Outsmarting Air From the Outside
A prescriptive path to simplifying a building's control layers

BY DOUG CAMERON

Photos by Doug Cameron

Over the last eight years, I have gradually changed my approach to detailing the control layers of building enclosures. I'm using Building Science Corp.'s terminology for the essential layers in a wall assembly that control, or limit, the movement of air, water, vapor, and thermal energy through a building enclosure. All are needed in the order given, with air being the first in order of importance and where I typically focus my attention. While the four different layers are helpful for understanding how an effective building enclosure performs, they are somewhat abstract ideas when it comes to putting the enclosure together. You don't have four separate layers that stack up neatly in a building assembly. Often, the air barrier functions as the water barrier. The air barrier and the thermal control layer—insulation—have to align (be installed adjacent to each other). Vapor control is its own animal; latex paint (a Class III vapor retarder) is usually enough in most climate zones provided that all the impermeable and permeable insulations used in a wall are installed in the right proportion.

There's a lot of "fine print" that gets confusing fast and that makes it hard to train crew members and subcontractors. In my experience, it's always better when the people doing the work understand why they are doing it. When they don't, the risk for errors increases. The approach I have come up with is all about simplifying how we build our wall and roof assemblies to address air, water,

Exterior restoration. The author's first experience with using a fluid-applied barrier was the restoration of a 1950s home in central Austin **(1–5)**. The building's diagonal sheathing had minimal isolated water damage, so restoring it rather than replacing it was prudent. The experience opened the author's awareness of the versatility of a fluid-applied barrier.

and thermal control in one "layer," with the vast majority of the detailing done from the outside. My goal, of course, is outstanding building performance. But I also want to educate people about how to build a very efficient home in a simple fashion. Successful building, I think, is not just about great building performance; it also must done in a way that can be easily taught and reproduced.

EVOLUTION OF OUR ENCLOSURE

My journey started in late 2010 when I moved to the Onion Creek neighborhood in Austin, Texas. We moved there right after one flash flood, and about a year later, a second one hit the area. Our home was not in the flood zone, but many of our neighbors were devastated by water that rose up 4 to 5 feet on the first-story walls. I helped repair some of these homes and quickly became interested in finding a more flood-resilient wall system. We focused on the lower part of the wall, and this meant doing things like raising electrical boxes and flipping exterior doors to swing outward so water pressure wouldn't force the door open. And to address the resiliency of the walls, I started to look closely at fluid-applied membranes.

At that time, the only place you could find people doing fluid-applied barriers was on commercial work. I found information online about Prosoco's hurricane tests, which helped me work out some of the flood repair details, and I reached out to the local rep. And shortly afterward, I started going to meetings of the local American Institute of Architects chapter and met a DuPont rep, who trained our team on DuPont's commercial applications for fluid-applied barriers. Our first complete exterior job using the DuPont product was on the remodel of a 1950s home in central Austin. This house had diagonal shiplap sheathing, some of which had rotted near the porches where there had been a lot of splash back, but for the most part, it was in excellent condition. I brought fluid-applied to the

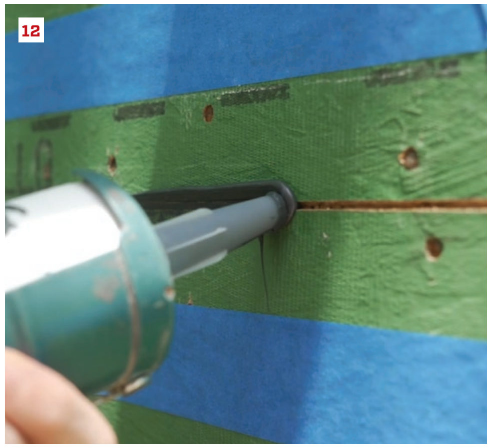
Block and caulk. On a new build, the author used DuPont's fluid-applied barrier in concert with Zip System sheathing **(6–8)**. Zip System was new to the author at the time, and he had more confidence in "finger painting" with fluid-applied than sealing panel seams with tape. It was on this and another, simultaneous new home that "block and caulk" was born **(9, 10)**.

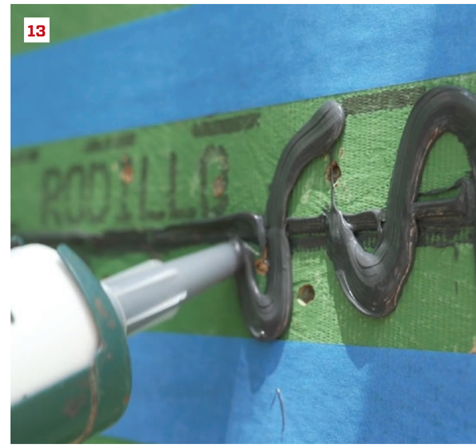
table during the planning phase because it allowed us to restore rather than replace the existing sheeting. The result, shown in the photos on the opposite page, was encouraging, and we felt fluid-applied membranes were an option we could use for exterior weatherproofing on other projects.

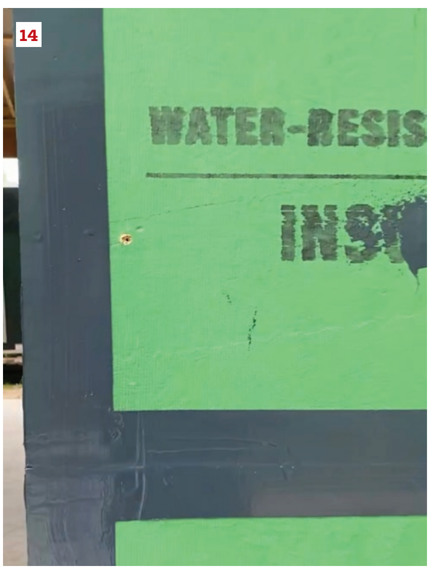
Shortly after this, we had two new builds in downtown Austin on which we were going to use Zip System sheathing for the first time. I liked the idea of a panel that combined the sheathing and water-resistive barrier (WRB), but I was skeptical about the tape. This was early on, and we didn't yet understand how well the acrylic-adhesive tape would work. Because fluid-applied was so new and so few retailers stocked it, we went through a wholesaler and with its discount, we could use fluid-applied to seal the Zip System seams for about the same price as the tape. I also felt we had better control with "finger painting" with fluid-applied than with an unknown tape. By this time, Huber had come out with its own fluid-applied product but only in sausage tubes, not in 5-gallon buckets. The company seemed to be marketing it mostly as a solution for door and window rough openings and framing transitions but wasn't geared up for the heavy applications that we wanted to do.

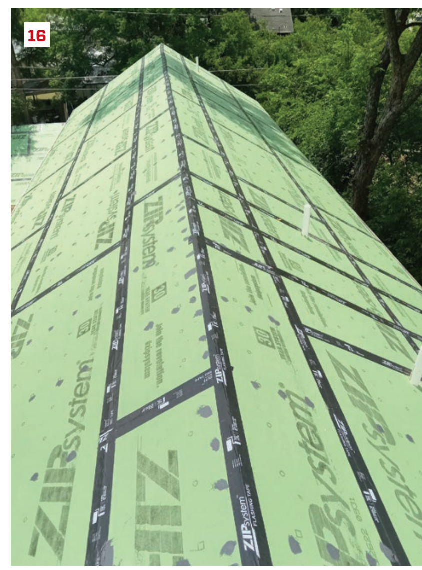
BLOCK AND CAULK

One of those first builds, shown in the photos above, was a job with some young architects. I had misgivings about some of the details, such as an enclosed outside roof deck. But if anything was going to work in this area, it would be a fluid-applied membrane. We included fluid-applied on all the seams and also hit all the nail holes. On walls, there is no driving force to push water through the holes from overdriven nails. But we started sealing all the nails because we could—we were right there with a material that we could dab on, the scaffolding was in place, and we felt maybe it would ensure an even tighter enclosure.





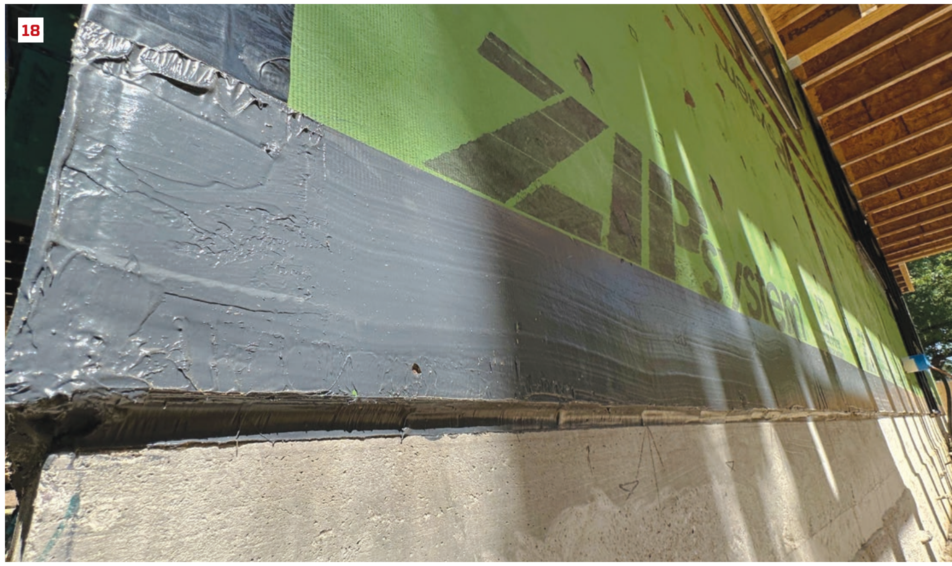




Panel seams. To seal the seams between sheathing panels, the author's crew starts by outlining them with 2-inch-wide painter's tape **(11)**. A first pass **(12)** fills in the joint, and the next zig-zag pass **(13)** applies enough sealant to lay down a thick bed when it's smoothed out **(14)**. To help take the cost out of the system, the author does now use Zip System tape on the wide expanse of the walls **(15)** and roof **(16)**. For these seams, rolling is critical to activate the pressure-sensitive tape adhesive.

The concept we employed goes way beyond just sealing seams and nail holes, though. We referred to our process as "block and caulk." To stop air, we focused on blocking all the air pathways through framing materials with the fluid-applied barrier. This included sealing not only the sheathing but also all the connections at the perimeter of the sheathed areas and making sure the sheathing plane extended up between rafters or cantilevers or behind any porch roofs or bump-outs. When we're working with our crews, we use a balloon analogy: We say the outside of the house is like a big balloon. We don't want any holes in it. If the crew thinks that way, we have a much higher chance of success. The analogy concentrates on air, but if we solve for that from the outside, we are solving for water, too.

And it worked incredibly well. When we tested those first couple of projects with a blower door, they both came in at .7 and .8 ACH50 at framing. We had all the mechanicals in place and the windows installed, but it was essentially just the frame—no insulation, roofing, or finishes. This convinced us that the process was well worth doing, and it had a simple elegance that made it easily understood by all involved.



Foundation-to-wall seal. At the base of the wall, the author's crew uses painter's tape to establish a clean line at the top and the bottom **(17)**. The tape makes it look nice, but it also allows the installer to apply a thick bed of sealant that is free of pinholes—a detail that trying to feather the edge to a chalk line won't effectively achieve **(18)**.

KEY DETAILS

Here are some of the key details that have we have developed over the last 10 years that give us confidence in making everything work from the outside:

Panel seams. In our initial ventures into sealing panels with fluid-applied, we used a fiberglass mesh tape, as specified by DuPont. Many manufacturers, Huber included, are reportedly adding microfibers to their formulations, so this is no longer necessary, but mesh was integral to our seam detail on our first projects (see photo, page 29). As with any product, but especially with chemical adhesives, it's important to follow each manufacturer's specifications to understand not only the sequencing but also the compatibility with the chemicals in other materials, such as the WRB facing on the panels, any flashing tape, or membranes that are part of the enclosure.

In our current process, we apply wide painter's tape to both sides of the panel seam, as shown in the photos on the opposite page. We take a first pass pumping the fluid into the joint followed by a zigzag pass between the two pieces of tape and then smooth it all out with a plastic paddle. Using the tape, of course, gives us a nice, clean line, but it also allows us to lay down a consistent bed of material that we feel confident is free of holes.

Foundation-to-wall seal. One place we especially liked the fluid-applied was at the intersection of the wall and the foundation. All the silyl-terminated polyether fluid-applied products bond well to a wide variety of materials, and because they are moisture curing, they aren't bothered by any moisture in the concrete.

I still have people telling me you shouldn't seal the bottom of the wall sheathing, but just seal under the sill, so water can drain out. A lot of people think the entire wall assembly is like a window, and you have to let water that might get into the wall escape. This is an example of how people get confused with concepts like "drainable assemblies." To set the record straight: Operable windows with moving parts have lots of pathways for water to get into the window assembly. The frames are designed so this water drains down to the bottom, and it needs a path out. That's why we need some sort of drainable sill (though maybe not a pan; more on that soon) and we don't seal the bottom flange.

Walls are not the same. Water will get behind the cladding, so you want some sort of drainable cladding assembly, preferably a vented rainscreen. And some water may get in the wall, typically condensation, but hopefully it's not a lot and the enclosure is dryable so this moisture can dissipate. You don't need to make the structure behind the sheathing drainable. But you do need to make it airtight. We felt that sealing the bottom of the sheathing to the edge of the slab with a fluid-applied flashing material was the most robust and long-lasting approach. An awesome painter who had worked with me for quite a while worked out a nice way to detail for this using painter's tape.

The advantage of using painter's tape is that we can load the joint with enough fluid that we are getting a good seal. If you use a chalk line, you are apt to brush it on lightly to make it look good but not necessarily to get a great air seal. The answer for some folks is to add a couple of beads of caulk under (and sometimes also over) the sill seal, in "belt-and-suspenders" fashion. We realize a little savings using painter's tape instead of the framers' applying another type of sealant before lifting their walls (plus eliminate the agony

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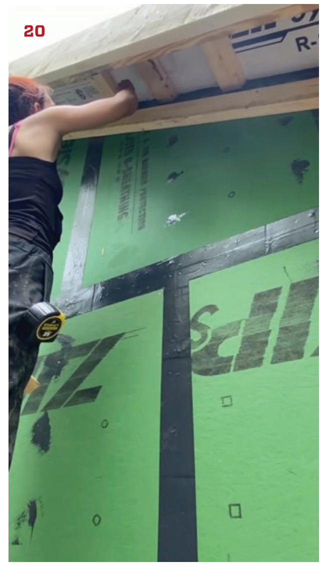

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Roof-to-wall seal. For an effective air seal around rafters, the crew cuts the sheathing to fit around the rafters, and the joint between the sheathing and the rafter tails is carefully filled with fluid-applied **(19)**. Similarly, the spaces between outlookers on the rake ends **(20)** and any roof transitions **(21)** are filled with a bed of fluid-applied sealant.

of stepping in it when they do so). Sometimes "belt and suspenders" is just not worth it. The durability of a thick layer of fluid-applied is suitably forgiving.

Roof-to-wall seal. Before we started doing block-and-caulk, the junction of the wall to the roof was our weakest link. We were mostly solving this with spray foam, but I felt terrible using it. My company name at the time was EcoSafe Spaces, and we were leaning on this product with a high GWP (global warming potential) that off-gassed terribly during the installation. It didn't look good to have guys wearing moon suits during the build. And when we added the fire-resistant coating in an enclosed attic, the noxious fumes lingered for years. None of this was helpful for marketing to sensitive clients. I'm not saying that spray foam doesn't have its place, but I felt there must be a better way to detail the air barrier at the roofline.

At the rake, we use outlookers that tie back to rafters or trusses so we have a strong uplift connection. Similarly at the eaves, we project rafters past the sheathing plane. Many of the houses we work on have cantilevers, too. We need a system that can accommodate these sorts of structural details. Just hanging fake rafter tails and bump-outs on the exterior skin is not going to do it, especially with the frequent wind loads we get in Texas.

Using the block-and-caulk method at the roofline certainly takes extra time and close attention to detail. But we feel we have dialed it in to the point that our framers now feel comfortable doing it. That's a major victory for us.

Windows and doors. On our projects, the windows are often one of the most expensive materials we use. A $150,000 window and door package is not atypical, so we don't mess around and don't take chances. We lean heavily on the distributor, starting with having a rep come out to verify every single window rough opening before delivery. We want the rough opening to be $3/4$ inch greater than the window unit in both directions, leaving a $3/8$-inch gap on all sides. We also make sure that all the framing sills are sloped about $1/2$ inch from back to front to help with drainage. Then we coat the entire sill and jambs on all sides with the fluid-applied barrier and lap it onto the face of the sheathing 2 inches on all sides. This creates a gasket that seems to suck the flange on. We need to add $1/16$-inch shims to push the bottom flange out slightly to make sure water can drain out the bottom. Once the unit is fastened in place, we apply another layer of fluid-applied over the face of the flange.

Most of the window manufacturers insist on bedding the flange at the head and the two sides (but never the bottom flange) in sealant, as well. I don't think this is needed with our fluid-applied gasket, but to satisfy this requirement, we will just use a bead of the same fluid-applied under the flanges, too. This makes it easy.

As Christine Williamson has said, "The metal sill pan is dead." I, too, see no reason to have a piece of metal to conduct heat through the enclosure just to collect water at the base of windows and doors when a fluid-applied sill will do the same thing. Some folks have balked at the possibility of tearing the rubbery, cured fluid-applied layer, but I have not had that trouble. We set our doors on plastic horseshoe shims, which helps to hold them off. We have also applied a layer of play sand into the wet fluid when we feel that site traffic across the opening might jeopardize the water-holding integrity of the installed material.


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Windows. Sealing window openings starts with a sloped sill on the rough opening **(22)**. A first pass with fluid-applied fills in nail holes and the joint between the sheathing and framing **(23)**. This is followed by a zig-zag pass, which is smoothed into a continuous bed **(24)** covering all the surfaces of the rough opening **(25)**. The fluid-applied laps onto the face of the wall to create a "gasket" into which the window flanges are fastened. The author installs horseshoe shims to create a drainage gap along the bottom flange **(26)**. Once the flanges are screwed on, a layer of fluid-applied is applied on top of them **(27)**.

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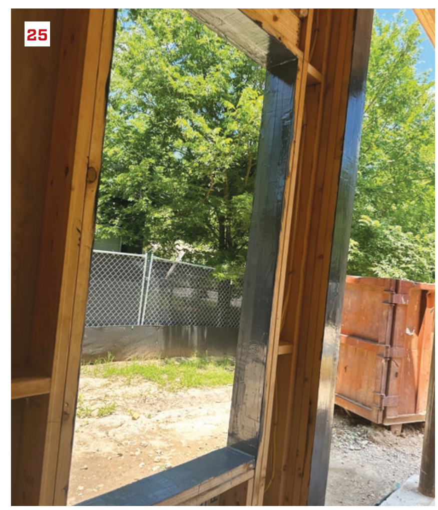
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Doors. Instead of using metal pans, the author creates sill pans using fluid-applied **(28)**. Note: Seams in the porch deck are also sealed with fluid-applied. Doors are installed on horseshoe shims in a bed created by lines of fluid-applied that are spaced wide enough apart so there are channels between the smushed-out beads to allow water to drain **(29)**. The spaces between shims **(30)** are filled with backer rod **(31, 32)**. After the shims are cut back, the window is protected by painter's tape **(33)**, and a bead of fluid-applied completes the inside air seal **(34)**.

Penetrations. For any penetration through the exterior, the author's goal is to limit its size. When the author was off site, electricians installed the wrong type of exterior outlet **(35)**. The author corrected this by removing the box, patching in the sheathing **(36)** and using a surface-mounted metal box so only the wire, not the entire box, needed to be sealed **(37)**.

The last step at the openings is to air-seal them from the inside. We push foam backer rod all the way to the back of the cavity and fill the spaces between the shims with more backer rod. This is an inexpensive material, and I feel it not only adds a little insulation but also provides some stability to the last layer of backer rod at the inside surface that holds the sealant. This inside seal we do with more fluid-applied, so we preserve the consistency of materials and we don't have to worry about compatibility or shrinkage. Best of all, we avoid the mess of canned foam.

THERMAL CONTROL

While our block-and-caulk method solves for air and water control, we have not yet solved for thermal.

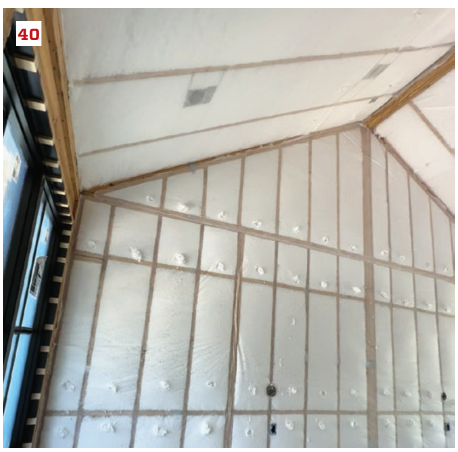
The roof and wall cavities are easy. To get away from spray foam, we prefer using HempWool, Rockwool, or a formaldehyde-free fiberglass blown-in-batt system. When it's a budget-driven decision, fiberglass usually wins. I like being able to blow this in before drywall, so we know we have thermal continuity. If we need more R-value in attic areas than we would normally get by filling the framing cavities, we have had good luck drooping the netting and filling up the resulting "bag" at each rafter bay, as shown in photo 41 on the next page.

To address thermal bridging, we typically use 1-inch Zip-R panels, which have 1/2-inch (R-3) polyisocyanurate foam adhered to an OSB sheathing panel. At first, I was concerned with vapor control in our roof assembly. My concern was put to rest when I had the good fortune to talk with Joe Lstiburek at a conference, asking him if he felt we should be using vapor diffusion ports. (For more on these, see "Avoiding Wet Roofs," by Peter Yost; Jun/18 and Jul/18). He told me that 1/2 inch of foam is enough in our climate zone (3A); the 1-inch Zip-R panels with 1/2-inch rigid foam would provide enough thermal resistance to mitigate any temperature differential great enough to create a dew point on the underside of the sheathing inside the roof assembly.

Vapor control. If we were in a colder climate, it would be critical for us to use more than 1/2 inch of an impermeable foam when the cavities in the walls and roof are insulated with a permeable insulation like cellulose or fiberglass. To get the proportion right, follow the guidance in Chapter 7 of the IRC, which specifies the proportion of continuous insulation to cavity insulation required to limit condensation when only a Class III vapor retarder such as latex paint will be used on the interior. If you don't follow this guidance, there is a chance that the surface temperature on the back of the wall sheathing can drop below the dew point and condensation can form inside the framing cavities. (For more on following the IRC Chapter 7 guidance on condensation control, see "Avoiding Wet Walls," May/17.)

While 1/2 inch of foam was enough for our hot, humid climate, Lstiburek told me that one would ideally seal the seams from below. In theory, you could have some moisture vapor migrate up between the panels and condense on cooler OSB surfaces near the exterior. But while that's possible in theory, he said there was a very low risk if the seams are well sealed from the top so there is no air movement. Without air movement, the only driver of water vapor through those seams would be diffusion (evaporation). Diffusion is a function of area, so we'd be concerned only with the vapor at the surface directly below the seams. That wouldn't be a concern unless there was a pool or greenhouse in the enclosure; an ordinary house is unlikely to have enough indoor moisture to create sufficient condensation at the panel seams.

Compressive strength. Huber has yet to market Zip-R for roof applications, so it's not a manufacturer-warranted installation. I went through my engineer, who did his own compression testing with Zip-R on the roof. He was satisfied with what we needed for



Thermal control is achieved using 1-inch (R-3) Zip-R sheathing on the walls **(38)** and roof **(39)** to limit thermal bridging. (Note: In colder climates, thicker foam would be needed for continuous insulation.) The author fills the cavities with blown-in fiberglass **(40)**. In attic areas, he drapes the netting to create a "bag" that can be filled with more insulation than the depth of the framing would otherwise allow **(41)**.

roof loads. Please keep in mind this will also vary by region. We don't have significant snow loads, and in locations where you do have these loads, you are going to need more foam to satisfy the Chapter 7 requirements of the IRC. You would have to evaluate for yourself if the compressive strength of the Zip-R is sufficient.

AN ONGOING EVOLUTION

I love that we have simplified the process of building an airtight, watertight building enclosure that can all be done from the outside. The only part we must do inside is the air seal around the windows and doors. But here we are using the same fluid-applied barrier we use on the outside, so there's very little complexity to this step.

The key to making this work is keeping the material choices simple and getting buy-in from all the installers. They know how it works and can apply themselves with attention to detail without getting lost in the concepts and the origami and the sequencing of a wide variety of materials.

I'm not saying this is an inexpensive process. But we have worked at taking some of the cost out of it. We have gotten comfortable with the performance of Zip System tape, which is more cost-effective to use in the large expanse of roofs and walls than a fluid-applied barrier. The tape has an incredibly tenacious bond provided it gets rolled. The rolling activates the pressure-sensitive acrylic adhesive; without that, the tape can bubble and peel. It's also important to apply the tape straight and without folds or fish-mouths at the edges. This is especially true on a roof, where little folds can create funnels in the surface of the tape that can become leaks.

Another detail we have to address: We run the tape about an inch long where it intersects with the fluid-applied at the wall base and openings and at the roofline, and here we need to wipe the tape down with acetone, alcohol, or vinegar to remove the residue from the backing tape. Every added material adds its own complexity but as long as our team knows these details, it's manageable. It's when you get a lot of different materials, each with its own set of rules, and many diverging sequences moving from outside to inside the enclosure that things get too complicated and you run the risk of losing control.

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