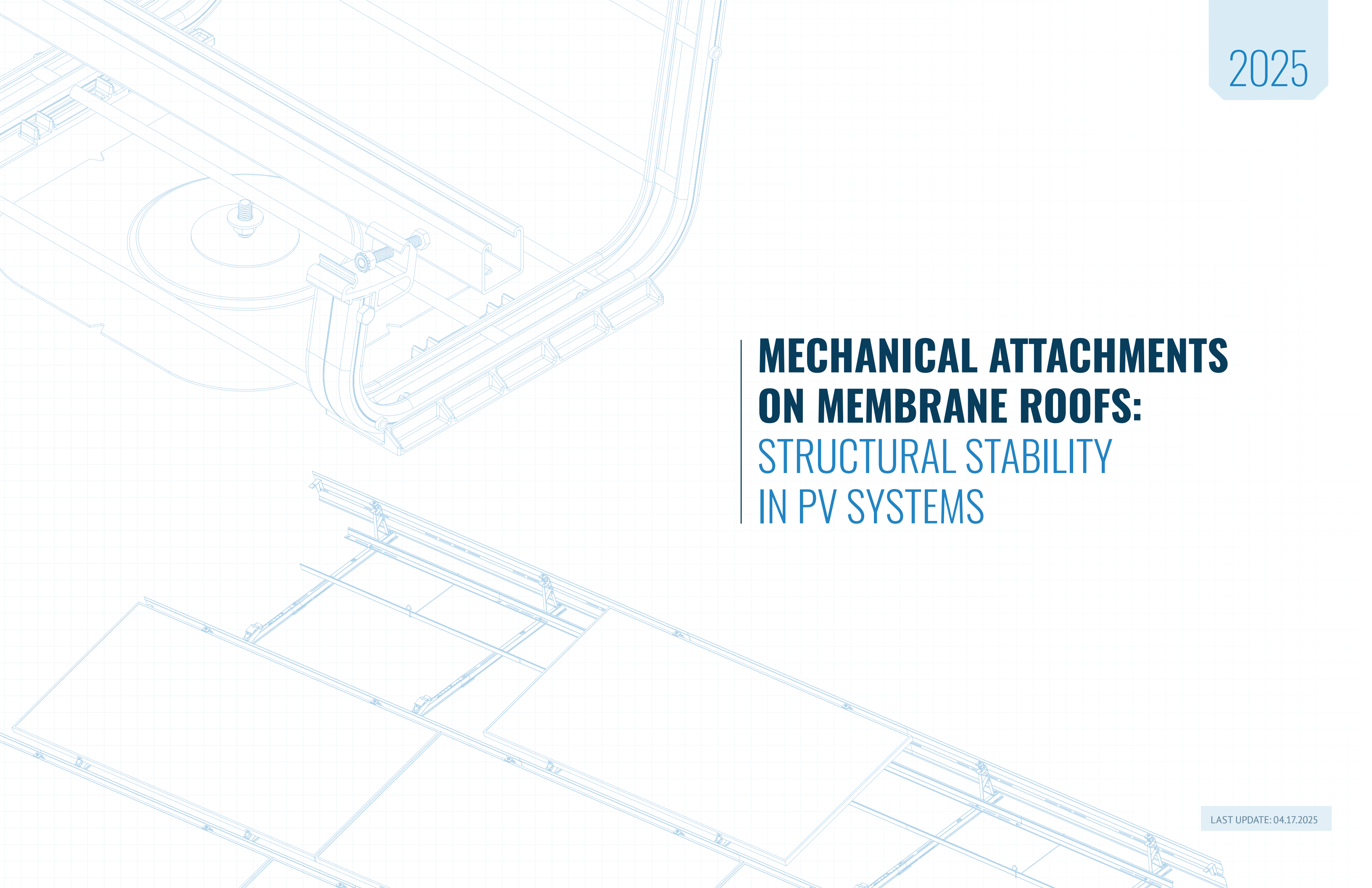


MECHANICAL ATTACHMENTS ON MEMBRANE ROOFS: STRUCTURAL STABILITY IN PV SYSTEMS



2025



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STRUCTURAL STABILITY IN PV SYSTEMS: MECHANICAL ATTACHMENTS ON LOW SLOPE ROOFS

CRITICAL OVERVIEW

Roof attachments are often utilized to optimize the design of photovoltaic (PV) systems on low-slope roofs by providing structural stability and reducing system weight on the roof. These mechanical PV attachments, when manufactured with the same waterproofing roof cover, create a watertight seal compatible with the roof. This waterproof seal ensures long-term performance and allows the attachment seal to be included in the roof manufacturer's system warranty. The efficacy of the PV system is achieved by reducing installation duration and complexity, minimizing labor costs and installation traffic, and maintaining the structural integrity of the roof. This whitepaper examines the role of photovoltaic mechanical attachments in enhancing the stability and longevity of PV systems on flat roofs, thereby providing an objective overview for developers, EPCs, and roof owners.

TRENDS AND EVOLVING PRACTICES FOR PV SYSTEMS ON LOW SLOPE ROOFS

As photovoltaic (PV) systems have become a prevalent form of renewable-energy generation, low slope roofs are often the most practical location to install a solar array. This placement is particularly relevant in constrained industrial or urban environments where rooftop space is the only real estate available for PV systems.¹

Building owners, facilities managers, and PV installation experts need to take into account that the roof will serve as the foundation for the array and need to ensure that PV installations do not compromise the roof's structural integrity or lifespan. Key considerations include interactions with various roof membrane types, the weight of the PV system, the system's stability during weather or seismic events, and the methods used to secure the PV system to a rooftop.

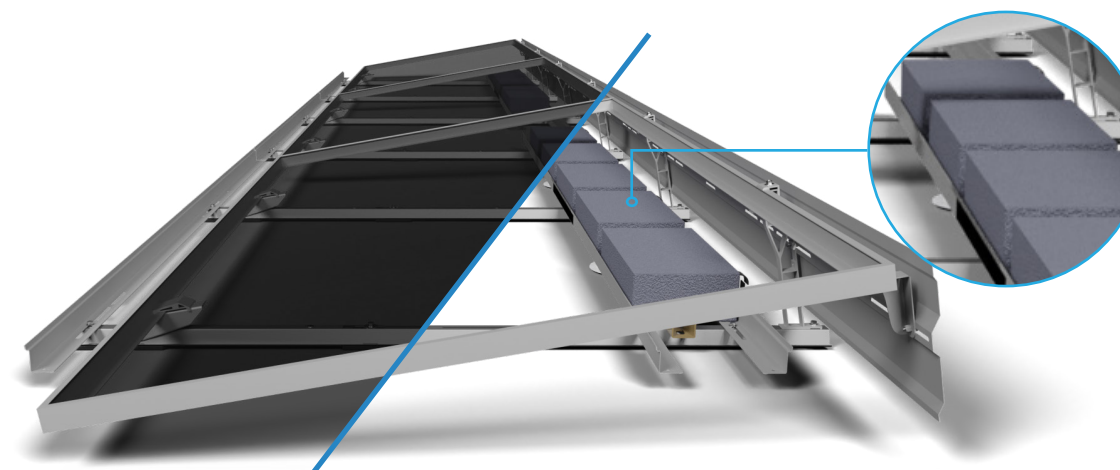
It is important to recognize that rooftop solar technology has undergone substantial advancements since its inception. These advancements have led to the development of building codes, safety standards, and certifications that regulate PV design and installation. As a result, more advanced installation methods, better system engineering, and various anchoring strategies—for both ballast and mechanical—are now acknowledged for their reliability and cost-effectiveness.

SECURING SOLAR PANELS: THE ROLE OF BALLAST

Ballast serves as a common method for resisting uplift and sliding solar panels on rooftops by utilizing weight and friction dynamics. Ballasting is typically accomplished through the placement of concrete blocks or other dense materials onto PV racking trays. Uplift and drag requirements are based on peer-reviewed boundary layer wind-tunnel testing and extensive system-level testing. The American Society of Civil Engineers (ASCE) code defines variables such as wind and seismic loads, risk categories, and even building geometry for use in the calculations to determine the amount of ballast required.²

When utilizing ballast to secure a solar array, it is crucial to consider the roof's load-bearing capacity. This capacity is typically evaluated by a structural engineer to determine total allowable dead load and allowable concentration of the weight in terms of Pounds per Square Foot (psf). If the roof can handle the required weight, then it is often preferable to have a fully ballasted system. If the roof is not able to support the combined weight of the ballast and PV system, two options are available:

- 1) Structural modification of the building can be made, often leading to significant additional costs, or
- 2) Mechanical attachments can be used to meet the calculated loads and offset ballast weight.

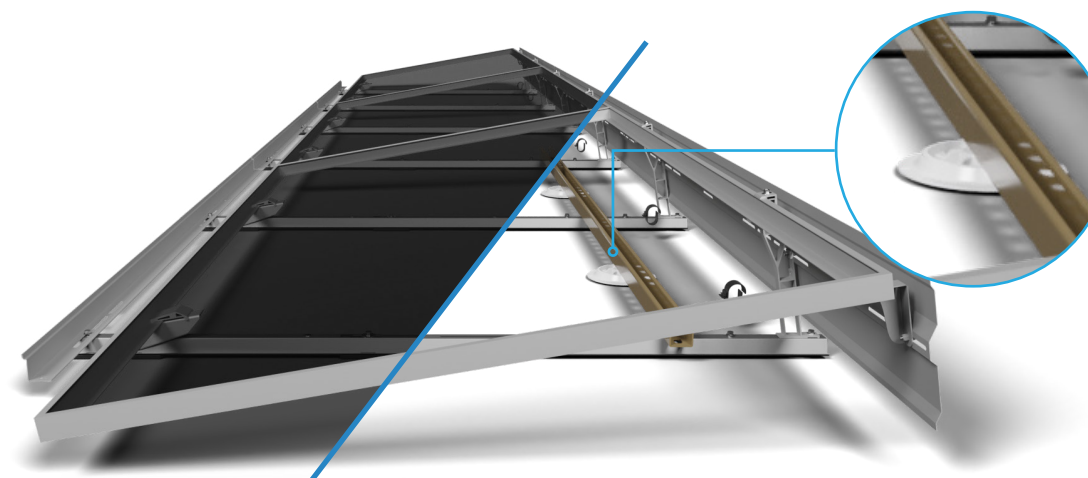


SECURING SOLAR PANELS: THE ROLE OF MECHANICAL ATTACHMENTS

A mechanical attachment connects the PV racking system to the roof structure for the purpose of resisting calculated loads per building codes. These devices rely on fasteners and/or heat-welding to provide structural capacity. While limiting the PV array's potential to shift over time, mechanical attachments mitigate risks arising from significant seismic and wind events, as well as thermal expansion and contraction.

Mechanical attachments are versatile and designed to accommodate diverse solar-mounting systems, roof

types, roofing assembly configurations, roof system performance, and local building codes. Engineered to be lightweight, watertight, and highly resistant to tension and shear forces, these attachments maintain a familiar installation experience for professional roofers. Available mechanical attachment options provide compatibility with common roofing materials such as TPO, PVC, EPDM, asphalt roofs, and liquid-applied coatings.





FUNDAMENTAL BENEFITS OF ROOF ATTACHMENTS

Mechanical attachments provide substantial system-level benefits that relate to system weight, roof capacity, array, roof stability, and roof system longevity.

Mechanical attachments within a PV system layout are specifically designed to take full advantage of the attachment's capacity and meet the needs of the roof structure. When attachments are properly installed, they provide the following primary benefits:

- Significantly reduces PV system dead load on the roof.
- Provides stability and integrity for seismic load requirements.
- Provides an alternative method to resist uplift forces from wind.
- Prevents lateral shifting due to roof vibration, wind events, or thermal expansion and contraction, which could result in premature failure of the roof system due to pavers, aggregates, and debris damaging the roof cover.
- Roof attachments are installed by professional roofers who hold a manufacturer's certification.
- Reduces wear on the roof due to decreased foot traffic when compared to installing and placing ballast blocks.

Additional benefits can be found at <https://www.spri.org/resources-education/>

COMMON FALLACIES REGARDING ROOF ATTACHMENTS

Despite the widespread use of photovoltaic (PV) mechanical attachments over the past decade, several misconceptions persist. These concerns often center on perceived higher costs, structural capacity, potential for leaks, roof construction, and the impact on roof manufacturers' warranties. However, roof-manufacturer approved designs, historical performance data, and extensive testing have validated the reliability and safety of these attachments. Modern advancements in PV mounting systems have further optimized their integration into rooftop designs.

PERCEIVED HIGHER COSTS

The cost of mechanical attachments is often viewed as a disadvantage. While it involves bringing a roofer into the installation process, the cost is generally justified. Small projects incur minimal site visit fees, and for larger projects, these fees are less impactful. The installation time for each attachment is typically between 5-15 minutes. When compared to the costs of ballasting—such as blocks, lifts, and associated labor—mechanical attachments can be more cost-effective. Additionally, vendors can connect you with roofing partners experienced with PV attachments, potentially reducing installation costs further. As mechanical attachments are sealed watertight, involve less installation time, and require fewer expensive on-roof hours, the additional cost of attachments is offset by installation, labor, and O&M expenditures.

STRUCTURAL CAPACITY

A critical consideration in the deployment of mechanical attachments for photovoltaic (PV) systems is their structural capacity. These attachments are meticulously engineered and rigorously tested to meet or exceed the strength requirements necessary for their secure installation.

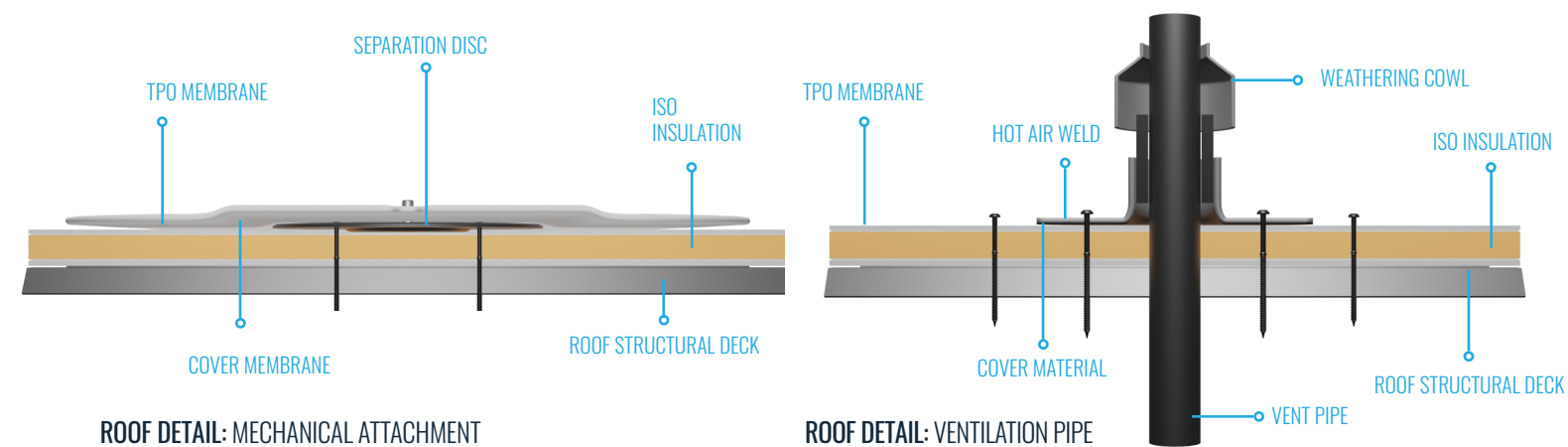
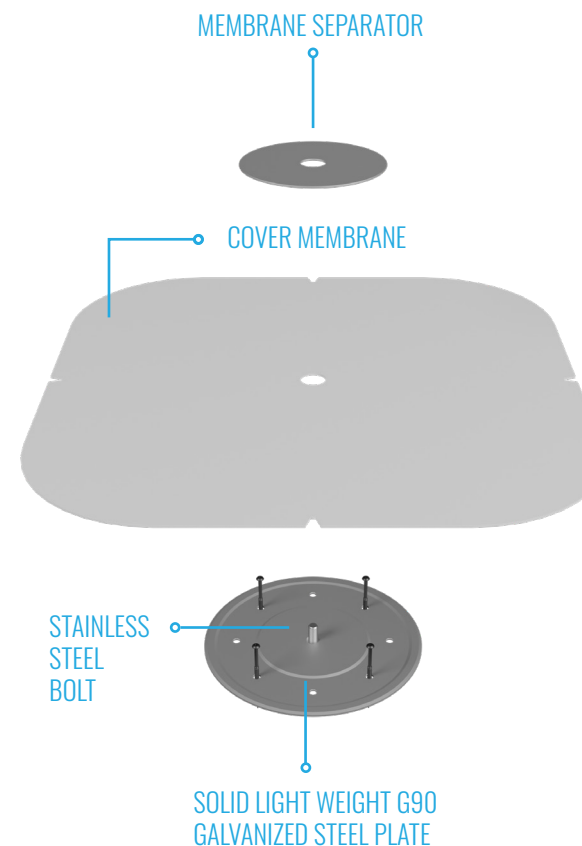
Design and Testing Standards: Mechanical attachments are designed to surpass the load-bearing capacities of the screws and connections that anchor them to the roof deck. The design process incorporates various factors including static and dynamic loads. Testing protocols, such as those outlined in the following standards—ICC AC467³, FM 4478⁴, FM 4481⁵ and UL 2703⁶—validate the attachment's performance under simulated wind and seismic conditions.

The Structural Engineer of Record (EOR) is responsible for calculating the appropriate dimensions and quantities of roofing fasteners per attachment, while the racking design specifies the total number of attachments needed. This calculation includes determining the length and quantity of the fasteners to ensure that the structural roof decking and attachment can withstand the maximum expected loads imposed by the PV system. The EOR's analysis ensures that the mechanical attachments are capable of maintaining system integrity under diverse environmental conditions⁷.

POTENTIAL FOR LEAKS

Another common worry is the potential for leaks around roof attachments. It's crucial to choose PV system mechanical attachments that adhere to roofing industry standards for securement and sealing. For example, the U-Anchor attachment is designed to integrate seamlessly with the existing roof membrane. By using the same membrane materials and techniques—such as induction and heat welding—the attachment creates a watertight seal that matches the roof's original waterproof barrier. Roofing manufacturers review these details for approval, and certified roofers install the attachments using established methods for flashings and membrane seams, including welding and corner overlap details. Long-term waterproofing performance and component(s) chemical compatibility are ensured by using the same roof cover materials as the underlying roof system. The in-kind roof attachments are also compatible with roof manufacturer maintenance and warranty requirements.

Categorization of PV Systems and Attachments: In terms of roofing warranties and construction practices, PV systems and their mechanical attachments are classified as both rooftop overburdens and standard roof details. This classification places them on par with other common rooftop elements such as HVAC systems and plumbing vents. For instance, U-Anchors or Compression Free™ Attachments are not considered overburden by most major roofing manufacturers and are considered warranted components.



ROOF CONSTRUCTION

Commonly, roofs include both construction details and overburden elements. Rooftops incorporate diverse roof details such as vents, pipes, skylights, and membrane seams. Roofing overburdens are defined as “any manner of material, equipment or installation that is situated on top of, and covering all or a portion of, a roof or waterproofing membrane assembly.”⁸ These overburdens include HVAC systems, plumbing systems, plaza decks, or PV arrays.

A mechanical attachment, such as those provided by Anchor Products, is categorized as a roof detail and the PV array is categorized as an overburden. U-Anchors that secure the PV system are sealed, inspected, and adhere to the same caliber of rigorous construction standards as other roofing details. Solar attachments should be installed by experienced and manufacturer-authorized roofers.

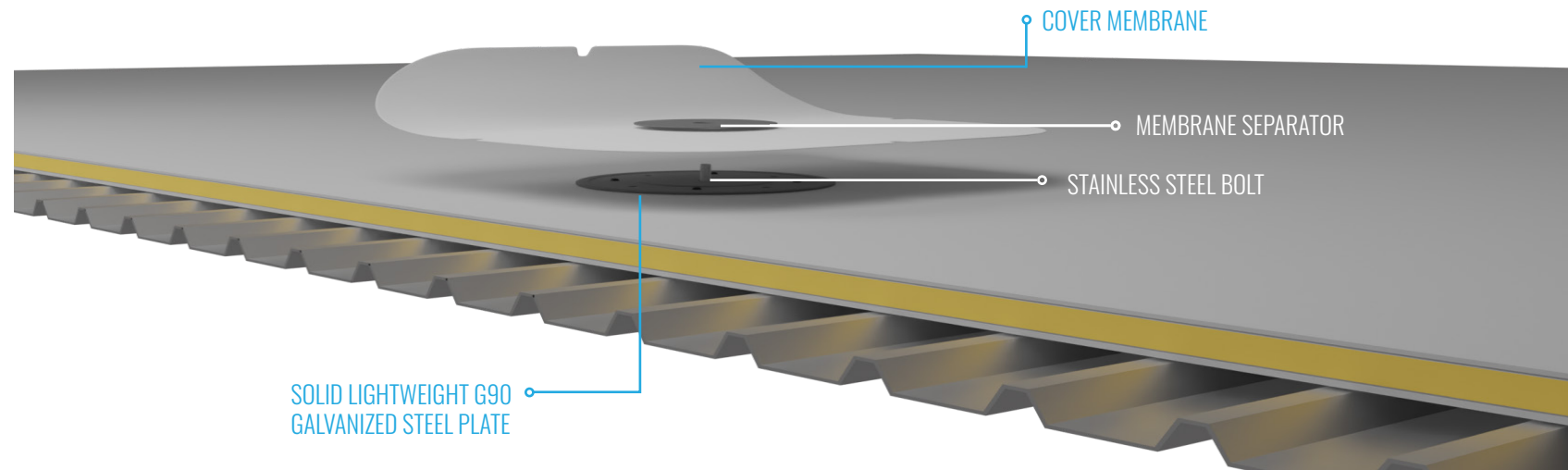
Consider the following:

Attachment Design: Plate features a membrane-to-plate-to-membrane overlap that provides triple-layered watertight seal. *

Waterproofing Compatibility: Ensures long-term performance matching the lifespan of the roof and the overburden (PV system). *

Versatility Across Roof Types: Attachments support consistent application on all common roof types. *

Warranty Integration: Attachments can qualify as roof manufacturer components included in warranties, ensuring that securement methods protect both the roof and the PV system as part of a unified investment. *



IMPACT OF MECHANICAL ATTACHMENTS ON ROOF WARRANTIES: UNDERSTANDING COVERAGE AND COMPLIANCE

In most cases, installing photovoltaic (PV) attachments will not negatively impact a roof warranty. While all warranties are different, the vast majority of roofs come with a manufacturer’s warranty which remains intact after the completion of a PV system. Generally speaking, to a roofing manufacturer, there are two categories of products for any alteration to a warranted roof: Included and/or Overburden. Included products are typically sold by the roofing manufacturer with language clearly stating that the product is included in the roof manufacturer’s warranty⁹. Overburden products are any products in contact with the roof surface¹⁰. Whether the product is overburden or included, the Roof Manufacturer’s Warranty states the work must be performed by an “Authorized Applicator” to maintain the roof warranty. Comparable to installing anything else on a roof, a PV attachment is covered under the umbrella of two distinct warranties after completion by the Approved Applicator: the workmanship warranty and the roof manufacturer’s warranty.



WORKMANSHIP WARRANTY

A workmanship warranty covers the labor performed by the approved roofing applicator installing the PV attachment for a term of 1-2 years. This workmanship warranty requires the installing contractor to return to the project for any installation issues during this period and is typically enough time to identify errors in installation or craftsmanship. The roof manufacturer “labor and material warranty” remains in effect during this period for the rest of the roof that is not associated with the PV installation.



ROOF WARRANTY

A standard roof manufacturer warranty spans 5-30 years and includes the replacement of the material and the labor to install. Most major roof manufacturers have a product offering that covers the waterproofing performance of PV attachments under their warranties. For instance, the U-Anchor PV attachment is sold or approved by many roofing manufacturers. With attachments or overburden, the approved applicator typically provides their own workmanship warranty. When the workmanship warranty expires for attachments, there is no more coverage for labor or installation issues provided by the installer. After the 1-2 year term of the workmanship warranty expires, any warranty claims related to the watertightness or waterproofing of the PV attachments would fall under the manufacturer’s roof warranty.

If the proper procedures are followed and approved attachments are used (including options like U-Anchor), the roofing warranty would remain intact. As an example, major roofing manufacturers such as Carlisle, Johns Manville¹¹, FiberTite¹², Sika Sarnafil¹³, IB Roof Systems¹⁴, Duro-Last, Versico¹⁵, Soprema, Siplast, Polyglass, GA, Elevate, and more, all accept U-Anchor under a roof-included attachment warranty.

It is advisable to consult the roofing manufacturer to verify that warranty guidelines are clearly defined and that all requirements are met.



ESSENTIAL INFORMATION FOR PV SYSTEM DESIGN ON FLAT ROOFS

To begin designing a PV system with mechanical attachments or ballast, it is important to provide a manufacturer-certified installer with the following information:

- Roof membrane and/or roof type
- Roof insulation/cover board average thickness
- Roof deck type (22ga. metal, plywood, OSB, etc.)
- The company that manufactured the roof
- The name of the roof installer
- The age of the roof
- Roof warranty status (active or inactive)

COLLABORATE WITH TRUSTED PARTNERS TO INSTALL A PV SYSTEM

Unirac and Anchor Products have partnered to disseminate technical information related to rooftop solar systems. Transparency and experience are valuable assets for developers, EPCs, and roof owners. The most important component of installing a PV system is to collaborate with partners that have an established track record of excellence in renewable energy. Unirac, a PV racking solutions provider with a proven history of innovation in the solar industry, maintains the highest standards of engineering and product certifications. U-Anchor, a trusted attachment manufacturer renowned for its expertise in the roofing industry, offers products designed for compatibility with a wide variety of roof types. Unirac integrates the U-Anchor into their rooftop systems to ensure reliability and performance.

* Please refer to page 10 for more detailed information.

ROOFTOP ATTACHMENT INTEGRATION SPECIFICATIONS

(CONTD from page 7)

- **Mechanical Attachment Design:** Plate design must feature countersunk fasteners, rolled edges to prevent damage to the existing roof surface, surface, and an appropriate surface to make a permanent seal at the connection point (the bolt or nut). Design must eliminate water intrusion during cyclical loading and require minimal maintenance. A membrane-to-plate-to-membrane overlap provides triple-layered protection and robust stability.
- **Waterproofing Compatibility:** Attachments must include brand-specific waterproofing components to ensure long-term compatibility and performance matching the lifespan of the roof and the overburden (PV system).
- **Versatility Across Roof Types:** Attachments must support consistent application on all common roof types, including TPO, PVC, EPDM, APP, SBS, BUR, acrylics, silicones, and other common roofing materials. This standardization enables predictable installation practices and reliable, low-maintenance performance.
- **Edge Flashing:** Perimeter edge flashings must form complete seals using conventional methods, ensuring fast, intuitive installation.
- **Warranty Integration:** Attachments must qualify as roof manufacturer components included in warranties, rather than overburden exclusions, to assure building owners and tenants that the securement methods will cooperatively protect both of their investments.

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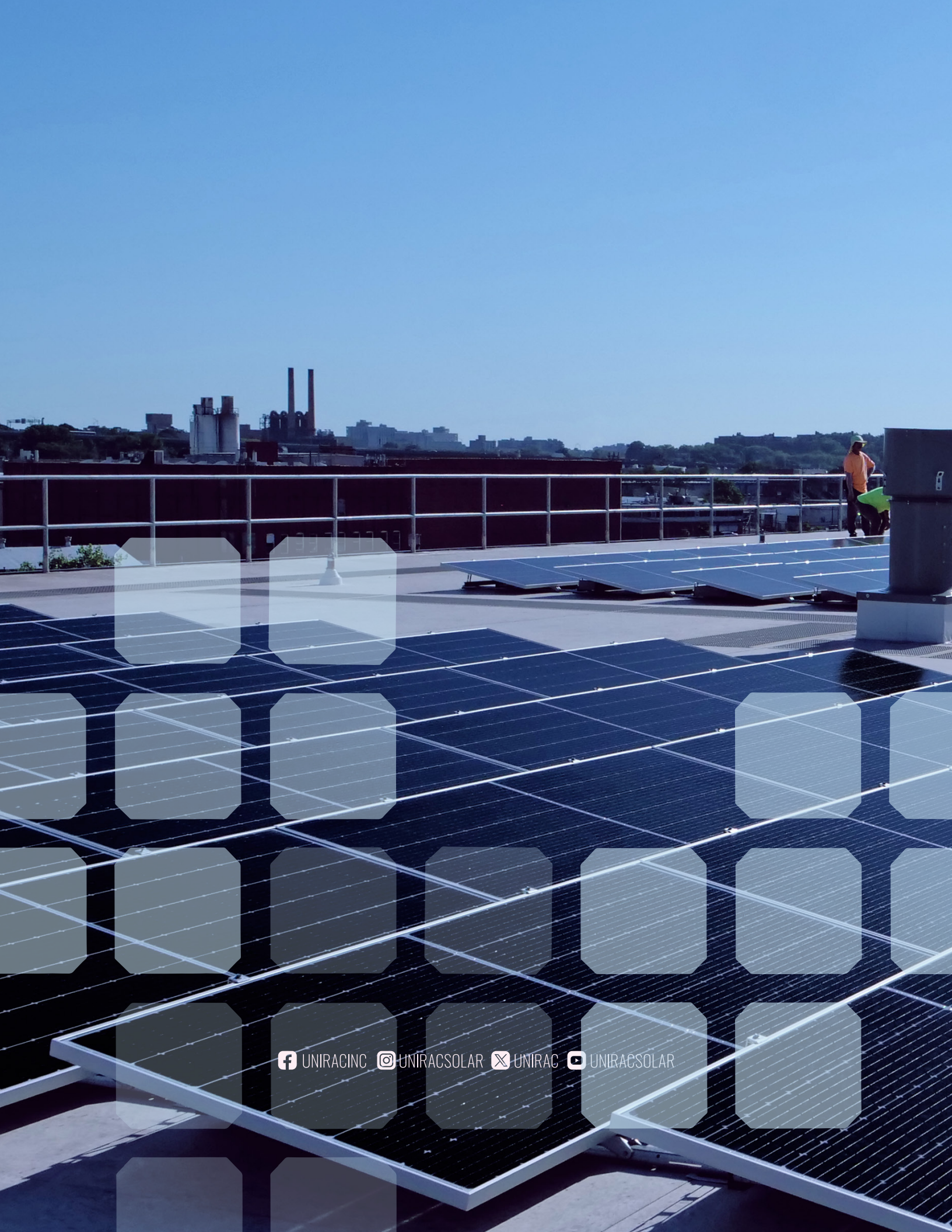
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