Designing and Building Leak-Free Sloped Glazing

Error-free projects demand careful detailing

by Fred Unger

Water has an uncanny ability to work its way into the most unexpected places, while the sun can quickly drive all life from an improperly designed sunroom. That's why sloped-glazing units—such as those in sunrooms, conservatories and large skylights—are among the most complex parts of the building envelope. They're also among the hardest to build correctly.

But with the right materials, careful attention to detail and a sense of how water behaves, well-functioning skylights and sunrooms are well within reach of most knowledgeable builders. Building a high-quality unit isn't cheap, but it will cost less over the long haul than endless callbacks or having to replace an entire structure later on. I tell sunroom clients that, while I can build a conventional small addition for $100 to $120 per square foot, they should plan to spend at least $160 per square foot for a comfortable, well-built sunroom with overhead glass.

Years of trial, error and refinement have passed since I worked on my first sloped-glazing project in 1974. I've learned that the secret to controlling water problems is a dry glazing system that depends not on caulks or sealants, but on gravity and physics. Before going into the details of the system, I'll review some general principles that apply to all wood-frame sloped glazing.

Custom or manufactured?—We custom-build many of our sloped-glazing units on site or in our shop. But why custom-build when there are plenty of manufactured products on the market? Part of the answer is that some glazing systems available to custom builders are superior to those found in most manufactured units (I can't understand why manufacturers have been so slow to use them). Although we do install some manufactured systems, we only work with companies that will customize their units to our specifications and with units on which we can install our preferred glazing system. To save time in the field and enhance quality control, we also preglaze some skylights in our shop, truck them to the site and hoist them into place with a crane. Most manufactured systems are designed to be site-assembled; thus, they aren't engineered to withstand the added stresses of transport and hoisting.

The other part of the answer concerns design. Architects and clients can be quite creative in their designs (for example, we recently completed an African mahogany pyramid skylight with heat-mirror glass), but there are limits as to how far manufacturers will go to customize their products. So far, we haven't found a manufacturer that meets all of our demands for design and detailing.

On architect-designed projects, we try to get involved early in the design process. By sharing our expertise, we can help specify the framing materials, glass and sealants. We also suggest details that will expedite the construction process and save the client money. Our goal is a durable, efficient, cost-effective structure that meets the architect's and the client's design goals. Offering such help has gotten us specified into projects without competition.

Choosing a frame—The most critical design factor we must deal with is movement. On a sunny winter day, the components of a south- or west-facing skylight or sunroom may be exposed to some extreme temperature changes. The differing rates of expansion and contraction of wood, metal, glass and rubber can lead to buckled flashings, torn caulk joints, failed water seals and even broken glass. The movement is even more pronounced in poorly designed, wood-framed spaces that house plants, a pool or a hot tub. I've seen sunrooms built with construction-grade lumber in which the frames had twisted or warped well over an inch.

Because movement is so potentially damaging, a dimensionally stable frame is a must (photo right). The use of unstable wood can lead to major problems even if all other aspects of the project are executed perfectly. We prefer to work with clear, kiln-dried, vertical-grain stock. The most dimensionally stable

Materials count. A skylight or sunroom must withstand wind, rain and sun, so even a simple project demands a dimensionally stable frame. The best domestic woods are clear, vertical-grain redwood and cedar (photo below). Outside, hips, valleys and angles can be covered with custom aluminum caps that can be fabricated at a sheet-metal shop (photo right). They're held in place by exposed stainless-steel screws with gasketed washers.

species we've found are redwood and cedar, although we've also had good luck with some species of mahogany. Good wood can be quite expensive. Luckily, however, laminated wood is also an excellent choice: It's less expensive and more environmentally friendly than solid stock cut from old-growth trees. It's also more stable. We never use solid sawn hem-fir, white pine, yellow pine or oak except as part of a composite member.

Regardless of the species, the best glazing systems we've found require the surface on which two pieces of insulating glass come together to be about 3 in. wide. The bearing area can consist of solid wood or of glued 2x or 1x stock. If these pieces will be exposed to high humidity, a two-part resorcinol or other waterproof glue should be used.

Precision and flexibility—We try to design our frames to meet two seemingly contradictory demands: precision and flexibility. The joinery on most of our projects is complicated, especially when hips and valleys are included. Because virtually every cut ends up as exposed finish work, our frames have to be precise. Structural connections demand careful planning and intelligent detailing. Once ordered, expensive insulating glass can't be trimmed to fit improperly framed openings. Because of this, we must design and build our frames to close tolerances.

We usually join our framing components with blind screws, dowels, biscuits or other hidden fasteners. We've also used exposed brass screws. Some areas, such as structural ledger boards, can be hidden. We attach them with nails or screws and then hide them with trim. Our choice of fasteners depends on the expected humidity level and the wood species we're using. In a high-humidity environment, the natural extractives in cedar and redwood will corrode even galvanized fasteners. We tend to use a lot of stainless-steel screws and nails.

Despite the fact that our frames must double as finish work, they also have to perform in the real world of construction. We can't expect framers, masons and foundation crews to work to 1⁄16-in. tolerances in three dimensions. We compensate by designing shim spaces into the system and then use trim to span the gaps.

The system—Many glazing systems rely on caulks and sealants to prevent water problems. But we've found sealant-dependent systems to have some real disadvantages. While some of them will stop leaks if installed under near-ideal conditions, most won't control condensation. These systems also make glass replacement difficult. I've spent hours with scrapers and solvents, removing broken glass that had been caulked in place. But it wasn't until a client's dog stepped on a gob of urethane caulk and tracked it across a $5,000 rug that I became determined to minimize our use of these products.

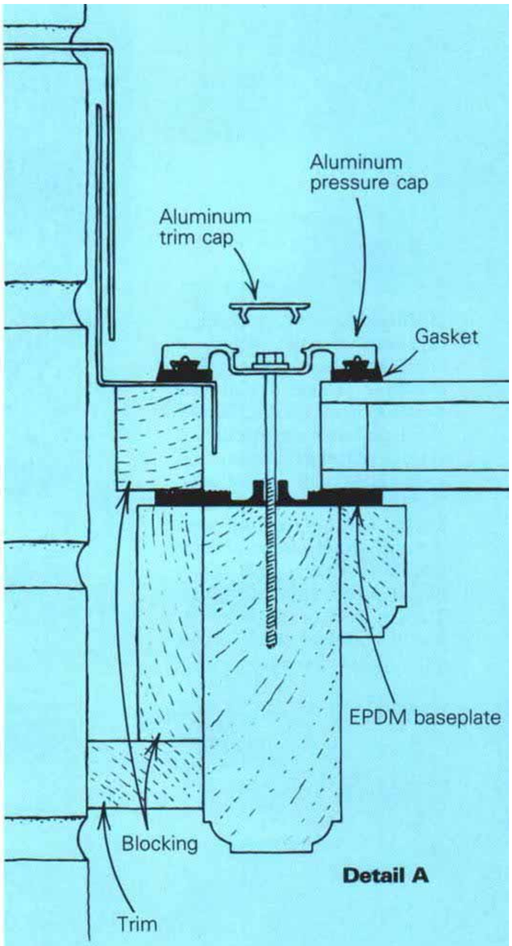
The dry glazing systems we now use employ rafter and purlin baseplates with internal gutters, EPDM rubber gaskets, insulating glass and a gasketed aluminum pressure cap (drawings right). The aluminum cap holds the glass in place. EPDM gasketing or closed-cell foam tape serves as the primary water seal. A removable trim cap hides the screws, which are installed with gasketed washers. On purlins, we use flat bar stock over closed-cell glazing tape because the resulting low profile prevents water damming. The glass sits on raised pads that prevent any water in the guttering system from puddling against the window's edge sealant. Such puddling is a leading cause of seal failure and fogging within insulated glass. To keep the glass from sliding and to keep adjacent pieces of glass from shearing relative to each other, we rest its bottom edge on rubber setting blocks and aluminum setting-block supports. These blocks support the glass and keep top and bottom lites from shearing relative to each other. The supports are positioned one quarter of the way in from the bottom corners of the glass.

But the guts of this system are the internal gutters in the baseplates. Good systems are designed to direct water from the purlin gutters to the rafter gutters to weep holes at the eaves. In effect, the gutters serve as a safeguard to the primary water seal. As one old-time glazer told me, "If you don't want water problems, you've got to design the system to leak." The dry system also permits quick, low-cost replacement of broken glass.

We use these systems because we consider them to be the most foolproof. Even though we'd like to pretend that our designs, our installers and our materials are perfect, they're not. For best results, workers should understand how water moves, along with why and how the system sheds water. Fortunately, however, the details we've developed will work even if installed on a Monday morning. On one job, we set the glass and then got a solid week of rain before we could cap the system off. We didn't get a single leak.

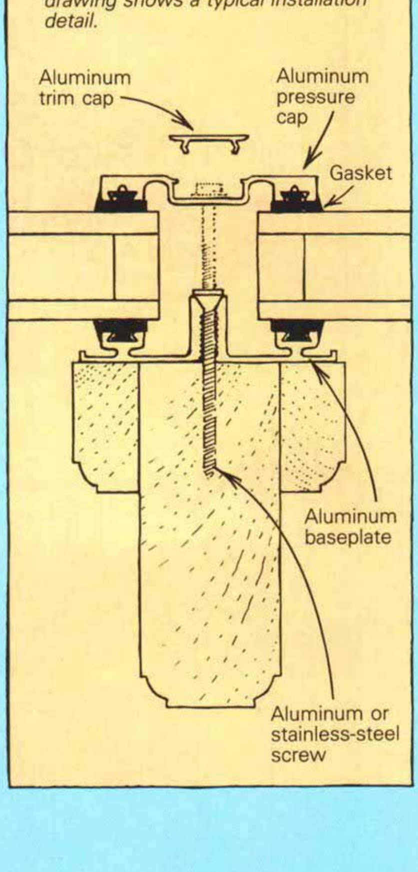
Baseplates can be aluminum with EPDM gaskets, or solid EPDM rubber (photo page 80). The best we've found are available from Abundant Energy, Inc. (P. O. Box 307, County Rt. 1, Pine Island, N. Y. 10969; 800-426-4859) and U. S. Sky (2907 Agua Frio, Santa Fe, N. M., 87501, 800-323-5017). The aluminum systems have been around for several years and many now include thermal breaks. Aluminum baseplates hold screws for the pressure caps more securely than wood systems do, and ensure a flat surface for glazing. But they take more time to install than the rubber ones and are hard to work around hips and valleys without adding cumbersome-looking details. If they don't include a built-in thermal break, aluminum baseplates themselves can cause minor condensation and interior frosting. Even thermally broken aluminum systems must be carefully detailed to prevent thermal conduction problems.

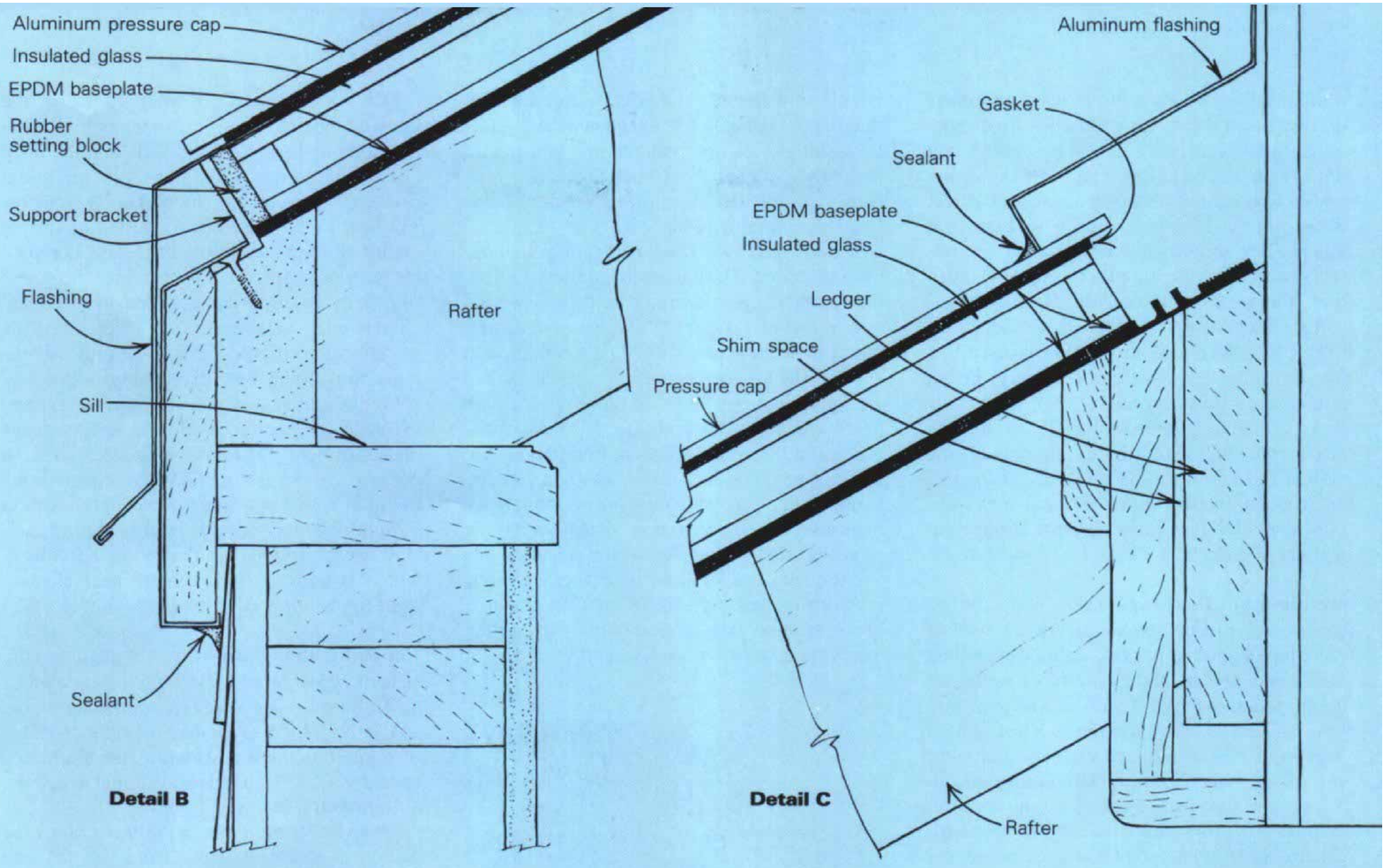
The EPDM baseplate, on the other hand, installs quickly and easily (it cuts with shears or



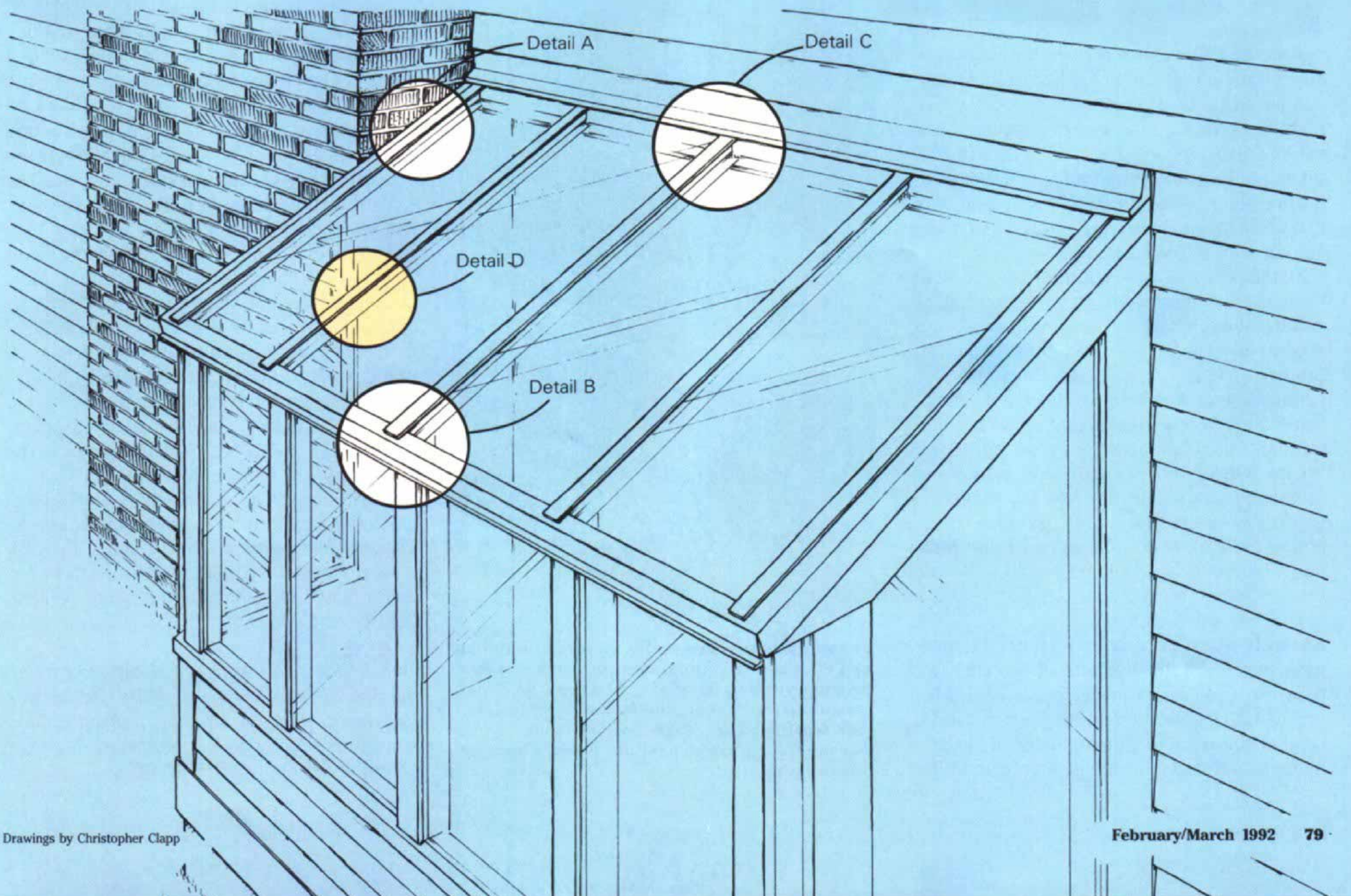
Detail D

Aluminum baseplates can be used instead of EPDM baseplates. This drawing shows a typical installation detail.





Shedding water. *A dry glazing system is designed around a system of aluminum or EPDM rubber baseplates with internal gutters. By directing any leaks or internal condensation to weep holes at the eaves, the gutters serve as a back up to the primary water seal. The system also includes EPDM rubber gaskets, insulating glass and an extruded-aluminum pressure cap. The aluminum pressure cap holds the glass in place: Raised pads beneath the glass prevent any water in the gutters from puddling against the window's edge sealant. The bottom edge of the glass rests against setting blocks and setting block supports. In addition to shedding water very effectively, the system also permits quick, low-cost glass replacement.*



Drawings by Christopher Clapp

a utility knife), bends around hips and valleys and isn't prone to condensation or frost problems. Unfortunately, the EPDM baseplates that have been available don't have condensation gutters and cannot be easily installed to direct water from a horizontal purlin to a vertical rafter. They should only be installed on systems with one lite of glass vertically. Even then, the glass has to be carefully detailed.

Abundant Energy is about to introduce an EPDM baseplate that incorporates cascading internal gutters. It's fast and flexible to install and can be cut with a utility knife, yet it costs less than the aluminum system. It also has the fastest-to-install setting block support of any system I've found on the market, isolates water from any penetrations through the baseplate and eliminates any concern about thermal conduction.

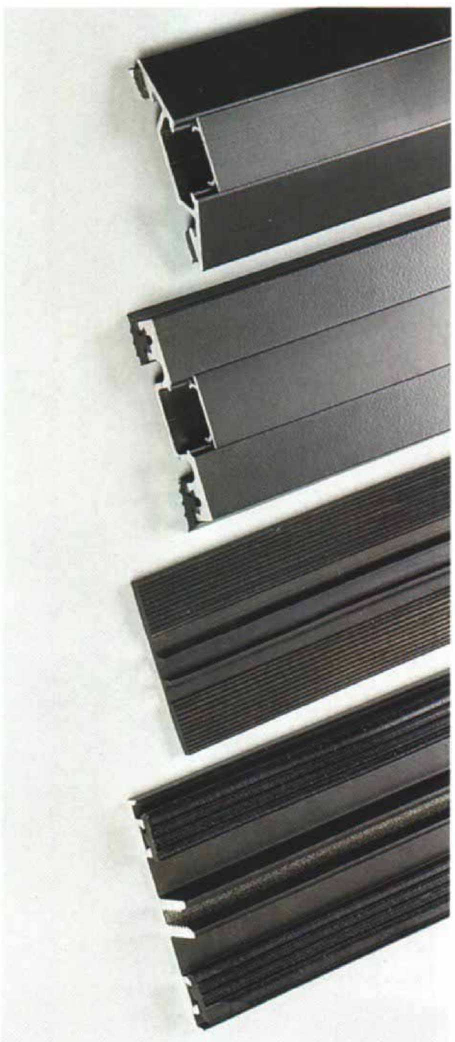
Metals and flashing—Even with rubber baseplates, metals remain a crucial part of any sloped-glazing project. Baseplate gutters aren't intended to handle rivers of water, so it's important to have good exterior cap and flashing details. We clad the exterior sloped portion of all our projects with an aluminum cap (photo page 77). Abundant Energy and U. S. Sky have excellent caps, as do most manufacturers of sunroom kits and curtain-wall glazing systems. Most of these caps are designed for use where two lites of glass meet on a flat plane. For hips, valleys and angles, we have a sheet-metal shop fabricate custom caps from heavy aluminum flat stock with an anodized or baked-enamel finish. These must be fastened using exposed stainless-steel screws with gasketed washers.

Occasionally, an architect will insist on copper or lead-coated copper flashings. But copper and aluminum are galvanically incompatible; using them together raises the possibility of corrosion (for an explanation of galvanic corrosion see *FHB* #62, pp. 64-67). When we have to put galvanically incompatible metals in close proximity, we make sure to isolate them with wide, closed-cell foam tape or with EPDM gaskets.

Metals expand and contract greatly with changes in temperature. Before screwing or nailing through caps or flashings, we always predrill or punch over-sized pilot holes. To protect against galvanic reactions, we use stainless-steel fasteners or fasteners of the same metal as the flashings. Prepainted aluminum flashings also can't be soldered. Where two or more lengths of flashing are required for a single run, we leave a ⅛-in. gap between them and then install a spline below the gap. When the edge of the flashing is bent over and splined, it locks the two runs together.

Sealants—Despite our best efforts to minimize them, we still use lots of sealants (for more on caulks and sealants see *FHB* #61, pp. 36-42). To prevent leaks, we always run a bead of silicone along the top edge of our purlin caps and eaves flashings, then extend it a couple of inches up the edge of the adjacent rafter caps. We also use sealants at butt joints in flashings. We use sealants that will permit high levels of joint movement; this is especially important when transporting preglazed skylights over bumpy roads.

At one time, we tried using only neutral-cure silicones. They're easily gunned, permitting a nice, clean bead, and they were the only silicones I could find that showed any tenacity in sticking to wood. Most silicones also adhere well in glass-to-metal connections. But we found that regardless of how well they adhered when first applied, the silicones would eventually begin to pull away from wood. We now use urethane sealants on all wood and masonry joints. The urethanes are absolutely remarkable in their adherence, though they're not as easily gunned or tooled as the silicones. We still use silicones for glass-to-metal connections (such as the leading edge of the eave flashing) or for metal-to-metal connections (such as the intersection between two flashings).



Pros and cons. **Baseplates can be aluminum or EPDM rubber. Aluminum provides a stable bearing surface for glazing but can be time-consuming to install, and it is subject to interior frosting. The EPDM doesn't frost up but doesn't have a condensation gutter. Photo by Susan Kahn.**

One thing to watch for when choosing sealants is potential chemical incompatibility between the field-applied products and the insulating glass-edge sealants. The chemical reactions between two incompatible sealants can lead to the breakdown and failure of one or the other. Several builders, glass companies and window manufacturers have been ruined by lawsuits that resulted from chemical-related seal failures. Your insulating-glass manufacturer should be able to provide sealant-compatibility test results upon request.

Caulks and sealants should only be applied to clean, dry surfaces. Before caulking, we clean adjacent surfaces with glass cleaner. To cut any oils or residual films, we usually wipe the joint with a rag dampened slightly with a solvent called xylol. This is also the best solvent we've found for removing silicone—which is why we take care to keep it away from the window edge sealants.

Choosing the glass—Insulating glass consists of two or more lites of glass separated by an air- or gas-filled space. A hollow aluminum spacer is joined to both laminations with a moisture-proof edge sealant. The aluminum spacer is filled with a dessicant that keeps the air between lites dry.

When ordering glass, be sure to check its warranty, code-compliance and thermal and solar characteristics. I'll touch on the first two here; the third is a subject for a future article. The glass used in a sloped-glazing unit should be guaranteed for use on a slope (most glass isn't). Putting glass on a slope adds differential stresses between the inboard and outboard lites that aren't present in vertical glazing. Most sloped-glazing units have a dual-edge sealant—a silicone structural sealant and a moisture seal consisting of some other material. A few companies are switching to a new single-seal urethane. If you're using urethane sealed units, it's important to ensure that all edges of the glass are capped. The sealant will break down if it is exposed to direct sunlight.

The second major consideration with sloped glass concerns safety and codes. Most codes require that sloped glass on commercial buildings include an outboard layer of tempered glass and an inboard layer of laminated safety glass. The tempered glass is strong enough for someone to stand on and usually won't break unless tapped on an exposed edge or hit with a sharp object. The plastic layer within laminated safety glass is strong enough to hold any tempered glass that does break, along with whatever broke it. These safety standards make sense for residential work, too; in fact, several states have incorporated the standards into their residential building codes. □

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