ROOFING

Low-Slope Roofing: Troubleshooting in Advance
A remodeler shares the lessons of experience

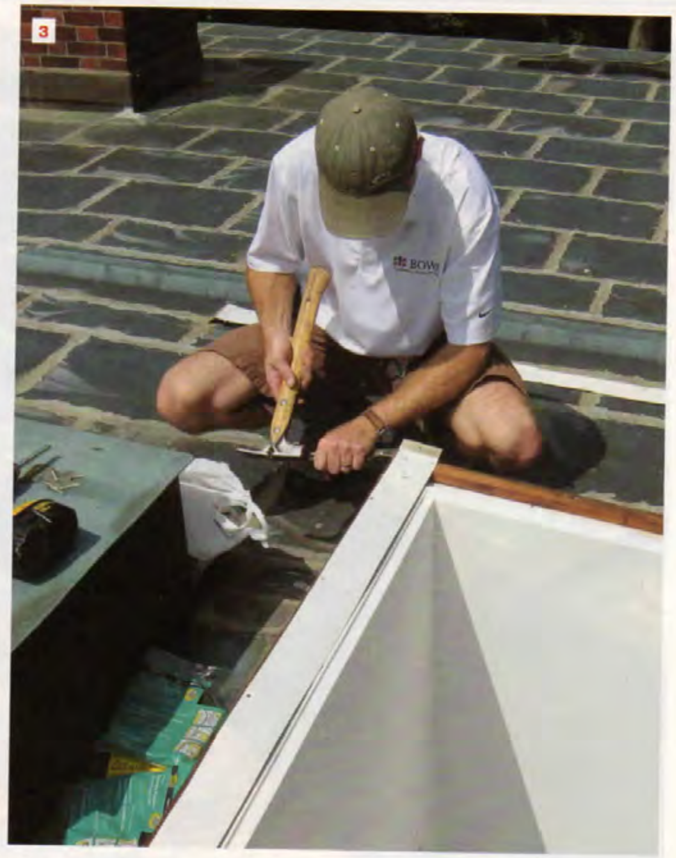
BY DOUG HORGAN

We're remodeling contractors working in Washington, D.C., and vicinity. After 20 years in business doing dozens of projects a year, we now have several hundred clients who call us for repairs and updates on their houses. At our company, I'm tasked with educating all our crews and trade contractors based on the lessons learned across all our projects. Here's some information on what we've learned about what works and what fails on low-slope roofs ("flat roofs," with a pitch lower than 3/12), and what materials are practical options for low-slope jobs.

All of the materials we commonly use are reliable in the field. When we see problems, they are mostly related to construction details rather than to materials. In previous articles, I've covered details for transitions to steeper-slope roofing ("Steep-Slope to Low-Slope Transitions," Apr/14) and explained why I prefer not to use drains or scuppers, instead opting for one edge of the roof being completely open ("Draining Low-Slope Roofs," Oct/15).

Other areas where we see failures are edge details, including parapets and skylight curbs; wall connections where roofs meet dormers or upper stories; and penetrations for vent stacks or hardware mounts. Roofing-material manufacturers and suppliers publish details for these potentially tricky situations that address the most common issues. Their manuals and websites are a great resource, and most of my recommendations that follow are drawn more or less from the manufacturers' published guidance.

Photos by Doug Horgan



SLOPE

Slope is very important! One-quarter inch per foot is the code minimum, and it's a very good idea. Any less, and ponding is inevitable—and with it, freeze/thaw, biological growth, and a ready reservoir of water waiting for the tiniest opening to pour through.

In remodeling situations, it can be hard to provide sufficient slope. We are often trying to fit a roof between a second-story door and a first-story ceiling height. It can be tempting to reduce clearance at the door sill, or to use less than 1/4-inch-per-foot slope. While the commercial "by the book" clearance at doors is 8 inches above the roofing, in my experience less than 4 inches is where it seems to cause problems in our climate. Four inches is also close to the minimum for good working room between the threshold and the roof plane. So, start with a 4-inch drop at any doors or windows, and slope down at 1/4 inch minimum.

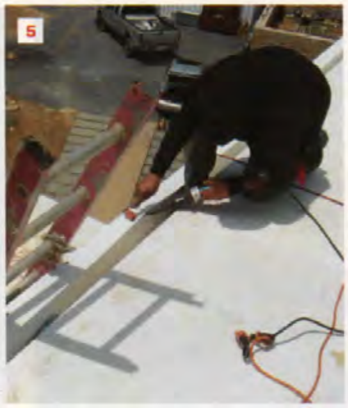
We like to buy "slope kit" foam boards from a roofing supplier. These tapered pieces of insulation can give flat framing a perfect slope. The expense compares favorably to our standard closed-cell spray foam, so it may not even add cost.

MATERIALS

Metals. Metal roofs have turned out to be problematic in our area. While a low-slope metal roof could in principle be properly built in the situations we encounter, that seems to be the exception.

For a slope below about 3/12, metal must be fully soldered in places that get snow and ice. This rules out steel and aluminum roofing. (There are some published directions for roofs as shallow as 1/12 slope for these metals, but the assemblies rely on the adhesion of peel-and-stick eaves membrane, and the details are expensive, labor-intensive, and kind of fiddly. We built one such roof and it hasn't leaked, but we decided it was a questionable idea.)

Copper and stainless steel can be used for low-slope roofs, but a fair amount of planning is involved. First, the metal must be cut down to pans no larger than 18 by 24 inches, so thermal expansion and contraction won't overstress the solder joints. Second, the solder joints require a fair amount of expert care to do properly. Pre-tinning the pan edges is recommended. Most importantly, all the connecting edge and valley metal is at risk of cracked solder joints (because these pieces are normally fairly long and will stress the joints), which means the roof will always require regular main-



Facing page: Tapered foam boards supplied as a "slope kit" **(1)** let the author's crews achieve a 1/4-inch-in-1-foot slope cost-effectively. Lesser slopes can allow ponding of water **(2)**, which causes leaks because of freeze-thaw damage and biological growth, and makes leaks worse when they do happen. Low-slope copper roofs **(3)** must be fully soldered, with pans sized no larger than 18 by 24 inches. Movement joints (seen to the rear of the carpenter) are necessary on larger roofs.

Left: A special heat gun melts both pieces of a TPO roof joint **(4)**; they are then pressed together to form a watertight seam. An installer applies pressure with a hand roller to form a heat weld in a PVC roof **(5)**. TPO makes a neat, attractive roof that clients often prefer to EPDM. In the roof edge shown here **(6)**, the TPO has been turned down over the face of the trim about 2 inches, then the metal drip edge has been applied over the membrane. Finally, a strip of TPO has been welded on top to cover the metal. This prevents leaks at the joints in the metal.

tenance. That's a problem in our market: On a cathedral, you can count on there being a staff to look after these joints; on a house, not so much.

Another common flaw we find in metal roofs is "unplanned expansion joints"—places where the metal rips apart in cold weather because planners didn't make any provision for metal movement. In our climate, we can expect copper to move about 3/8 inch in 10 feet, so a 30-foot roof should have a movement joint partway across. The Copper Development Association, SMACNA, and the Revere Company all publish guides and details for metal movement. Since the entire visual look of the roof, the gutter and downspout locations, and any penetrations need to be planned to work with metal movement, we've found metals to be somewhat impractical for remodeling projects, where many of those aspects are dictated by the existing situation.

Membranes. Instead of metals, we usually work with single-ply membranes. Our experience with these has been good overall. Of course mistakes can be made, but at least membranes won't rip themselves open from thermal stress, as I've seen with metal roofs.

EPDM, the black "inner tube" type of rubber, was the most common material in our area until recently. The sheets are strong and durable, especially in the .060 thickness we normally use (they come in .045 and .090 as well). EPDM is said to last well over 20 years, even in full sun. I have seen a hole poked in it once, but that's the only failure in the field of a sheet I've ever seen. Seams, on the other hand, had been a problem until we stopped using glue and started using "seam tape," a roll of adhesive that makes much better joints. We also cap seams with "lap sealant." EPDM seams require maintenance; the lap seal will fail. It needs to be replaced, or freeze-thaw can push open the seams over time.

TPO is another single-ply membrane, and we've been using it more and more. TPO seams are heat-welded: The installer warms up both sheets with a special heat gun and hand-rolls the layers together. The sheets become one in the process, and these seams don't require maintenance. For that reason, TPO is a better choice under decking or pavers, where access to maintain seams may be limited. Some clients also prefer the white, beige, or gray colors of TPO to the black EPDM. When we put decking over TPO, though, we often lay a sheet of EPDM on top first, because the black rubber is less noticeable.

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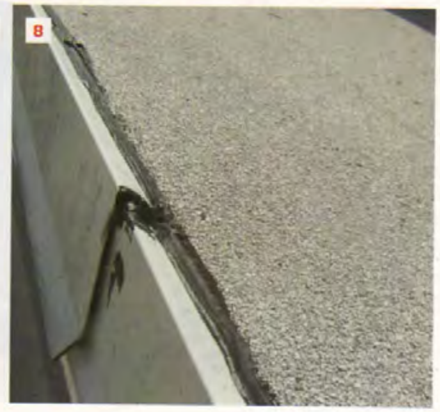

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We have used flexible PVC membranes on a couple of roofs, and they've worked fine. Like TPO, PVC is also heat-welded, so the seams should be durable. I have heard that raw PVC is not very flexible and that roofing is made with softeners, which eventually leave the material, leading to failure. Because we have a good track record with TPO (which does not have this problem), we've been using that unless something else is specified by a designer.

Occasionally we install a modified bitumen "torch down" roof. Double-layer "mod bit" was once considered to be the gold standard of low-slope roofs, and once installed it provides peace of mind. However the open-flame process required is nerve-wracking. I remember a few years when this type of roofing was basically not available because—after a few too many fires—insurance companies were refusing to cover roofers who installed it. New protocols were developed and we can get it nowadays, but it's expensive and not very pretty to look at so it's used selectively.

One place it's perfect for, however, is where old asphalt roofing residue remains on a building. "Mod bit" is compatible with old asphalt and roof cement, where TPO, EPDM, and especially PVC are not compatible.

EDGE CONNECTIONS

The main issue I've seen on edges is that metal always leaks at joints. We've been brought in to repair leaks at metal drip edges, parapet caps, and even skylight flashings. As we know from metal roofs, metal changes size significantly over the seasons. This puts a lot of stress on the joints between pieces. Two 10-foot-long drip-edge flashings will move a lot, breaking any seal between them and allowing water to work its way through the joint.

The general principles for keeping water out are to slope things well below the metal and to run flexible roofing materials under the metal and down the vertical surface. The first reduces the leaks; the second sends any leaking water out of the building.

On a drip-edge situation, choose a detail where the membrane runs over the edge and down the fascia. The edge metal is applied over the membrane, and flashing tape is applied on top. Any minor leaks between metal pieces are handled by the first layer of membrane. Firestone has a good published detail for this situation.

For parapet walls and skylight curbs, run the roof membrane all the way up over the top of the curb and down the other side. The metal parapet cap covers the last bit on a parapet, but for a

Facing page: The edge metal on this roof **(7)** was applied before the roofing. Water leaking at this point will go into the building. Metal drip edge moves almost $^3/_8$ inch in 10 feet as temperatures change between summer and winter—too much to effectively seal. The large gap shown here **(8)** illustrates how far this kind of joint can open up. For a pool shelter **(9)**, we were able to wrap the EPDM roof all the way over the skylight curb, which is sloped to the outside. A bead of sealant at the inner edge will help prevent leaks, but if a leak does develop, the water will simply drip into the pool.

Left: This EPDM roof **(10)** turns about 10 inches up the wall (8 inches is our normal requirement), and a termination bar holds it firmly in place. Sealant at the top edge prevents water from leaking behind it. Finally, the WRB on the wall is pulled out in front of the roofing material. A tall stainless steel Z-flashing **(11)** connects a PVC roof to the stucco we'll install later. This maintains clearance and allows the roof to be reworked later. A termination bar fastened to brick at the top edge of an EPDM roof **(12)** will be covered by a metal flashing cut in to the joint above in this solid masonry wall.

skylight, you may need to get creative with finishes on the inside. Curb-mount skylights often include or require aluminum "pans" with a turned-up inner edge. If the skylight curb has a slight slope to the outside, and the metal is sealed well to the membrane at the innermost edge, then almost any leaks between pan segments will run down the slope and outside. On a job with an indoor pool, we ran the membrane all the way to the inside of the trim so any water leaking through would drip into the pool, but most skylights don't offer such a convenient option.

WALL CONNECTIONS

The key at walls is to prevent water from getting behind the roofing material. It seems obvious, but don't forget there's usually a drainage plane buried behind the wall finishes, and if it can't drain out onto the roof, you'll have a leak.

It's common to find brick or stucco on a wall we're tying a roof into. If we want to be sure there will be no leaks in windy rainstorms, we need to remove the finish and install a through-flashing above the roofing tie-in. The same is true for siding. All of these claddings should have felt or housewrap behind them. We pull this layer out in front of the through-flashing or the roofing, so any water running down it lands on the roof.

The roof tie-in is fairly straightforward. In our area, it's common to glue the membrane to the wall and install an aluminum flashing to cover the top edge. We've seen a fair number of leaks where this technique has been used, though, so following the manufacturer's details, we normally use a "termination bar"—an aluminum extrusion that's nailed to the wall and pinches the roofing in place. The top of the joint is caulked, and then a flashing is applied to cover all of that. When water makes it past the flashing, the caulk and the bar keep it out of the roof.

When we work on an older building with solid masonry walls, we cut a horizontal slot into the masonry just above the roofing and slide the flashing into the kerf. We've found that $^3/_4$ inch is the "right" number. Any deeper, and you can be opening a pathway for water into brick cores or poor head joints; any shallower, and the roofer may not get enough metal into the kerf. When we used to ask for $^1/_2$ inch, sometimes the slot would be only $^1/_4$ inch deep—then on a hot day, the metal would be prone to "oil can" itself out of the slot, leading to a leak.

Left: This site-made metal flashing **(13)** is less reliable than a factory-built one. Factory boots for these vent pipes **(14)** are reliable and easy to install. A factory EPDM collar for this plumbing vent **(15)** is more reliable than a site-made flashing. Rectangular penetrations **(16)** are flashed using skylight details, with overlapping layers of flexible flashing tape.

One thing we won't allow is metal applied only to the face of the masonry without cutting in. This does not work in our climate—hot days invariably push the metal off the wall, no matter how great your preferred brand of caulking is.

We also insist on stopping cladding materials well above the roof surface. For splashing, snow and ice, and wind, we want 8 vertical inches on the roofing material that turns up the wall. In addition, many claddings require clearance above a flat surface. While 2 inches is the normal distance for roof clearance (with fiber cement and wood siding or stucco, for example), often the recommendation is 4 inches or 6 inches from a deck or paved area. It's safer to use the larger clearance, to avoid splash staining and the added wetness that comes with proximity to a horizontal surface.

Another reason to leave ample clearance becomes evident down the road, when it's time to re-roof. If we've left only a couple of inches of clearance above the roof, it's hard to get the new roofing material turned up the wall properly. Taking a page from a Hardie install guide, we often bend up a piece of metal to visually fill the space between the roof and the cladding while leaving room for later repair or replacement.

PENETRATIONS

The best way to handle penetrations is with factory-made "boots." These are flexible, reliable, and easy to install. It's often best to plan penetrations so these can be used; for example, by using round steel posts to mount solar panels and satellite dishes. Trying to use square or I-section bars creates extra sealing work and more chances for a leak to form. Of course sometimes we have a shape there is no boot for. Roof manuals include details for larger round shapes, and rectangular ducts can be treated the same as skylight curbs.

Another method for penetrations is a "pitch pocket." A small curb is formed up around the penetration using roof membrane or flashing tape and filled with a liquid that cures into a watertight barrier. These are a bit expensive to make, and in manuals they're said to be less reliable than a boot. I also find that many roofers aren't aware of details such as priming the surfaces the liquid needs to adhere to, and forming a slope on the top of the liquid as it cures. Still, pitch pockets are useful where a boot can't be installed.

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