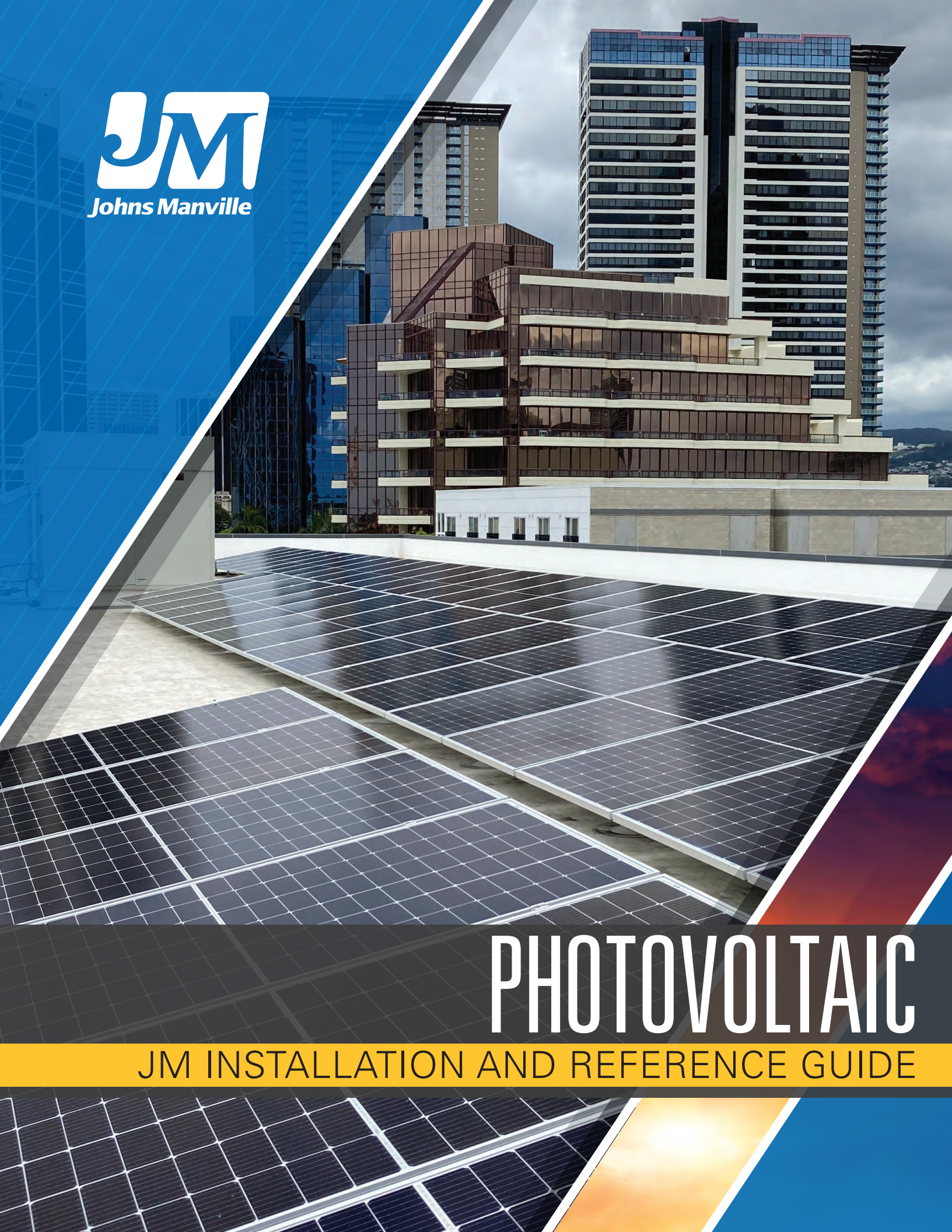




PHOTOVOLTAIC

JM INSTALLATION AND REFERENCE GUIDE

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UNDERSTANDING PV ROOFS

The decision to install a photovoltaic (PV) array on your building is complex and requires understanding several critical issues. Determining the size and scope, retaining a design professional and photovoltaic contractor and understanding the costs and benefits take time and focus.

WHEN MAKING PLANS
FOR YOUR BUILDING,
IT'S IMPORTANT
TO RECOGNIZE
THE EFFECTS OF
PHOTOVOLTAIC ARRAYS
BEYOND JUST THEIR
IMPACT ON ELECTRICAL
SYSTEMS. CONSIDER
THESE QUESTIONS:

What are the current mandates and code requirements?

Has the building been designed to absorb the additional weight of the array?

How effective is the current drainage system or the layout for a new roof? A large PV array may impact how quickly the roof drains.

What is the overall condition of the rooftop environment?
Are the building walls, parapets, skylights and RTUs
in good condition?

The presence of a PV system likely will make other projects more complex and costly. Ideally, if the roof and other components are in sufficient condition, major service or replacement will not typically be required over the lifecycle of the PV array.

A multitude of PV arrays are available for commercial applications. Some provide much easier interfaces with the roofing system. Given the critical nature of the roofing asset, it is important to consider how PV system components and overall design will affect the roofing system. The PV system should be designed to resist or accommodate movement due to weather changes, seismic activity, thermal expansion and/or structural load. One of the most critical design aspects is how the PV system is attached to the building structure.



PV ARRAY CONSIDERATIONS

Review and consider the following when installing a particular PV array:

» If you are using thin-film blankets, laminate them to a compatible sacrificial layer of like membrane; then apply the sacrificial sheet to the waterproofing membrane using an approved method.

» JM advises caution when considering the use of PV anchoring systems that rely on adhesive or heat-welded attachment to the primary roofing membrane. Anchoring systems for PV arrays should attach directly to a structural component of the building. Relying solely on attachment to the roof membrane to secure the PV system may result in failure of the roof system assembly and would not be covered under the terms and conditions of the Johns Manville Guarantee.

» If penetration of the membrane is required to secure a racking system to the building structure, circular steel tubing will provide the best possible flashing option and facilitate the use of prefabricated accessories.

» Regardless of the type of penetration used, it is important to confirm it can be flashed in accordance with JM-approved details. A properly designed PV array will see maximum sunlight. Gaskets or washers that serve as a primary waterproofing component should be minimal or concealed as much as possible from sunlight, as they will require maintenance/replacement over time.

» Caulks and/or sealants as the primary method of waterproofing the attachment to the roofing system is not recommended, and it would not be covered under the terms of the JM Peak Advantage Guarantee. JM advises against use of these waterproofing methods.

» Ensure structural penetrations have a minimum diameter of 1" flashing tie-ins to the roofing system to provide sufficient surface area to create a watertight seal.

» Ballasted PV arrays often use concrete pavers or blocks to create wind uplift resistance. Use high-density concrete that has been tested to not break down under the stress of sunlight and freeze/thaw.

Check ballasted systems to determine that the point load at each roof interface is appropriate for the type of roof system.

This is especially important on bituminous systems.

» A PV system must consider thermal movement. Use racking clips and attachments that accommodate thermal expansion without transferring movement to the underlying roof system, as damage can occur, particularly on bituminous systems.

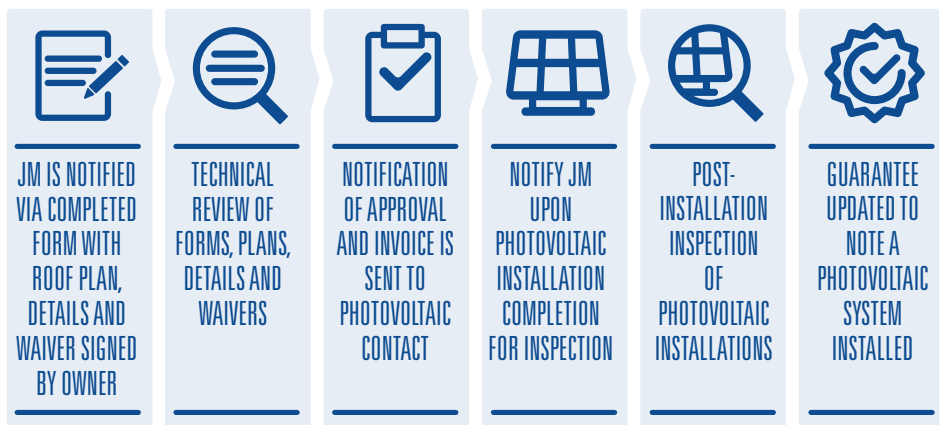
An alternative is to separate large arrays into smaller sub-arrays.

» Mechanically attached racking systems may require the use of flexible flashing details to allow for movement of the array.

» Depending on conduit material and length, you might need to use thermal expansion fittings.

KNOW THE JM PHOTOVOLTAIC SYSTEMS PROCESS >>>

This high-level process goes through a series of steps to document the addition of solar components, ensuring the PV array and its installation do not affect the terms of the guarantee.



ADDING SOLAR TO EXISTING ROOFS

WHEN ADDING PV TO AN EXISTING BUILDING, THE ROOF IS THE MOST IMPACTED. IT IS IMPORTANT TO CONSIDER THE MANY WAYS A PV SYSTEM CAN AFFECT THE ROOF.

If a roof replacement is not planned as part of your photovoltaic project, understanding the current condition of the roof becomes much more critical.

On an existing roof, it may be prudent to upgrade components or some details: add liquid flashing at all penetrations, mitigate areas prone to ponding water or introduce additional walkpads to protect the roof surface during solar maintenance.

WHAT IS THE ANTICIPATED REMAINING SERVICE LIFE?

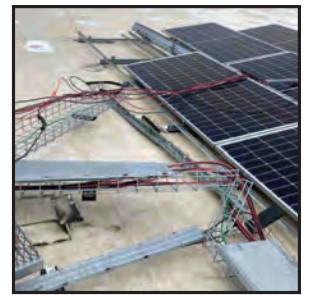
It is critical to align the roof system's lifecycle with the anticipated PV life, which is often 20 to 25 years.

IS THE ROOF UNDER GUARANTEE?

Most manufacturers have specific requirements when adding photovoltaic. Regardless of the guarantee status, a professional evaluation of the roof by a licensed engineer or photovoltaic consultant can be invaluable when considering a PV installation. Whether done by a roofing consultant or trusted professional contractor, a thorough inspection of the roof system and related components is a vital step.

ONCE THE ROOF'S BEEN FULLY EXAMINED, ASK:

- » Is simple maintenance enough, or is a more comprehensive restoration of the roof system necessary?
- » Is it more cost-effective to re-cover the existing system, or is a complete replacement more appropriate?



Proper design and installation of PV systems is critical. Above is an EPDM ballasted roof that has compromised wind uplift performance due to reduced ballast to accommodate structural limitations and a ballasted PV array that failed due to insufficient wind uplift resistance.

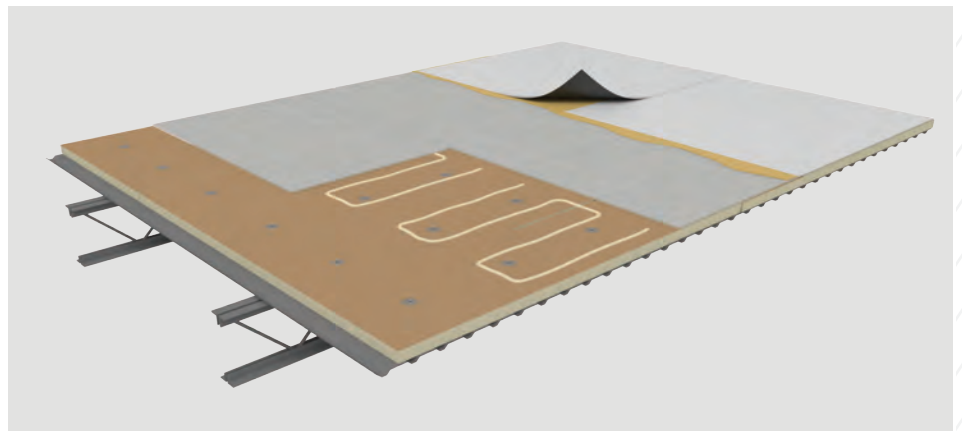


ADDING SOLAR TO NEW ROOFS

**SPECIFY A MORE
ROBUST, RELIABLE
SYSTEM THAT
REQUIRES LESS
MAINTENANCE
WHenever
YOU REPLACE A
ROOF SYSTEM
THAT'S PART OF
THE OVERALL PV
INSTALLATION.**

JM RECOMMENDS THE FOLLOWING:

- » For ballasted PV arrays, specify an adhered high-density cover board (minimum 100 psi compressive strength) and a fully adhered membrane. This configuration will distribute loading and minimize long-term point-loading impacts on the waterproofing membrane.
- » On single ply systems, higher mil thickness membranes have additional resistance to scrapes, gouges and foot traffic, as well as a longer service life.
 - 80 mil thermoplastics (TPO and PVC) and 90 mil EPDM.
- » The roof system should have walkpads at all access and service points, as well as any corridors where foot traffic will be concentrated.
- » Design the drainage system with minimum ¼" slope, with particular attention to cricket width, which should not exceed a 3:1 ratio.
- » The slope of the roof should not exceed 1:12" (one inch per foot) for single ply systems and ¼:12" (one-quarter inch per foot) for bituminous membrane systems.
- » Install crickets on any projection or curb perpendicular to the drainage flow that is wider than 24".
- » Consider using 25- and 30-year details, which typically are more robust and require less maintenance over time.
- » Given the cost to remove and store a well-used PV array, it's worth considering a roof design that's eligible for a longer guarantee term of 25 or 30 years.
- » Please consult with a design professional for your project-specific needs.



WITH MORE THAN 165 YEARS OF INDUSTRY EXPERIENCE, JOHNS MANVILLE HAS RESOURCES TO ASSIST YOU WITH YOUR ROOFING PROJECT. FROM TOOLS TO EXPERTISE TO THE PRODUCTS THEMSELVES, YOU'LL HAVE EVERYTHING NEEDED TO BE SUCCESSFUL.



LAYOUT OF PV SYSTEMS

THE ROOF MUST BE ADEQUATELY PROTECTED FROM TRADE-RELATED ROOF TRAFFIC AND DAMAGE DURING INSTALLATION:

» Protect areas of the roof that are used for PV maintenance and access in accordance with JM published details using either walkpads or pavers. Best practice is to protect the membrane in high-traffic areas.

PV layouts should provide reasonable access to all RTUs, drains and other projections to allow for service.

» On ballasted PV array installations, install a compatible protection sheet at PV mounting contact points to protect the primary waterproofing membrane from premature wear and degradation. Recommended protection sheet materials include JM DynaTred® walkway pads or DynaLastic® polyester reinforced modified bitumen cap sheets for bituminous systems and JM walkpad material or a minimum 60 mil single ply membrane of the same type as the primary waterproofing membrane for single ply systems. The color of the protection sheet should match the primary membrane.

» Projections through the roof system should not be located within 2' of valleys or drainage-collection points adjacent to drains, scuppers or gutters.

» Depending on the specific system chosen and the roof slope, consider modifying PV racking heights to counter varying thicknesses of tapered insulation.

» Ballasted systems should not impede the flow of drainage. A minimum height of 1"-2" above the roof surface is recommended. All systems should allow water to drain completely within 48 hours of a precipitation event.

» Rack-supported PV arrays should provide proper clearance to the roof membrane for maintenance or repairs.

» Keep the number of roof penetrations to a minimum.

» Cables passing through the roof assembly should not travel horizontally within a roof system, such as directly under the roof membrane or in a notched-out section of the insulation.

» Penetrations for electrical conduit into the building should be properly flashed to the roof system. Run electrical conduit passing through a roof assembly inside a sheet-metal enclosure with a roof curb; you can use a gooseneck vent where a cable needs to pass-through a roof assembly.

» Penetration pockets (pitch pockets or pitch pans) are acceptable as a last alternative for flashing PV system electrical connections that pass through a roof assembly.

» Ensure the protection layer extends a minimum of 2" beyond the point of contact in all directions.

» When installing ballasted PV assemblies on gravel-surfaced bituminous membrane, JM requires using a ¾" minimum rubber pad, or place a piece of 1.5" minimum thickness extruded polystyrene (40 or 60 psi compressive strength) directly on the loose, un-swept gravel surface in accordance with this guide. Then cover the XPS with a protection sheet to shield it from UV. Please reach out to JM Owner Services Technical to discuss other available options. JM will also accept a semi-rigid 1" minimum thickness EPDM rubber pad installed in the same manner.

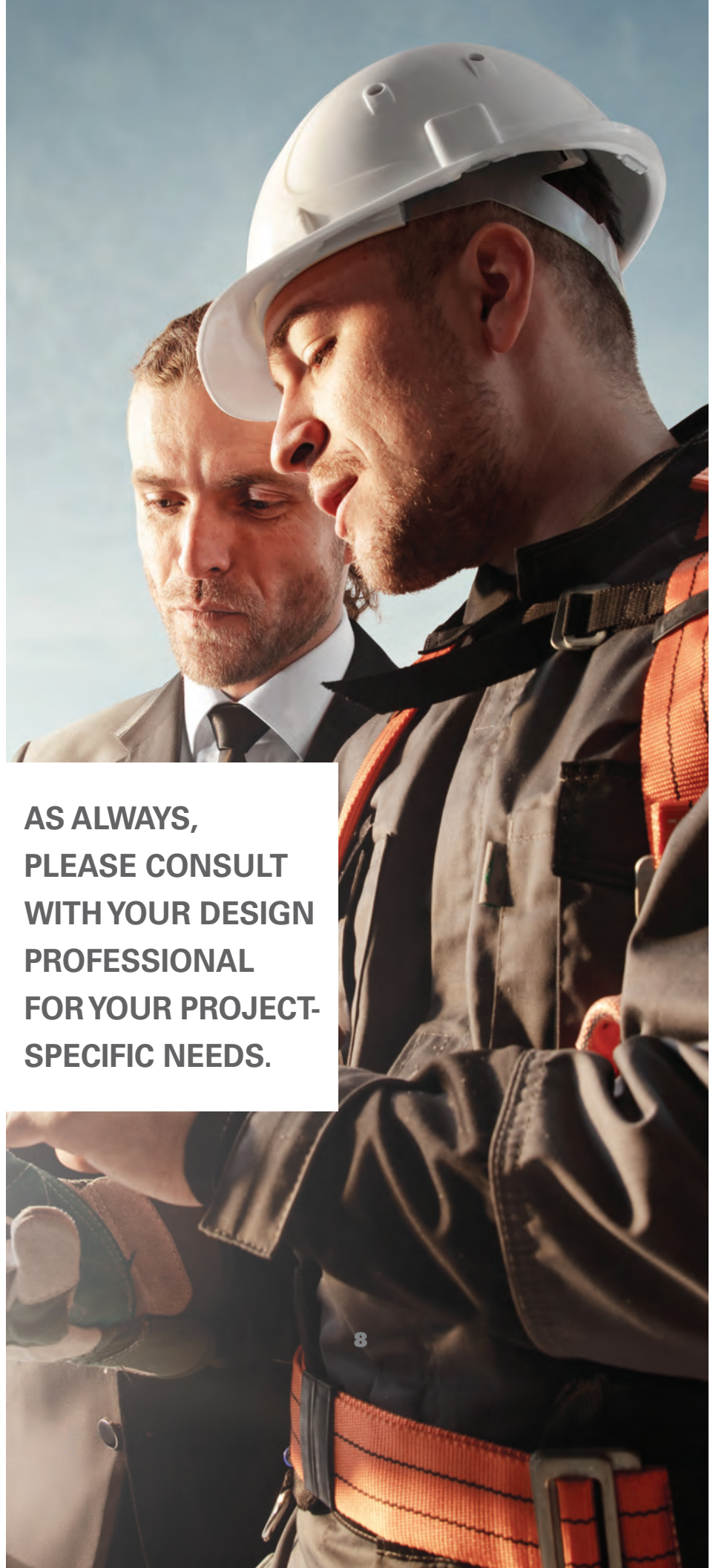


» JM recommends against the installation of ballasted PV assemblies on stone aggregated ballasted single ply membrane roof systems. For these installations, contact the JM Owner Services group for requirements and guarantee implications.

» Closely examine all waterproofing membrane T-joints in areas where the PV array will conceal access. Use non-reinforced T-joint patches of the same membrane material as the primary waterproofing membrane for single ply systems. Apply JM PermaFlash or JM PMMA at bituminous cap sheet T-joints.

» On single ply membranes, thoroughly examine and strip-in all seams with a membrane-appropriate cover strip in areas where the PV array will conceal access. NOTE: If the roof system has not received an approved final inspection from a JM Field Technical Representative prior to the installation of the PV array, you must strip-in any seams that will be covered by the PV array.

» JM recommends the weight at the point of contact on single ply roofs over standard polyisocyanurate insulation and bituminous systems not exceeding 25 pounds per square foot. Single ply systems that include a cover board should not exceed 50 pounds per square foot.



**AS ALWAYS,
PLEASE CONSULT
WITH YOUR DESIGN
PROFESSIONAL
FOR YOUR PROJECT-
SPECIFIC NEEDS.**

GUARANTEE IMPLICATIONS

**PV SYSTEMS WILL
CONCENTRATE
SERVICE TRAFFIC
TO SMALLER
AREAS AND WILL
REQUIRE PERIODIC
MAINTENANCE.
JM HAS VARIOUS
PUNCTURE RIDERS
(DEPENDING ON THE
SYSTEM) WITH OUR
NDL (NO DOLLAR
LIMIT) GUARANTEES.
THESE CAN OFFER
THE BUILDING
OWNER ADDITIONAL
PROTECTION
FROM ACCIDENTAL
DAMAGE.**



JM Guarantees offer valuable protection to the building owner. Guarantees impart obligations on the part of both manufacturer and building owner.

You should review the terms and conditions of your specific guarantee to understand your responsibilities. JM requires that all proposed alterations be communicated to JM for approval prior to project start. For any type of alteration, including PV, understand the following:



» Any change to the roofing system must be approved by JM and utilize JM products installed in accordance with our details and specifications.

» All alterations or changes to the roofing system must be performed by a JM Approved Peak Advantage Roofing Contractor.

» While JM may permit a certain product to be installed on the roof system, only JM branded products are covered by the guarantee.

» When reviewing proposed alterations, JM evaluates the proposed layout, products and details to ensure that there is not a significant issue with the proposed changes. This “approval” is not an endorsement or warranty of the design or products being used. For additional information, please see the Photovoltaic Overburden Additions on JM Guaranteed Roof System link.

» When a PV system is being installed, review and understand your responsibilities as outlined in JM’s Peak Advantage® Guarantee Photovoltaic Overburden Waiver, which includes but is not limited to the following:

The JM Guarantee does not cover any leaks, changes in appearance, damage or loss of performance in the roofing system resulting from the installation, operation or presence of a PV system on the roofing system.

JM is not responsible for any claims related to the JM Guarantee that are attributable, either in whole or in part, to the installation, operation and/or presence of a PV system.

Should the removal of any part of the PV system be required to complete repairs, whether covered by the JM Guarantee or not, these costs shall be the owner’s responsibility and are not covered.

JM does not guarantee or approve the suitability, installation or performance of any PV system or component.

Guarantee Maintenance

» Once your PV system has been successfully installed, remember that, like the roofing system itself, photovoltaic arrays will require periodic inspection and maintenance.

» Inspect the PV system at least twice a year, ideally in the spring and fall. Here are some factors to consider during an inspection:

Have all the slip sheets remained in place? Is the PV array abrading the roof surface at any location?

Are all the electrical connections secure?

Are the penetration pockets filled with pourable sealer and still watertight?

Are all the caulks and sealants adhered and free of cracking or deterioration?

Is any debris building up under the photovoltaic system and preventing proper drainage?

PEAK ADVANTAGE *Johns Manville*

Johns Manville offers one of the most comprehensive guarantees in the roofing industry. That's the advantage you can expect from a longtime, dependable leader with the financial backing of Berkshire Hathaway.



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