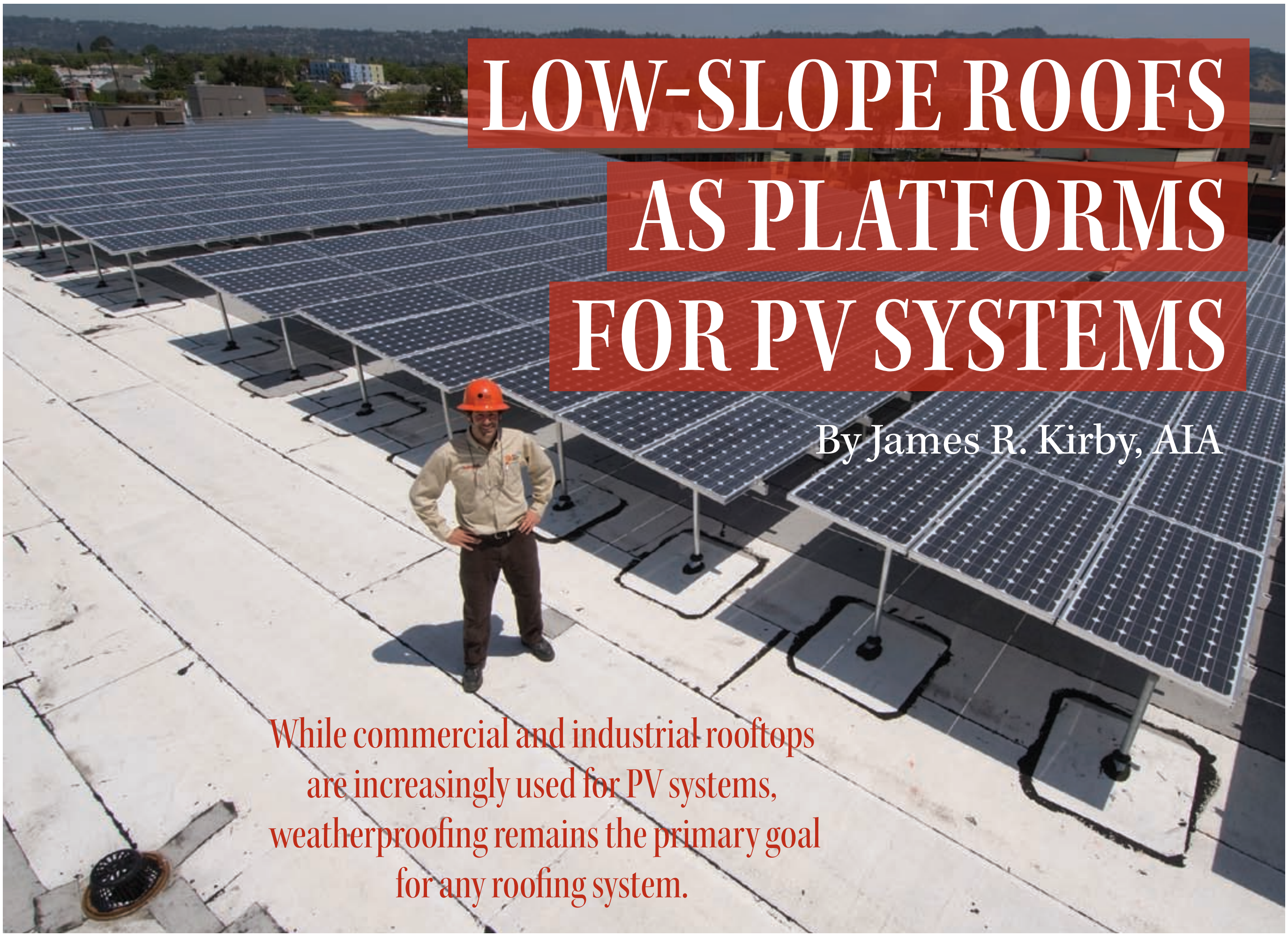


Shawn Schreiner

LOW-SLOPE ROOFS AS PLATFORMS FOR PV SYSTEMS

By James R. Kirby, AIA

While commercial and industrial rooftops are increasingly used for PV systems, weatherproofing remains the primary goal for any roofing system.

Low-slope roofs are ideal locations for PV systems: the solar resource is good; power is generated in close proximity to loads; the location is secure and unobtrusive; and one- and two-story buildings in particular have favorable ratios of roof-to-wall area. Best of all, low-slope roofs are plentiful. As a platform for PV systems, they represent an excellent business opportunity for both PV and roofing contractors.

Although the roofing and PV industries often work together by choice, this collaboration will soon be mandated. The 2012 edition of the *International Building Code* will have PV-specific information in Chapter 15, which covers "Roof Assemblies and Rooftop Structures." This means that, in addition to existing UL 1703 requirements, rooftop PV systems will need to meet the same requirements for fire, wind and impact resistance as are required for the roof systems on which they are installed.

The roof system is the building's interface with the PV system, so it is important to recognize the unique issues and concerns that come into play when using a rooftop as a platform for PV. In this article I discuss the components of low-slope roof assemblies, the most common material types and typical roof system construction. I introduce some roofing professionals' concerns about the application of PV systems on rooftops. Finally, I discuss guidelines and best practices for installing rooftop PV systems that are endorsed by the National Roofing Contractors Association (NRCA).

Low-Slope Roof Assemblies

The NRCA defines *low-slope roofs* as those with slopes equal to or less than 3:12 (see definitions, p. 34). A low-slope roof assembly consists of a roof deck, insulation and roof membrane or other weatherproof cover. An air or vapor retarder is sometimes included.

Roof deck. The most common roof decks for low-slope roof systems include steel, concrete and wood. There are regional differences in usage. For example, in the Southwest plywood and OSB are used regularly for low-slope roof decks in light commercial construction, whereas in the Midwest steel roof decks are more prevalent. Roof systems commonly are attached to wood decks with fasteners, but may be adhered if a separator layer, such as an asphalt-coated base sheet, is first nailed to the wood deck. Roof systems are commonly attached to steel roof decks with screws and plates. However, it is becoming more common to use adhesives to attach roof systems to steel decks, although NRCA does not recommend this method. Screws and plates may be used to fasten an entire roof system or only the bottom layer, such as a gypsum-based board used for fire resistance. When only the bottom layer is fastened, the insulation and membrane are likely adhered with asphalt, liquid adhesive or foam adhesive.

Roof systems are generally adhered to concrete decks with asphalt. In the past, this meant hot asphalt, but today there are additional choices like cold adhesives and foams. The less common roof deck types include poured gypsum, precast gypsum panels, cementitious wood-fiber panels, lightweight insulating concrete and thermal-setting insulating fills. Fastening standoffs for PV mounting systems to these roof deck types requires knowledge of the unique materials and fasteners necessary for a long-term installation.

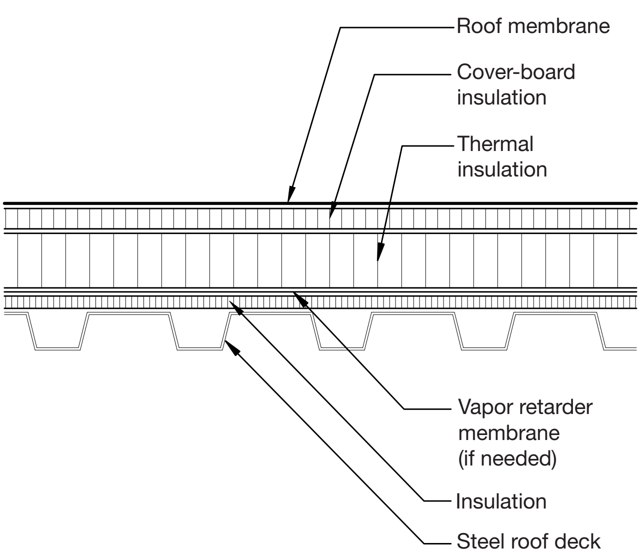


Diagram 1 A representative cross-section of an insulated low-slope roof assembly is shown here.

Insulation. Insulation for roof systems is best installed in layers with a cover board included as the top surface. The most common insulation material for low-slope roof systems is polyisocyanurate, but many other types can be used: cellular glass, expanded or extruded polystyrene, fiberglass, mineral fiber, perlite and wood fiberboard. Common cover boards include perlite, wood fiberboard and gypsum. Insulation is all too often installed in one layer and without a cover board, thereby reducing the system's overall R-value.

Membranes and weatherproof coverings. Several weatherproof coverings are used for low-slope roof systems. Built-up roofing (BUR), polymer-modified bitumen (MB), single-ply (for example, EDPM, TPO, PVC), metal panel and spray polyurethane foam (SPF) roof systems are used in all climate zones of the US, with some expected regional variation in market share. Because BUR, MB and single-ply coverings are rolled goods or sheets, they are considered to be membranes. Metal-panel roof coverings are formed from metal coils and sheets and typically have vertical seams that are locked together to raise the joint out of the drainage plane. SPF is applied on-site to make an insulation-based roof system.

Although roofing professionals may be able to visually determine roof types, subtleties can be hard to discern. There are several white and light-colored single-ply membranes, for example, and each has its own chemical recipe and base polymer. It is important to know the proper method—glue, tape or hot-air welding—to use for long-term adhesion of seams. A BUR roof may be asphalt or coal-tar based; each has different properties. MB sheets come in several common types, and each is installed using different adhering methods.

All low-slope roof systems are required to have a certain level of wind resistance, which is achieved through the attachment method. Roof systems can be adhered, mechanically attached, or loose-laid and ballasted. BUR and MB membranes commonly require hot and cold asphalt and asphalt-based adhesives. Some MB sheets can be torch applied, and single-ply membranes can be mechanically attached or adhered. Loose-laid and ballasted attachments are commonly used in EPDM membrane roof systems.

Low-slope metal panels, such as steel or aluminum products, achieve wind resistance using mechanical clips attached to a metal-frame structural system, such as purlins and beams. In most cases, these metal panels comprise both the roof system and the structural deck.

SPF roof systems are unique. These two-component systems are sprayed on-site. The SPF insulation reacts and adheres to the substrate to create an insulation layer. SPF roof systems require a weatherproof coating for long-term durability. Most coatings are acrylic-, polyurethane- or silicone-based. Flashing a metal-panel roof system or SPF roof system requires specific knowledge about the system and the proper tools and equipment for a proper installation.

To ensure that flashing details are correctly constructed, it is important that a roofing contractor is engaged in the installation of rooftop PV systems. Asphalt-based roof systems, for example, are flashed with asphalt-based flashing membranes. Single-ply roof membranes are flashed with the same membrane used in the field of the roof system: EPDM is used to flash EPDM, PVC is used to flash PVC, and so on. These materials require different methods to attach field sheets and flashings or to make seams, including glues, tapes, heat, and hot- and cold-applied asphalt-based adhesives. Some membranes have fleece backs and require asphalt or SPF as an adhesive. Metal-panel flashing installations often require custom-built metal flashing pieces. SPF is considered self-flashing because it is spray applied.

Air barriers. To save energy and improve energy efficiency, efforts are underway to reduce the airflow through building envelopes. As building codes are updated, requirements for the use of whole-building air barriers are expected to be mandated. Within the decade, many more buildings, likely starting with government-owned facilities, will be built with an air barrier around the entire building.

Successful air barriers (and vapor retarders, for that matter) cannot have breaches at any building envelope penetration, including rooftop penetrations like drains or vent stacks—and especially not at the perimeter where walls transition to the roof. Installers of mechanical attachments for PV mounting systems need to know whether the building has a continuous barrier. If so, the additional air barrier or vapor retarder layer must be accounted for. It must be properly repaired during the installation and weatherproofing of the mechanical attachments that will penetrate these layers. Contractors who are qualified and accustomed to installing the materials used for air barrier and vapor retarder layers—namely, adhered membranes and SPF—should be used to help ensure a long-term installation.

Knowledge about and experience with air barriers, vapor retarders, insulation and weatherproofing layers is critical for the long-term success of a roof system and a rooftop PV system. It is also important to recognize that roofing membranes and systems have evolved over the years. The number of systems to choose from and to understand continues to grow. Vegetative roof systems are a good example. Because of the push for energy efficiency and sustainability, roof systems are being used as platforms for vegetation of CONTINUED ON PAGE 36

Definitions: Glossary of Low-Slope Roof System Terms

The following definitions are excerpted from the NRCA's *Guidelines for Roof-Mounted Photovoltaic System Installations* (see Resources):

Base flashing (membrane base flashing): Plies or strips of roof membrane material used to close off and/or seal a roof at the horizontal-to-vertical intersections, such as at a roof-to-wall juncture. Membrane base flashing covers the edge of the field membrane and extends up the vertical surface.

Counterflashing: Formed metal or elastomeric sheeting secured onto or into a wall, curb, pipe rooftop unit or other surface to cover and protect the upper edge of a base flashing and its associated fasteners.

Cricket: A relatively small area of a roof constructed to divert water from a horizontal intersection of the roof with a chimney, wall, expansion joint or other projection.

Curb: (1) A raised member used to support roof penetrations, such as skylights, mechanical equipment, hatches and so on, above the level of the roof surface; (2) a raised roof perimeter relatively low in height.

Shawn Schreiner

Technically speaking Polymer-modified bitumen base flashing extends up the sides of this parapet wall, which is capped with custom fabricated formed-metal counterflashing.

Low-slope roofs: A category of roofs that generally includes weatherproof membrane types of roof systems installed on slopes at or less than 3:12.

Penetration pocket (pitch-pocket or pitch-pan): A flanged, open-bottomed enclosure made of sheet metal or other material placed around a penetration through the roof, properly stripped in to the roof membrane and filled with grout and bituminous or polymeric sealants to seal the area around the penetration.

Roof assembly: An assembly of interacting roof components, including the roof deck, vapor retarder (if present), insulation and membrane or primary roof covering designed to weatherproof.

Roof system: A system of interacting roof components, generally consisting of a membrane primary roof covering and roof insulation (not including the roof deck) designed to weatherproof and sometimes to improve the building's thermal performance. ●

all kinds—garden roofs, publicly usable landscaped roofs and urban farming—as well as energy production.

Roofing contractors, electricians and PV integrators should be knowledgeable about the general requirements of the other trades. This does not mean solar electricians need to become roofing professionals or vice versa, but each can learn from the other. Each trade has hard-earned, industry-specific skills that should not be undervalued. These unique skill sets help to ensure a safe workplace, a successful building and a long-term service life for the building systems.

Roofing Industry Concerns

The roofing industry has learned over the years how to successfully design, install and maintain roof systems so they are weatherproof and durable. Fire, wind and impact resistance, system design, material selection and construction details are some of the big-picture issues dealt with on each roofing project. In addition, the roof has to accommodate everything building owners desire or need to have on their rooftops.

PV systems are in many ways equivalent to other rooftop equipment, like HVAC units, mechanized fans, TV antennas and satellite dishes. Not only do the components of PV systems need to be flashed properly and weatherproofed, but the installation of PV modules on rooftops also requires consideration of other issues: wind and fire resistance; maintenance of roof system warranties; drainage and dirt buildup; access for rooftop traffic, maintenance or reroofing. These are all legitimate roofing industry concerns relevant to the installation of rooftop PV systems.

Wind resistance. A low-slope roof is divided into three zones for wind resistance analysis: field (or interior), perimeter (or end) and corner zones. The corner zones of a roof see the highest wind loads; the interior or field zone of the roof has the lowest loads; perimeter zone wind loads are somewhere in between the two. Therefore, wind resistance becomes an even more important consideration when rack-mounted PV modules encroach into perimeter and corner roof zones.

The popularity of ballasted PV mounting systems in particular deserves closer analysis. The roofing industry has learned from experience that ballasted rooftop equipment does not necessarily remain stationary. Structurally attached equipment is more reliable in this regard. Wind uplift may have the potential to move rooftop PV equipment, especially when it is not structurally attached to the building. The possible consequences range from the catastrophic—racks actually coming off of rooftops—to the undetected—racks sliding across the membrane. Both scenarios have the potential to damage persons and property.

Because rack-mounted PV modules located in the perimeter and corner roof zones are subject to additional wind loads, many of these mounting systems use additional ballast. But how much weight is enough? While the roofing industry assesses wind uplift in *pounds per square foot* (psf), my experience is that the PV industry provides *miles per hour* (mph) ratings for PV mounting systems, which makes design substantiation difficult.

Wind loads acting on buildings are calculated based on the basic wind speed at the location of the building, roof height, building configuration, exposure category and occupancy, which determines the importance category. Using this information, the design uplift resistance is determined in psf. Wind resistance information about rack-mounted PV systems should also be in psf in order to facilitate an apples-to-apples comparison. A PV system and a roof system can then be analyzed to verify adequate wind resistance. It would benefit all stakeholders if racking manufacturers serving the PV industry provided psf ratings for mounting systems, rather than mph ratings.

Fire resistance. Roof systems are classified as Class A, Class B or Class C for their fire resistance, with Class A being the highest rating. The NRCA and other organizations in the codes and standards community are concerned that a roof system's fire classification may effectively be altered by the addition of a PV system. Solar ABCs, for example, recently completed fire-resistance testing of rooftops with PV systems in partnership with UL. An interim report was presented at the Solar ABCs (see Resources) stakeholder meeting on October 15, 2010. Many of the combined PV module and roof covering systems did not meet the expected fire resistance classification that the roof systems alone achieve. Although more testing is needed to determine whether code changes are required, the initial results clearly indicate that further analysis is necessary.

Photo courtesy FEMA's Hurricane Charley and Katrina Assessment Team

Weathering the storm As documented here by one of FEMA's Hurricane Charley and Katrina mitigation assessment teams, ballasted equipment is less likely than structurally attached equipment to remain stationary in the event of an extreme wind event.

Roof warranty. According to the report "Successful Rooftop Photovoltaics: How to Achieve a High-Quality, Well-Maintained, Compatible Rooftop PV System," published by the Center for Environmental Innovation in Roofing CONTINUED ON PAGE 38

(see Publications), limited manufacturer warranties cover billions of square feet of commercial roofing. "Like all limited warranties, however, the coverage offered may be severely limited if critical design, installation and/or maintenance procedures are not followed," the report warns. This means, for example, that the flashing detail for all roof penetrations must meet the roofing manufacturer's specifications in order for the roof warranty to remain intact. In addition, rooftop equipment cannot interfere with long-term roof maintenance. A good way to ensure that these criteria are met is to communicate with the roof system manufacturer and work with an approved roofing contractor. The building owner and facilities personnel also should be engaged. Contractors that fail to do so run the risk of assuming the liability for a voided roof warranty.

The roof system warranty is especially important when adhering PV panels to BUR, MB, and single-ply weatherproof coverings. White and light-colored roof membranes are used because they reflect heat energy. As a result, their surface temperatures are typically 10°F to 15°F above ambient, which is lower than the surface temperature of dark roof coverings or PV modules. These cool roof membranes are not designed to withstand very high temperatures. A dark PV laminate, meanwhile, absorbs heat energy. The temperature of an adhered thin-film PV product may exceed the maximum temperature limit of a white or light-colored single-ply membrane. The Midwest Roofing Contractors Association (MRCA) is currently researching rooftop temperatures in conjunction with adhered PV laminates at a site in Manhattan, Kansas. Live data from the demonstration project, "Roof membrane temperature monitoring of thin-film PV arrays," is available on the MRCA website (see Resources).

Reroofing and maintenance. A lack of consideration for future roof maintenance and reroofing activities is one of the most common design mistakes specific to roof systems and their interfaces with other parts of the building. Where roofs are penetrated or ended, use of construction details that include counterflashing (see definitions, p. 34) allows for the removal and replacement of the roof membrane without much disturbance to adjacent materials and building components.

This should be true for PV installations as well. PV mounting systems should be installed with maintenance and future reroofing in mind. A building owner who is confronted with a reroofing project 10 years after a PV installation, for example, will not be very happy with the added expense of removing and reinstalling the PV array. Paying for design and installation details that allow reroofing without deconstruction of a PV array is likely a good use of a building owner's money, especially when looked at over the life of the system.

It will do neither the roofing nor the PV industry any good, however, if in 10 years we have a number of building owners faced with reroofing projects that have increased expense because of the presence of a rooftop PV system. PV system removal and reinstallation expense can make return on investment projections very inaccurate. The PV and roofing industries need to make sure we are not setting ourselves up for unhappy building owners in the future.

Courtesy Diamond Solar Solutions and the MRCA

BIPV testbed This PV demonstration project, which features seven different roof membranes, was installed at Diamond Roofing Company's facility in Manhattan, KS, with support from the Midwest Roofing Contractors Association. To monitor how the addition of BIPV laminates affects roof membrane temperature, 32 thermocouples installed around and under the subarrays are being monitored over a 3-year period.

NRCA Guidelines

How do you get a long-lasting roof system when installing a rooftop PV system? NRCA has developed best-practice guidelines for roof-mounted PV system installations. The information that follows highlights recommendations found in the NRCA's *Guidelines for Roof-Mounted Photovoltaic System Installations* (see Publications). These guidelines are focused on providing a weatherproof installation that meets the requirements of the *International Building Code,* including those for fire, wind and impact resistance, as well as the requirements found in the *NEC.*

GUIDELINES FOR ALL ROOFTOP PV SYSTEMS

NRCA's guidelines for rooftop PV systems are conservative. The relative newness of rooftop PV systems means that the durability and longevity of certain practices are simply not known. NRCA does not recommend the following practices: using ballast to provide uplift resistance, adhering PV laminates on the surface of mechanically attached membranes or installing a rooftop PV system over a ballasted roof membrane.

CONTINUED ON PAGE 40

Ballast used on roof systems, such as river rock or concrete pavers, sometimes moves during wind events. In fact, building codes limit the application of loose ballast in certain regions. Loose rock on rooftops may have the potential to damage glass-faced PV modules. Mechanically attached roof membranes billow in the wind. This billowing may damage adhered PV modules over the life of the roof system. This billowing can also lead to localized abrasion of a roof membrane as it rubs the edges and corners of a PV mounting system (at ballast trays, for example).

Positive attachment of rooftop devices is the most effective method to ensure long-term wind resistance. Therefore, the NRCA recommends that rooftop PV systems use structurally attached mounting systems with properly flashed penetrations or adhered PV laminates on approved membranes.

Design loads need to be considered for all roof-mounted PV systems. A structural evaluation of the deck and structure should be done, and upgrades implemented as necessary.

GUIDELINES FOR NEW CONSTRUCTION

For all low-slope roof systems acting as a platform for PV systems, NRCA recommends that designers specify the following:

- High-compressive–strength roof insulation boards
- Thermal-barrier board directly under the roof membrane
- Thicker membranes with increased puncture resistance (relative to what would otherwise be necessary)
- Reflective roof surfaces or coatings that provide enhanced protection from the effects of UV and high temperatures

These guidelines enhance the overall durability of a roof system being used as an equipment platform. It is always best to install PV on a new roof system—one that is durable, appropriate for a PV system and well insulated.

BEST PRACTICES FOR EXISTING CONSTRUCTION

If you do install a PV system on an existing roof system, acquire as much information as possible from the manufacturer and the contractor who installed the roof. First, check for both contractor and manufacturer roof system warranties. If warranties are in place, the roof system manufacturer needs to be notified and likely included in the process of designing the roofing components. Second, it is prudent to work with the contractor who installed the roof system because of his or her knowledge of the design and the materials. At a minimum, you should work with a contractor who is approved by the roof manufacturer or experienced with the roof system. Following these recommendations is key to a successful long-term project.

Roof substrate evaluation. Whenever a PV system is being considered for an existing roof, a roof substrate evaluation is necessary. The building owner needs to consider whether the remaining service life of the roof system is equivalent to the expected service life of the PV system. It should be noted that adding a rooftop PV system affects the service life of the existing roof system.

Additional rooftop penetrations, increased rooftop traffic and potentially elevated roof surface temperatures, particularly with adhered PV panels, are important factors to consider when determining equivalent service life. Adequate membrane thickness is also an important factor. Few existing roof systems have single-ply membranes that are thick enough to meet the NRCA recommendation.

It is important to inform a building owner of all costs associated with the 20- to 30-year service life of a rooftop PV system. If the expected service lives of the roof system and the PV system differ greatly, either a new roof system should be installed or reroofing and maintenance should be accounted for when designing the PV mounting and attachment system.

PV MOUNTING OPTIONS

Rooftop PV systems fall into three general categories: adhered to the roof surface, rack-mounted with low clearance, and rack-mounted with ample clearance. As CONTINUED ON PAGE 42

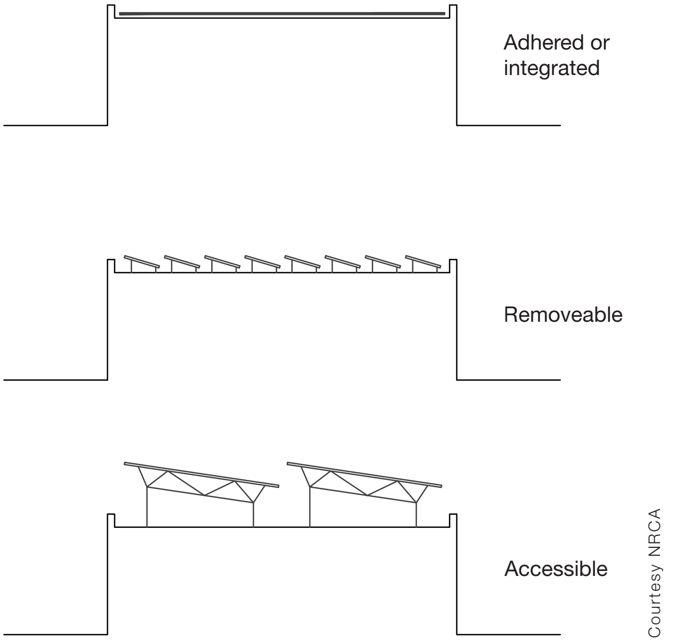


Diagram 2 Adhered and low-profile rack-mounted PV systems need to be removed to accommodate reroofing activities. However, if the roof remains accessible to roofing professionals, roof maintenance, repair and replacement will not result in PV system downtime.

illustrated in Diagram 2 (p. 40), when roofing replacement is necessary, adhered PV laminates and rack-mounted PV systems with low clearance likely will require disassembly and reassembly of the PV arrays and rooftop wiring. To avoid this extra work during reroofing, it is best to either reroof at the time the PV system is installed or to install a rooftop PV system that has adequate clearance for reroofing.

Adhered PV. Some in the building and roofing industries consider a PV laminate adhered to a roof membrane to be a building-integrated photovoltaic (BIPV) product. Whether adhered in the field or in a factory, however, the roof membrane manufacturer should always approve the installation of adhered PV products. One of the roofing industry's biggest concerns arises when PV panels are adhered to an existing roof system without notifying the roof membrane manufacturer. This is a quick and easy way to void a manufacturer's warranty and perhaps take on the liability for that warranty.

Adhered PV products are often specified for their low profile, which may provide aesthetic and wind loading benefits, as well as their low weight relative to rack-mounted PV systems. Given the relatively short service history of adhered panels on low-slope, single-ply roof systems, NRCA recommends the following guidelines:

- Use with adhered membranes only
- Specify a minimum membrane thickness of 72 mils for single-ply membranes
- Specify single-ply membranes with higher-than-commodity-grade levels of stabilizers, including UV stabilizers, that are recommended by the roof membrane manufacturer for photovoltaic applications
- Specify thermally resistant insulation cover board directly under the membrane
- Use high-temperature–resistant insulation (expanded and extruded polystyrene boards are not appropriate for adhered PV applications)

Mechanically attached single-ply roof membranes are attached at their seams, with sheets in the range of 5 to 9 feet. During high winds, single-ply membranes flutter because of negative air pressure. In many cases, high internal building pressures exacerbate this fluttering. Will fluttering of a single-ply membrane transfer stresses to the adhered PV panel? Perhaps. Therefore, it is best to be conservative and to use adhered membranes that cannot flutter.

Rack-mounted PV. For rack-mounted rooftop PV systems, NRCA recommends penetrating or curb-fastened supports attached to the structural deck or beams and flashed into the roof system. Sufficient vertical and horizontal clearance is needed to appropriately install low-slope membrane flashings, which are recommended to be at least 8 inches high and often extend 6 to 8 inches horizontally onto the roof surface.

Adequate clearance for roofing workers is also needed. NRCA recommends 12 to 24 inches CONTINUED ON PAGE 44

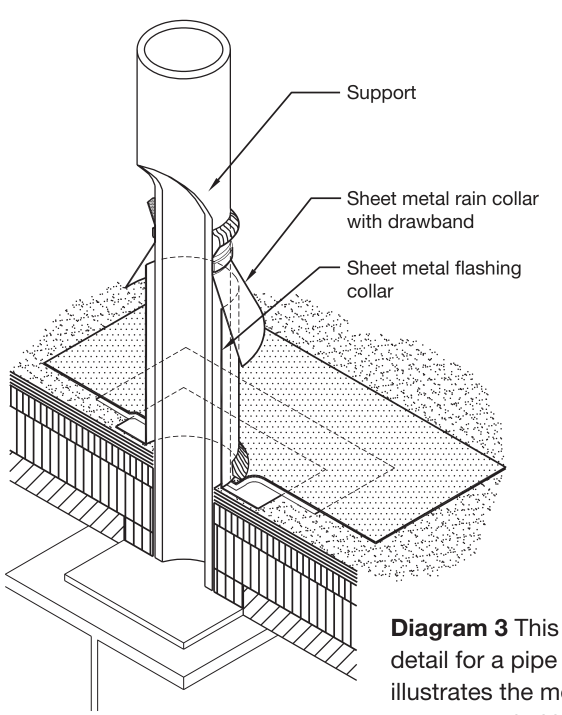


Diagram 3 This construction detail for a pipe support flashing illustrates the method recommended by the NRCA.

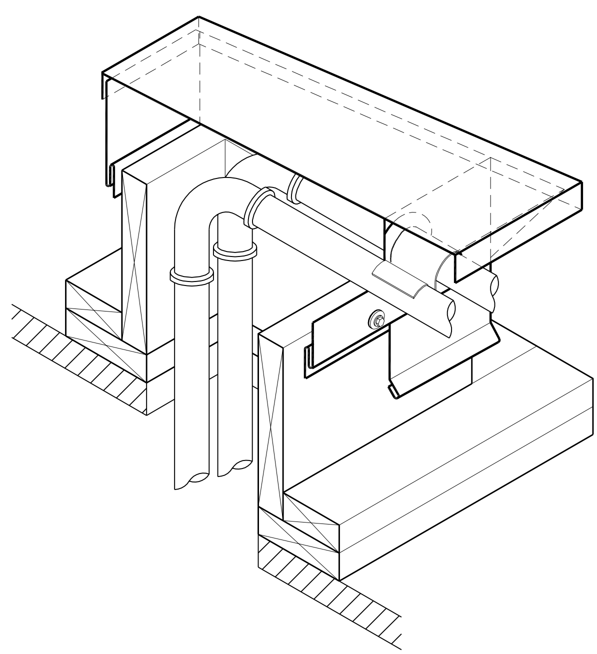


Diagram 4 Electrical conduit is shown passing through a roof assembly inside roof curbs capped with a sheet metal assembly.

Courtesy NRCA (2)

RISE Certification

The roofing industry recognizes the need for education and credentialing of those who install roof-mounted PV systems. In 2010, the Center for Environmental Innovation in Roofing and the National Roofing Contractors Association founded Roof Integrated Solar Energy (RISE) "to provide a means of evaluating and certifying solar roofing professionals to support the widespread use of rooftop solar energy." As explained on its website: "RISE evaluates and certifies solar energy installers for knowledge about critical roof system construction and maintenance practices necessary to support successful rooftop solar energy installations based on principles regarding the installation and maintenance of rooftop solar energy systems without adversely affecting roof system performance and service life. RISE also provides the public with tools to identify skilled rooftop solar energy professionals."

The certification created by RISE is the Certified Solar Roofing Professional (CSRP), which is "awarded by RISE to individuals who meet all the requirements for certification established by the RISE board of directors." In addition to PV-specific roofing issues, someone with CSRP certification will have a basic understanding of how PV systems function. Understanding the entire system helps coordination and cooperation on a jobsite. The use of CSRP and NABCEP-certified professionals on a project is beneficial for the building owner and the long-term success of rooftop PV system installations. ●

between penetrations. Twelve inches is adequate between pipe penetrations; 24 inches is appropriate between support curbs and walls. In addition, vertical clearance is necessary. Small curbs should be at least 8 to 12 inches high, and large support curbs should be as much as 3 to 4 feet high. Maintenance and reroofing under rooftop devices is very difficult if vertical access is not provided.

The construction details used for PV system penetrations—at standoffs and conduit entry points, for example—are the same basic details used for all types of common rooftop penetrations. In the roofing and weatherproofing sense, flashing a penetration for a PV system is similar to flashing a conduit for an HVAC unit or flashing a skylight or a roof vent. Diagrams 3 and 4 (p. 42) feature two typical flashing details.

For metal-panel roof systems, support stands and curb flashing should be shop-fabricated by roofing professionals or premanufactured to ensure appropriate flashing materials and methods are used.

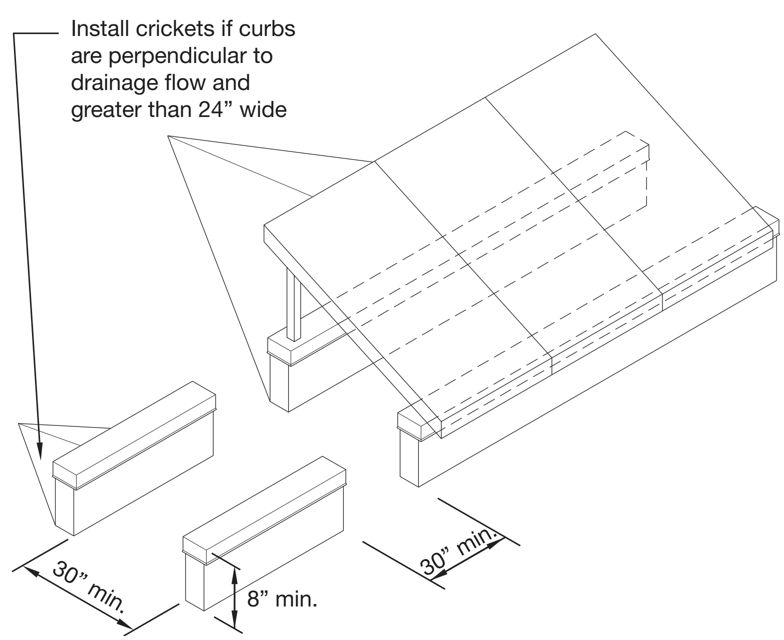
Roof drainage. A PV system should not interfere with or block the roof drainage pattern. Where a mounting system may block drainage, a membrane-compatible drainage mat should be installed between the rack and the roof membrane. If a curb system is used to support racks for PV modules, the curbs should not block drainage, as shown in Diagram 5.

Dirt buildup. A related concern is the dirt buildup that results from small amounts of undrained water atop low-slope roof coverings. Construction tolerances and roof slopes are often so low that the mere presence of a roof seam may limit drainage. This is especially true when seams cross the drainage flow.

This has implications for how best to lay out and install PV laminates. Ideally, adhered PV products are installed running parallel to the slope of the roof. This helps reduce dirt accumulation and standing water, which over time can cause problems with PV laminate-to-roof membrane adhesion. This also minimizes the cell shading that compromises PV performance.

Roof traffic. Believe it or not, roof membranes are not intended to be walked on frequently or CONTINUED ON PAGE 46

Diagram 5 The crickets called out in this diagram are intended to ensure proper roof drainage. This and other curb criteria are published in the NRCA *Guidelines for Roof-Mounted Photovoltaic System Installations.*



Courtesy NRCA

Shawn Shreiner

Access This rooftop PV system in Berkeley, CA—designed and installed by Sun Light & Power for Clif Bar & Company—provides walkways for roof traffic, working clearance at roof-mounted equipment, and roof access for roofing professionals and firefighters.

used as a work surface. Installing and maintaining a rooftop PV system invariably results in increased rooftop traffic. Rooftops used as equipment platforms will have more traffic—electricians, roofing workers and HVAC mechanics, for instance. These people need to be able to move around safely and have access for maintenance and repair.

In addition to roof system enhancements that improve durability, a roof membrane should be protected in highly trafficked areas, such as a loading or staging location where a lift is being used. Walkways or permanent walk pads may also need to be included in a rooftop PV system installation.

ACCESS AND SAFETY

The NRCA provides guidelines concerning roofing worker safety in the *NRCA Safety Manual, Second Edition.* However, the "Solar Photovoltaic Installation Guideline" published by the California Department of Forestry and Fire Protection—Office of the State Fire Marshall (CAL FIRE-OSFM) is becoming the definitive resource concerning overall rooftop worker safety and access recommendations when rooftop PV systems are installed. It includes guidelines for ladder placement on the ground or roof edge, conduit run locations (below structural beams when possible), trip hazard mitigation and roof coverage limitations. This type of information assists a designer when laying out a PV system and helps ensure the safety of those on the rooftop.

There will be new language in the 2012 edition of the *International Fire Code* (IFC) that specifically applies to rooftop PV systems. Much of the information follows the guidelines in the CAL FIRE-OSFM document. This addition to the *IFC* will give the *IFC* (and fire marshals) code-mandated authority over the installation of rooftop PV systems.

Conclusion

When your work truck or family car is in need of repairs, do you take it to a plumber, an electrician or a roofer? Of course not. You take it to an automotive service technician, a professional with specialized training and expertise. This is analogous to why it is important to work with roofing professionals when installing rooftop PV systems.

The roofing industry has a tremendous amount of experience flashing penetrations and keeping buildings weatherproof. Roofers have specialized knowledge about roofing systems and materials. Roofers are specifically trained to properly design and install flashing, using appropriate and high-quality materials. While many trades share the roof platform, ultimately roofers are responsible for providing and maintaining a long-term roof system. ⏚

CONTACT

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RESOURCES

Center for Environmental Innovation in Roofing / 866.928.2347 / roofingcenter.org

Midwest Roofing Contractors Association / 800.497.6722 / mrca.org

National Roofing Contractors Association / 847.299.9070 / nrca.net

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