:

- Nonpaper-faced drywall (DensGlas,)
- Durable wood species (white oak, cyprus, tropical hardwoods).
- Marine-grade finishes (Spar Urethane,)

Rooms that have 'accidents' 😯

Other rooms get wet 'by accident.' They seemingly have no control over whether they stay dry or get wet: rooms with below grade walls and floors, rooms with plumbing chases, rooms with ceilings that have plumbing lines in them.

To be fair though, even the puddle-jumping rooms have accidents.

Cut down on these accidental disasters with these five rules:

1. Use stainless steel supply lines for laundry, sinks, and toilets. Always.
2. Construct extremely good footing drains on new construction and additions.
3. Have a surface water management plan ***that works*** (gutters and downspouts with drains that lead to daylight downhill of the house).

4. Install an interior perimeter drain in below-grade living space with a sump pump in case of emergencies.
5. Follow the materials guidance above for all below-grade rooms.

To find out how your favorite building materials will withstand the water, EPA points us to ASTM D3273-00 (2005) Standard Test Method for Resistance to Growth of Mold on the Surface of Interior Coatings in an Environmental Chamber.

Builders and designers can ask product manufacturers for results of these tests to learn the moisture-resistance properties of their building materials.

—Daniel Morrison is senior technical editor of ProTradeCraft.com and a former remodeler and cabinetmaker. You can reach him at dmorrison@sgcmail.com

More to explore:

- **Building Science Corporation:** Capillarity—Small Sacrifices
- **ProTradeCraft:** The Pen Test.

Relevant building code sections

2012 IRC:

- SECTION P3302 SUBSOIL DRAINS
- SECTION P3303 SUMPS AND PUMPING SYSTEMS
- SECTION R317 PROTECTION OF WOOD AND WOOD BASED PRODUCTS AGAINST DECAY
- SECTION R322 FLOOD-RESISTANT CONSTRUCTION
- SECTION R405 FOUNDATION DRAINAGE
- SECTION R406 FOUNDATION WATERPROOFING AND DAMPPROOFING
- Section R702 Interior Covering
- Chapter 13 — General Mechanical System Requirements
- Chapter 14 — Heating and Cooling Equipment and Appliances
- Chapter 15 — Exhaust Systems
- Section M1507 Mechanical Ventilation
- Chapter 16 — Duct Systems

Moisture Management Guide: Three Design Rules is based on a section of the Environmental Protection Agency's Water Management Guide.

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www.protradecraft.com/moisture-management-guide-three-design-rules