PV Racking Criteria for Low-Slope Metal Roof Systems

By: Center For Environmental Innovation In Roofing

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CENTER FOR ENVIRONMENTAL INNOVATION IN ROOFING

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FOR IMMEDIATE RELEASE:

Center PV Taskforce Releases Public Version of PV Racking Criteria for Low-Slope Metal Roof Systems

Washington, D.C. – July 8, 2013 – The Center PV Taskforce today is releasing the public version of ***PV Racking and Attachment Criteria for Effective Low-Slope Metal Panel Roof System Integration*** during the first day of the Intersolar NA conference in San Francisco, California.

The public version of the document contains five fundamental principles for the effective deployment of rooftop PV on metal panel roof systems. Each principle includes examples and recommended action items for the design, installation and long-term maintenance of rooftop racking and attachment systems.

"For the past two years, the Center PV Taskforce has filled a critical gap in communication between the solar and roofing industries," said Center VP of Sustainability James Kirby, AIA. "The dialogue within the Taskforce focuses on the long-term performance and reliability of both the solar energy system and roof system, which are critical elements to the long-term success of the rooftop solar industry as a whole."

PV Racking and Attachment Criteria for Effective Low-Slope Metal Panel Roof System Integration was developed with input from a broad coalition of roofing and solar professionals, and reflects careful consideration of comments submitted during two rounds of public comment.

The document is the second in a series of guidelines published by the Center PV Taskforce. Additional information on the Taskforce and links to download the guidelines are available at www.RoofingCenter.org/special/pv.

The Center for Environmental Innovation in Roofing (Center) is a non-profit organization headquartered in Washington, D.C., whose mission is to promote the development and use of the environmentally responsible, high performance roof systems and technologies. For more information on the Center, visit www.RoofingCenter.org.

The Center PV Taskforce was formed by the Center to accelerate the deployment of properly installed, well-maintained solar energy roofing systems. For more information on the Center PV Taskforce, visit www.RoofingCenter.org/special/pv.

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PV RACKING AND ATTACHMENT CRITERIA FOR EFFECTIVE LOW-SLOPE METAL PANEL ROOF SYSTEM INTEGRATION

Public Version 1: July 8, 2013

The Center PV Taskforce is publishing the first public version of *PV Racking and Attachment Criteria for Effective Low-Slope Metal Panel Roof System Integration* to address the critical interaction between the solar racking system and roof system.

The PV Taskforce was formed by the Center for Environmental Innovation in Roofing to accelerate the deployment of properly installed, well-maintained solar energy roofing systems, and continues to work to bridge the gap and increase communication between the roofing and solar industries.

PV Racking and Attachment Criteria for Effective Low-Slope Metal Panel Roof System Integration is the second in a series of guidelines published by the PV Taskforce. More information is available at www.RoofingCenter.org/special/pv.

This criteria document identifies five fundamental principles of effect PV system integration for low-slope metal panel roofs:

A. External Forces
B. System Integration
C. Roof Drainage
D. Roof and PV System Maintenance and Access
E. Roof Safety

Each fundamental principle is parceled into specific examples and recommended action items.

The Center PV Taskforce intends *PV Racking and Attachment Criteria for Effective Low-Slope Metal Panel Roof System Integration* to provide a guide to the practitioner for the design, installation and long-term maintenance of rooftop solar racking systems.

Questions/Comments

Please send questions or comments regarding the document to the Center PV Taskforce by email at PVTaskforce@RoofingCenter.org, or by telephone at 202.380.3371.

The Center is a non-profit organization headquartered in Washington, D.C., whose mission is to promote the development and use of environmentally responsible, high performance roof systems and technologies. For more information on the Center, visit www.RoofingCenter.org.

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The Center PV TaskForce™ is a taskforce of the Center for Environmental Innovation in Roofing

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Fundamental Principle A: External Forces

FUNDAMENTAL PRINCIPLE	EXAMPLE	RECOMMENDED CRITERION	APPLIES TO
A. EXTERNAL FORCES. The racking and attachment system shall be designed so that external forces acting on the rack or attachment system do not compromise the roof's waterproofing integrity. All vertical and horizontal loads should be transferred to the building structure without overloading or damaging the roof system. Loads to be considered include horizontal wind loads, wind uplift loads, dead loads, snow loads, seismic loads as well as thermal expansion / contraction and non-specific vibratory loads from external forces or building equipment.	A.1. Mounting points of PV systems may overload (in a positive or negative direction [e.g., snow or wind uplift]) the underlying clip / fastener attachment method for the roof or structure, possibly causing failure of the roof or structure.	A.1.a. Use appropriately engineered, non-ballasted modular tilt system or flush mounted system taking into account wind loads and additional roof loading. Attach with appropriate fastener type and frequency that spreads loads in a uniform manner. Verify adequacy of building structure and roof. A structural analysis shall be performed by a licensed Professional Engineer to account for positive and negative loads in accordance with the most recent edition of ASCE-7.	Standing seam roof panels with rigid, framed PV panels and exposed fastener metal roof systems.
		A.1.b. Use PV modules directly adhered to the metal panel surface or direct attach methods.	Flat-pan roof panels with PV modules directly adhered to the metal panel surface and direct attached PV systems.
	A.2. Mounting systems that penetrate the standing seam roof are potential source of water infiltration.	A.2.a. Use non-penetrating standing seam clamps with setscrews that establish a mechanical interlock with the standing seam (interlocking clamps).	Standing seam roof panels with rigid, framed PV panels.
		A.2.b. Use non-penetrating standing seam clamps that compress seam material to establish a friction connection to the standing seam (friction clamps).	Standing seam roof panels with rigid, framed PV panels.
		A.2.c. Use field or factory-applied fully adhered PV modules.	Flat-pan roof panels with PV modules directly adhered to the metal panel surface.

FUNDAMENTAL PRINCIPLE	EXAMPLE	RECOMMENDED CRITERION	APPLIES TO
A. EXTERNAL FORCES. (Continued)	A.3. Mounting systems that attach to standing seams with one-piece concealed clips may reduce or eliminate the thermal cycling capacity of the metal panels relative to the roof substrate.	A.3.a. Mounting clamps (interlocking and friction clamps) should be located on standing seams at locations that are far enough away from concealed clips to not prohibit thermal movement of the panels.	Standing seam roof panels with one-piece concealed clips with rigid, framed PV panels.
		A.3.b. Use field or factory-applied fully adhered PV modules.	Flat-pan roof panels with PV modules directly adhered to the metal panel surface.
	A.4. Mounting systems that penetrate a metal roof with exposed fasteners are potential sources of water infiltration.	A.4.a. Use a penetrating mounting device with a non-curing isobutylene polymer tape or compatible sealant between the mounting device and the metal panel for fasteners in or out of the drainage plane. Curing compounds like silicone or EPDM rubber gaskets can be used with fasteners that are not in the drainage plane. Sealant should be protected from over-compression, and exposure to sunlight should be minimized.	Exposed fastener metal roof systems.
		A.4.b. Whenever possible, avoid penetrations in the drainage plane.	Exposed fastener metal roof systems.
	A.5. Mounting points of racking systems may experience fatigue from movement induced by rack expansion and contraction, causing fatigue of the roof panel at the mounting locations.	A.5.a. Use racking systems and/or attachment devices that enable thermal movement of racking components without transferring loads and stresses to the roof system.	All racking systems on standing seam roof panels and exposed fastener metal roof systems.
		A.5.b. Use PV modules directly adhered to the metal panel surface or direct attach methods, eliminating continuous cross members of the racking system.	Flat-pan roof panels with PV modules directly adhered to the metal panel surface and direct attached PV systems.
		A.5.c. Use rack systems that include expansion joints.	All racking systems on standing seam roof panels.

FUNDAMENTAL PRINCPLE	EXAMPLE	RECOMMENDED CRITERION	APPLIES TO
A. EXTERNAL FORCES. (Continued)	A.6. In areas where snow occurs, racking systems with horizontal elements (structural elements, wireway, or wind deflectors) directly impinging on the roof plane may cause drifting snow build-up for which the roof and structure were not designed, potentially leading to collapse.	A.6.a. Use a structural analysis performed by a licensed Professional Engineer to account for possible snowdrift build-up in accordance with the most recent edition of ASCE-7. In addition, consideration shall be given to large horizontal racking components, such as covered wireways and wind deflectors.	All racking systems on standing seam roof panels and exposed fastener metal roof systems.
		A.6.b. Use PV panels installed parallel to the roof using appropriately designed mounting systems.	All racking systems on standing seam roof panels and exposed fastener metal roof systems.
		A.6.c. Verify adequacy of structural system taking into account design snow loads and any surplus drift loads.	All metal roof applications where design snow load is considered.
	A.7. PV systems that are fully adhered to the roof surface may exert upward lift forces or shear forces that could dis-bond or displace the laminate.	A.7.a. Use integrated PV and roofing systems documented for compatibility by the respective PV and roofing system manufacturers. Only adhere PV modules to flat-pan roof panels; intermediate ribs or striations reduce the adhesion capability of the PV module to metal panel.	Flat-pan roof panels with PV modules directly adhered to the metal panel surface.
	A.8. PV systems that are fully adhered to the roof surface may allow capillary entrapment of moisture at the edge of the assembly (leading to corrosion).	A.8.a. Only adhere PV modules to flat-pan roof panels; intermediate ribs or striations reduce the adhesion capability of the PV module to metal panel.	Flat-pan roof panels with PV modules directly adhered to the metal panel surface.

Fundamental Principle B: System Integration

FUNDAMENTAL PRINCIPLE	EXAMPLE	RECOMMENDED CRITERION	APPLIES TO
B. **SYSTEM INTEGRATION.** All components and materials of the racking and mounting systems, and all components of the roofing system shall be designed for performance, durability and service life that is equivalent to the expected PV module service life. (This includes construction details.)	B.1. Use of racking, combiner boxes, rooftop conduit, wire chases and cable tray supports that use wood blocking, rubber pads, polycarbonate or other materials can trap moisture (including capillary entrapment) on the roof surface. This can damage the metallic coating and lead to premature deterioration of the roof.	B.1.a. Use seam clamps that are made from a material that is metallurgically compatible with metallic and organic coatings so clamps do not damage the metallic coating.	Standing seam roof panels with all types of PV panels.
		B.1.b. Any component in contact with roof panels should be completely sealed to prevent moisture intrusion, or provide capillary breaks to prevent moisture entrapment.	Standing seam roof panels with all types of PV panels.
	B.2. Dissimilar metals in electrolytic contact may induce galvanic corrosion of the less noble metal and cause premature deterioration of the roof. Run-off from copper elements can be damaging to certain roofing materials, such as aluminum or aluminum-zinc alloy-coated steel.	B.2.a. Verify metallurgical compatibility according to Metal Construction Association's *Compatibility of Fasteners with Metal Roof and Wall Panels*.	Standing seam roof panels with rigid, framed PV panels and exposed fastener metal roof systems.
		B.2.b. Exposed copper wire shall be insulated to prevent copper leaching and/or dissimilar metal corrosion.	Standing seam roof panels with rigid, framed PV panels and exposed fastener metal roof systems.
	B.3. Different attachment methods between the PV mounting system and the roof system can lead to unwanted penetrations that may cause leaks or reduce thermal movement of the roof panels which may jeopardize roof integrity.	B.3.a. If the design of the roof system is one that generally avoids penetrations of the exposed surface, then the PV mounting system should also avoid penetration of the exposed roof surface.	Standing seam roof panels with concealed clips.

FUNDAMENTAL PRINCIPLE	EXAMPLE	RECOMMENDED CRITERION	APPLIES TO
B. SYSTEM INTEGRATION. (Continued)	B.3. (Continued)	B.3.b. If the design of the roof system is one that uses fasteners that penetrate the roof surface for attachment, then the PV mounting system may also use fasteners that penetrate the roof surface. The method of waterproofing shall be with a non-curing isobutylene polymer tape or compatible sealant (if fasteners are in or out of the drainage plane), or EPDM rubber gaskets (if fasteners are not in the drainage plane). Sealant should be protected from over-compression, and exposure to sunlight should be minimized. (*See* A.4. for more information.)	Exposed fastener metal roof systems.
	B.4. Flashing details not reviewed and approved by the roof system manufacturer / roof warranty issuer or not in conformance with industry guidelines may compromise roof system performance and service life.	B.4.a. Consult with the manufacturer of the metal roof panels or roofing industry trade associations regarding the proper method to seal penetrations.	All metal panel roof systems.
	B.5. Use of a laminated PV system will likely reduce roof surface reflectivity that may lead to a loss of building energy efficiencies.	B.5.a. The party responsible for the design of the PV system should disclose to the owner of the rooftop PV system that the use of a laminate will alter cool roof attributes in areas where laminates are located.	Flat-pan roof panels with PV modules directly adhered to the metal panel surface.
	B.6. Use of a dark-surfaced laminated PV system may reduce the service life of metal roof panel coatings if surface temperatures increase significantly.	B.6.a. Consult with the manufacturer of the metal roof panels regarding the installation of adhered PV modules onto the metal panels. The metal panel coating and adhered PV module should be compatible and have equivalent service life.	Flat-pan roof panels with PV modules directly adhered to the metal panel surface.

FUNDAMENTAL PRINCIPLE	EXAMPLE	RECOMMENDED CRITERION	APPLIES TO
B. SYSTEM INTEGRATION. (Continued)	B.7. During installation of a PV system, excessive foot traffic, roof panel abuse (dropping tools with sharp edges or abrasive materials stuck in soles of shoes) and careless placement of construction materials on the roofing system can cause scratching and damage to the roofing system.	B.7.a. Metal roofing systems are sufficiently durable for moderate foot traffic provided soft sole shoes are worn. When roof traffic is heavy and/or uncontrolled, temporary walkways should be used to prevent scratching of the roof coating.	All metal panel roof systems.
		B.7.b. Installer should use care when placing materials and tools on the roof in order to avoid scratching of the roof coating. Temporary roof protection should be used to prevent damage to the roof coating.	All metal panel roof systems.
		B.7.c. Installer and other trades and professions should walk in the pan portion of structural metal panels and only on standing seams that have structural capacity, such as the seams of a trapezoidal panel. Seams of exposed fastener systems should not be walked on.	All metal panel roof systems.
	B.8. Service life of adhesives, sealants and flashing materials or construction details may not be consistent with the durability and service life of the roof and/or PV system.	B.8.a. The durability, ability to maintain and service life of all adhesives, sealants, and flashing materials must be consistent with that of the roof system. Construction details should be designed for long service life as many metal roofing systems are relatively maintenance-free.	All metal panel roof systems.

FUNDAMENTAL PRINCIPLE	EXAMPLE	RECOMMENDED CRITERION	APPLIES TO
B. SYSTEM INTEGRATION. (Continued)	B.9. Scratching or removing coatings because of abrasive seam clamps, or grounding / bonding mechanisms can cause localized corrosion, which may lead to premature panel deterioration and leakage.	B.9.a. Avoid using attachment devices that have teeth or use screws with sharp points or edges. This includes cup-point setscrews that breach or abrade roof material or its coating.	All racking systems on standing seam roof panels and exposed fastener metal roof systems.
		B.9.b. If grounding / bonding of the roof system is required, it should be done in a manner that does not jeopardize roof warranties.	All racking systems on standing seam roof panels and exposed fastener metal roof systems.
	B.10. Construction loads may exceed allowable design point loads, leading to unwanted permanent deflection.	B.10.a. Construction materials should be staged on the roof in a manner and quantity that minimizes point loads. Point loads should be located over primary structural framing.	All metal panel roof systems.
	B.11. Differences between the remaining service life of the metal panel roof, racking and mounting equipment, and the PV system could mean a roof replacement is necessary before the end of the PV system's service life. This may have significant economic impacts on the PV user and roof owner.	B.11.a. Remaining roof service life should be assessed by a roofing professional. If roof service life is determined to be less than the PV system service life (e.g., 25 - 30 years), the owner of the roof and PV system should be informed about the likelihood of roof replacement prior to the end of the PV system's service life.	All metal panel roof systems.

Fundamental Principle C: Roof Drainage

FUNDAMENTAL PRINCPLE	EXAMPLED	RECOMMENDED CRITERION	APPLIES TO
C. ROOF DRAINAGE. The racking and attachment system shall be designed so that water drainage on the roof is not compromised.	C.1. Racking systems with horizontal elements (either structural elements or wireways) that block the roof drainage plane may cause water to pond on the roof and allow for debris accumulation.	C.1.a. Maintain clearance between the roof surface and horizontal elements of the racking system sufficient to allow effective roof drainage. The drainage design of the roof and PV system shall be calculated based on the most recent edition of the International Plumbing Code. Assure that all areas where debris may accumulate are accessible for cleaning.	All metal panel roof systems.
		C.1.b. Do not use ballasted PV racking systems in conjunction with metal panel roof systems. (*See* Notes)	All metal panel roof systems.
	C.2. Placement of racking systems may impede access to roof drains for periodic maintenance.	C.2.a. Provide access to roof drains for periodic maintenance. Array-perimeter screens used to prevent debris and animal entry should be accessible for periodic maintenance.	All metal panel roof systems.
	C.3. Roof curbs greater than 30 inches wide* used to support PV equipment such as inverters and combiner hardware may block drainage and cause water to pond on the roof. (*As measured perpendicular to the slope per most recent edition of the International Building Code.)	C.3.a. Whenever possible, orient roof-integrated and flashed equipment supports (i.e., roof curbs) greater than 30 inches wide* supporting PV equipment so that they provide drainage in both directions or include crickets / saddles to redirect water around the curb. (*As measured perpendicular to the slope per most recent edition of the International Building Code.)	All metal panel roof systems.

Fundamental Principle D: Roof and PV System Maintenance and Access

FUNDAMENTAL PRINCIPLE	EXAMPLE	RECOMMENDED CRITERION	APPLIES TO
D. ROOF AND PV SYSTEM MAINTENANCE AND ACCESS. The racking and attachment system shall be designed to allow effective roof and PV system inspection, maintenance, repair, and access for emergency personnel.	D.1. The PV system may obstruct safe and effective access to rooftop equipment, ancillaries, and PV modules that may require periodic inspection, maintenance, repair, or replacement.	D.1.a. Provisions in PV layout, design and construction details shall take into account walking paths to accommodate inspection, cleaning and repair of rooftop mechanicals and PV system components.	All metal panel roof systems.
	D.2. PV cleaning materials may cause premature deterioration of roof's protective coatings.	D.2.a. Use relatively pH neutral cleaning agents (e.g., mild soap and water) to be safe for all PV panels and metal roof panels. Avoid cleaning agents that may deteriorate or stain metal roof panels. Strong alkali content is harmful to aluminum. Strong acids are harmful to most metals.	All metal panel roof systems.
	D.3. Fire-fighting personnel may require access to rooftops in emergencies. Utility personnel, as well as other rooftop equipment maintenance personnel will require access periodically.	D.3.a. PV system design and layout should follow requirements in the most recent International Fire Code and allow for safe access and mobility of emergency and non-emergency personnel.	All metal panel roof systems.

Fundamental Principle E: Roof Safety

FUNDAMENTAL PRINCIPLE	EXAMPLE	RECOMMENDED CRITERION	APPLIES TO
E. ROOF SAFTEY. The racking and attachment system shall be designed to assure worker safety during roof inspection, maintenance and repair, as well as during PV installation, inspection, maintenance and repair.	E.1. Racking system components may impinge on designated maintenance and service walkways.	E.1.a. Whenever possible, design racking systems to allow unimpeded access along all designated walkways. In all cases, design and layout of walkways shall conform to the requirements of the most recent edition of the International Fire Code.	All metal panel roof systems.
	E.2. Racking system layout may create an unnecessary fall exposure.	E.2.a. Develop and implement a long-term fall protection plan to allow safe access to the PV system both during system installation and ongoing system maintenance.	All metal panel roof systems.
	E.3. Construction loads may exceed allowable design point loads. Staging PV materials on the roof could overload roof panels or structure.	E.3.a. Construction materials should be staged on the roof in a manner and quantity that minimizes point loads. Point loads should be located over primary structural framing.	All metal panel roof systems.
	E.4. PV system installation could jeopardize worker safety during PV system integration.	E.4.a. Potential fall hazards within the roof system should be identified and adequately protected to prevent accidents. For example, metal roofs often use skylight materials integrated within the metal roof panels. Such skylights may not be obvious to the casual observer, and can be a fall hazard.	All metal panel roof systems.
		E.4.b. Use of fall protection, temporary railings, ladders and scaffolds shall be OSHA compliant.	All metal panel roof systems.
	E.5. Roof and PV maintenance that requires disassembly of working PV modules can be a safety concern to maintenance personnel. Walking on modules can be a slipping hazard and can damage the PV performance.	E.5.a. Removal / decommissioning of working PV modules should be minimized. Inter-row spacing should be provided to allow for maintenance and to prevent maintenance personnel from walking on PV modules.	All metal panel roof systems.

Glossary:

- **Adhered PV Modules:** Adhesively backed flexible PV modules installed directly to the surface of flat-pan metal panels.
- **Directly Attached PV Panels:** Framed, rigid PV panels attached directly to mounting devices that are attached directly to standing seams. Rails are not used between PV panels and the metal roof system
- **Exposed Fastener Metal Roof Systems:** A metal panel roof system whose primary attachment method is exposed, penetrating fasteners. This system typically has little expansion and contraction capability. Exposed fastener metal roof systems do not have standing seams; typically they have overlapped and fastened panels.
- **Flat-pan:** A metal roof panel that has a smooth, planer surface between the seams. A flat pan metal roof panel does not have striations, intermediate ribs, etc.
- **Friction Clamp:** A clamping device that relies on compression and friction for securement to a standing seam and does not include mechanical interlock.
- **Interlocking Clamp:** A clamping device that relies on compression and deformation for securement to a standing seam. A portion of seam material is deformed by compression between male and female elements of the clamp, such as a setscrew or node (male) and a recess, divot or receiving portion (female).
- **Mounting Device:** a clamp or penetration used on a metal panel roof system used to attach PV rails or PV panels. Mounting devices include friction clamps and interlocking clamps.
- **PV Panels with Rails/Racks:** Framed, rigid PV panels attached to rails or racking systems that are attached to the standing seams.
- **Standing Seam Roof Panel:** Standing seam roof panel: a metal panel with vertical seams and concealed clips that allow expansion and contraction capability.
- **Structural Metal Panel:** A metal panel that has the structural capacity to span from support to support without requiring a roof deck beneath it. Examples include metal panels with trapezoidal ribs (and intermediate ribs) and flat-pan metal panels with vertical (standing) seams.

Notes:

1. This document is written with the assumption that the most recent building code requirements, electrical code requirements, fire code requirements, plumbing code requirements, and manufacturer's instructions will be followed.

2. Do not use ballasted PV racking systems in conjunction with low-slope metal panel roof systems. Ballasted PV racking systems on low-slope metal roof systems create point loads and long-term permanent deflection, which allow ponding and the possibility of leakage and roof system failure.

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