Summertime Moisture Problems

Troubleshooting condensation in hot, humid weather

BY DOUG HORGAN

I work in eastern Virginia, where summers are long, hot, and humid, and winters are relatively short and mild. When I was learning construction in the 1990s, I read a lot of articles about how to install a good vapor barrier on the inside face of walls and ceilings—describing how to wrap plastic around corners, connected in a vapor-tight manner, and so on. Those articles represented a northern-climate point of view: The concern was with wintertime vapor drive from the indoors out, rather than summertime vapor drive from the outdoors in. Eventually, however, building scientists started to realize that the practice of installing an interior vapor barrier was not appropriate to most climates in North America, and that, in fact, in many climates, putting plastic on the inside of a wall can cause serious problems.

That risk is becoming significant throughout the United States. In the past, summers in the northern tier of states generally weren't warm and humid enough to create problems with interior vapor barriers. But over time, I've watched my relatives in Vermont go from using no air conditioning to using one window-rattler a couple of weeks a year to using central air conditioning for weeks on end. Adding air conditioning to buildings with interior vapor barriers poses a serious risk of moisture problems, so my recommendation is to stop using Class 1 vapor barriers anywhere in the continental U.S. and learn about ways to control wintertime moisture that aren't as risky in humid summers.

Photos by Doug Horgan

Masonry mass walls like this stone wall **(1)** and this stucco-covered brick wall **(2)** can soak up and hold rainwater. When sun strikes these walls, moisture can be driven inward and condense if it is prevented from drying further inward by materials such as poly vapor barriers, vinyl wallpaper, or vapor-impermeable paint (see page 39).

UNDERSTANDING THE RISKS

Warm, moisture-laden outdoor air poses a risk of condensation when it encounters a cold surface in a building, and air-conditioned buildings have a number of surfaces that are at or below typical summertime dew points. The mid-Atlantic now experiences months of dew points above 65°F, weeks above 70°F, and a fair number of days above 75°F. If you work in the hot, humid South, you're familiar with these conditions. If you work in the northern states, this weather is headed your way as the planet warms.

Central air conditioners typically cool the air in the duct system by about 20 degrees below the thermostat set point. Most people set their thermostats between 72°F and 78°F in summer, so duct temperatures in the 50s are normal. This cold air is often blown directly on windows and exterior walls, and if runtime is long enough, those building-shell surfaces can drop below the outdoor dew point temperature.

If humid outdoor air hits those cold surfaces, moisture from the air will condense on them. When this occurs inside a building assembly, the moisture must be allowed to dry inward. Traditional Class 1 vapor barriers like sheet plastic or foil can block drying and result in a problematic accumulation of condensed water in the assembly.

Air leaks can also cause problems. A current of humid outdoor air hitting a cold surface inside will drop a lot of water quickly. This can be particularly problematic when moist outdoor air contacts cold ductwork. Ductwork outside a building shell must be designed with typical dew point temperatures in mind. Of course, it's best to avoid putting ductwork in attics and unconditioned basements and crawlspaces, but if ducts are in those spaces, they need to be wrapped to prevent condensation.

In addition, ductwork outside the envelope often leads to depressurizing the house. Most ductwork installed before the last few years was fairly leaky (testing was not required until the last few code cycles). Typical systems we see have short return ducts with few joints, and multiple long supply ducts with many joints. When the system runs, it blows much more air out through the supply leaks than it pulls in through return leaks, resulting in a net loss of air from the building. This air leaks back in through any hole it can find, driving many of the problems we see.

On some houses, a vicious cycle can drive serious issues. The more the air conditioner runs, the more humidity is sucked in and the less comfortable the clients become; they use the one control they have and set the temperature even lower, resulting in longer

The ceiling near this bath fan **(3)** had a persistent mildew problem. Diagnostic testing **(4)** indicated a pressure difference driving moist outdoor air into the room. An open joist bay **(5)** created a highway for moist air. To fix the problem, the author's crew sealed up the joist bay **(6)** with rigid foam board and canned foam sealant.

runs of air conditioning and even more leaking humid air, exacerbating any issues.

Over the years, my company has accumulated a lot of experience with complaints resulting from indoor condensation during a hot, humid summer. Some of these issues have been related to air leaks encountering cold indoor surfaces, and others involved vapor drive through wall assemblies. Here are a few examples that we've learned from.

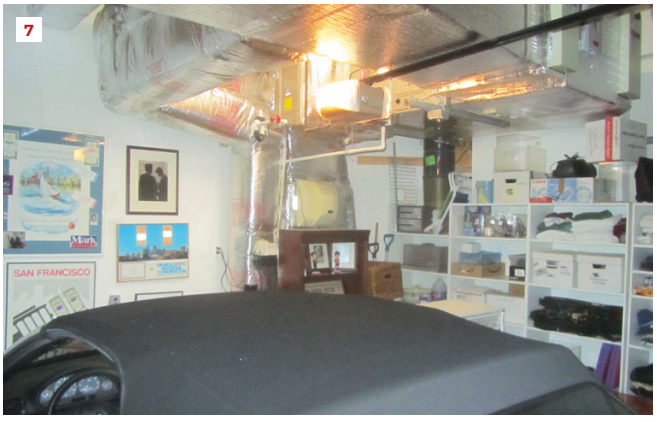
MILDEW NEAR A BATH FAN

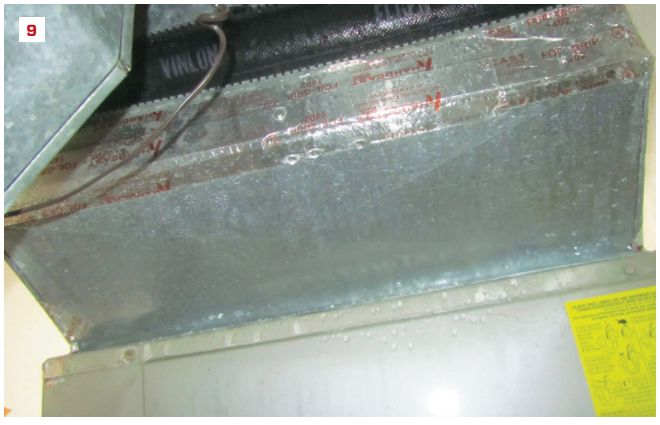
In one case, clients called us to say that their cleaning service had cleaned mildew off the ceiling in the main-level powder room several times, but mildew kept returning. This room was on the middle of three levels and at least 20 feet from the outside walls on the same level. As the formal powder room, it had no shower or bath and was used extremely rarely. The mildew pattern did not look like a leak from above either. So how else could moisture be getting into this interior room?

This issue appeared in summer, so there was plenty of available moisture in the outdoor air. The only relatively direct connection to outdoors from this room was via the bath vent fan. We used a pressure gauge to check whether pressure inside the fan was positive relative to the room (so air would move from the fan to the room) and if the room was negative relative to outdoors (so air would be sucked in from outside).

The pressure readings confirmed that both conditions existed, causing air to come in through the fan. Typical bath fan dampers are not airtight; a small amount of air can come through. If you depressurize a bathroom and pull air in through the bath fan duct over days and weeks, a fair amount of moisture can enter.

With the pressures we were measuring, air could leak in around the fan just as easily as through the fan duct. So we decided to





Air-conditioning ductwork in this garage **(7)** was a setup for moisture condensation. Infrared imaging detected cold spots on the ducts **(8)**. Uninsulated ducts were dripping with condensed moisture **(9)**. Inside the house, someone had tried to address the problem using XPS foam and packaging tape **(10)**.

check the joist bay around the bath fan, and sure enough, the joist bay seemed to connect to the outdoors too.

Our solution was to block off the joist bay with foam board and can foam and add another damper to the bath-fan duct. We first tried a fabric "sock"-style damper, but it didn't seal well under the low-flow conditions. So we installed a Fantech RSK spring-loaded butterfly backdraft damper, which did a better job.

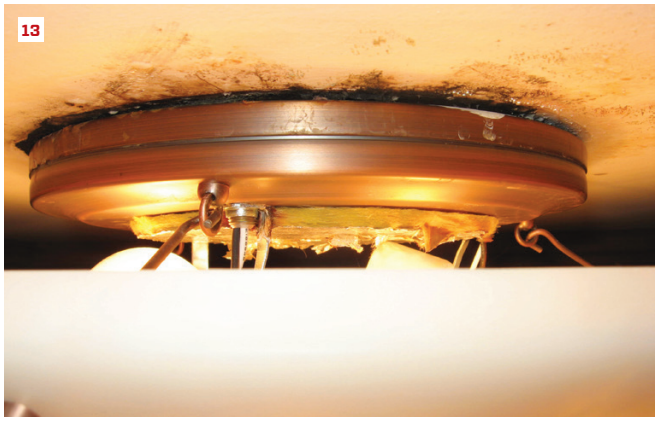
CONDENSATION ON DUCTWORK

"Our ducts are sweating! What do we do?" Our clients had bought a house in the autumn and had us renovate the kitchen and master bath before they moved in. Now it was summertime, and they asked us to figure out a previously unknown issue they were seeing for the first time.

The house was an unusual five-story townhouse, built in a commercial style with metal framing. The two areas where ducts were covered in drips of condensation were the attic and the garage. (That's right, they had an HVAC system mounted in the garage—a risky proposition considering the pollutants.) Condensation forms when a surface is colder than the dew point of the air, so the ducts must have been colder than the dew point of the air in those locations.

Checking the ductwork with a thermal camera, we found that it was cool: in the 40s and 50s. The outdoor dew point in summer in our area is usually above 50°F, and sometimes even above 70°F. If humid air leaks into the house and hits the ductwork, condensation will form, and other than water leaks, air leaks are the most common source of the moisture condensing on ducts.

The thermal camera showed some cold spots worth investigating. In fact, in the photos above, you can see that someone must have recognized the problem in the attic area because they tried to use XPS foam board and what looked like packaging tape to block the air coming in. We used a blower door to depressurize the house, which makes air leaks very easy to find (you can feel the air blowing in from the bad ones, and you can use the thermal camera to find the others). Sure enough, there were some serious



Moisture had soaked insulation above the poly vapor barrier of this wine room **(11)**. The author vacuumed up puddles of water from on top of the poly **(12)**. Bulk water was leaking into the room through a light fixture **(13)** and around a thermostat **(14)**.

leaks near the attic ducts: The bright yellow areas on the thermal pictures show warm temperatures where the hot summer air is leaking in.

Air leaks like these are easy to fix; in fact, even a homeowner with foam board and packaging tape can do an adequate job if they address the right areas. We use sheet materials, foams, tapes, and sealants that do a better job and last longer, but it's the same idea: Find the leaks and block the airflow with a combination of materials suited to the sizes of the gaps.

The garage was a different story. Garage doors are usually leaky when they're shut, and when they're open, they let in a lot of outdoor air. In this case, we added more insulation around more of the ductwork (there were some bare spots), and we tuned up the weatherstripping on the door as best we could. We also recommended a plug-in dehumidifier for the garage if the condensation continued to be an issue. Needless to say, ductwork and air handlers in garages are a bad idea, and no one should install such a setup in a new construction scenario.

WINE-CELLAR WEIRDNESS

We installed a refrigerated wine room in the middle of a slab-on-grade ranch house. The next summer, the clients called us to report some unusual things: brown drips from the thermostat and around the door, mildew on the ceiling near the light, and an unpleasant smell.

At first, I thought it was condensate leaking from the mini-split cooler head, but on looking more closely, I saw that the water in that area started higher up the wall. "Roof leak," I thought, so I ran up to the hot, humid attic. I found lots of water up there—so much that it was dripping off the batt insulation I moved to see the ceiling. The surrounding wood framing was soaked, and I had to vacuum water off the plastic sheeting we had carefully applied across the wine room ceiling.

We had installed that plastic because we followed the wine cellar cooler company's installation instructions. It's true that untold amounts of moisture had been blocked from entering the wine cellar by the plastic, which presumably was the idea. The problem is,

The author has seen more than one case of vapor drive through walls from the outside in. In one case, drywall screws were rusted by condensation **(15)**. In another, mildew formed on the painted walls of the room **(16)**.

since the plastic was on the cool side of the assembly, moisture condensed into liquid on the cold plastic and then couldn't dry anywhere. It just pooled up, then leaked into the walls and the ceiling light.

We applied a layer of closed-cell spray foam over the top of the wine room. This blocks moisture as well as the plastic did, but because of its insulating properties, the attic side of the foam stays close to the attic temperature and never gets cool enough for moisture to accumulate on it. Our standard spec now is for a layer of foam board or spray foam surrounding any wine room.

PICTURE-HANGER SURPRISE

We had the opportunity to build a beautiful custom home, designed to look like an older farmhouse that has had additions and changes over time. There were some unusual details, including projecting window bucks that brought the windows nearly flush with the face of the 5-inch stone veneer.

A couple of summers later, the clients called to say they'd been awakened in the middle of the night by a picture crashing to the floor; on inspection in daylight, the hanger had pulled right out of the wall and taken a strip of the vinyl wallpaper with it. When I went by, the exposed drywall was very soft and felt cool. Out of curiosity, I put my moisture meter on the wall and was shocked to see it pinned at its max reading. It was decided to remove the drywall on the wall in question.

The drywall was still damp and had signs of mildew on the back. The kraft facing on the insulation also had some spots of moisture. The drywall screws and interior trim nails were rusty. But everything else was dry from there to the outside. The studs were clean (other than the very inside faces). The sheathing was dry and pristine. There was no water, staining, leaks, wet areas, nothing.

After lots of research, we identified the problem: A combination of rain wetting the stone exterior and sun heating it drove moisture into the walls, where, during air-conditioning season, the moisture condensed on the cold wallpaper. The accumulating moisture could not dry toward the interior.

Since that episode, I've run into this problem a few times. Often there's a localized area that's worse: where an air-conditioning vent blows directly on a wall, or below windows, where more water soaks into the masonry or stucco outside. I've seen it multiple times with vinyl wallpaper, but also with plastic interior vapor barrier, with a decorative painting technique that used several coats of oil paint, and even with large mirrors mounted directly to the drywall. Vinyl wallpaper, oil paint, and mirrored glass don't permit the passage of

This wall became damp when moisture was driven in from a stone exterior by sunshine and condensed on the back of the vinyl wallpaper **(17)**. Parts of the wall that were opened up were able to dry to the inside and were quite dry when the author checked them **(18)**. Removing the rest of the vinyl wallpaper addressed the problem satisfactorily.

moisture, so it accumulates behind them, when vapor drive is from outside in. This happens fastest when there's a "reservoir" material on the outside (something like masonry or stucco that can absorb water and hold it), direct sun on the wall, and air conditioning inside.

MYSTERIOUS MOLD

Neighbors of a client called us with a mystery their handyman couldn't figure out. Apparently, a bulletin board that had hung on the wall fell down spontaneously in late July one year. When the handyman removed the vinyl wallpaper from that part of the wall, he found stuff growing behind it and wet drywall. They cut out the drywall, removed the insulation, and waited for rain so they could figure out the leak source that must be there. But no leak came, no matter how hard the rain.

Sounds familiar, right? Coming into this diagnostic with another option besides "water leak" was pretty helpful. There was an air-conditioner register blowing right on this part of the wall. The parts of the wall that were opened up were quite dry by the time they brought us in, weeks after the vinyl wallpaper had been removed and the wall cut open. Obviously, a lot of drying can happen when there's no wall covering at all and the wall was no longer accumulating moisture from the sun hitting the stone veneer outside. The clients took our advice to remove the wallpaper, and the wall has been fine since.

MASS-WALL WETNESS

Another house started showing black spots in the wallpaper in the first summer after the clients renovated it. It started in a corner where an air-conditioner vent blasted cold air onto the wall, so originally we were hopeful that blocking half the vent would solve the issue by eliminating the cold spot. But as time went on, black spots started appearing in other locations—first below a window, and later all over the wall.

The house is a historic brick building covered with stucco. I know there are loads of these performing fine all over the country, but I do see a few with problems, and I sometimes think there's just not an easy fix. More precisely, I am not sure there's a way to guarantee water won't accumulate in the masonry under some conditions. If the building is air conditioned, it's much better to allow it to dry to the inside. So avoid impermeable coverings, and maybe consider paper-free drywall as an interior finish, so mold won't have an easy food source.

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