Rooftop Photovoltaic Systems – Windstorm Guidelines

Highly Protected Risk (HPR) Asset Protection "starts on the roof"

Overview

The roof is a building's most critical and yet most vulnerable asset. When the wind begins to blow, all elements of the roof must perform uniformly including equipment that is installed on the roof. Similar to how seatbelts function in a car, well designed rooftop equipment securement will prevent equipment movement up to the limits of the structure's design. Roof mounted Photovoltaic (PV) electric power generation systems present unique engineering design challenges as compared to other roof mounted equipment. When subjected to high winds, inadequately secured PV systems may become dislodged resulting in severe damage system, roof cover and structure making the building more vulnerable to the ongoing wind threat.

Typical rooftop PV system with panels near the roof edges

Purpose

Common PV system installation practices expose your roof to severe windstorm damage

This guideline is intended to draw attention to typical rooftop PV System installation practices and deficiencies. Despite close attention being paid to windstorm resistance for roof structures and roof covers; rooftop equipment including most PV systems are commonly installed without any means for securement other than weight. Also, often there is less rigorous control over the methods used to secure PV systems when the installation occurs in between new construction or re-roofing projects. When improperly secured, PV system components may become dislodged during high winds resulting in windborne debris damage to other equipment and the roof cover. In addition, damaged PV systems have the potential to become a significant rooftop fire ignition source. When rooftop equipment is not well secured, damage to the roof makes all of the assets within the facility more vulnerable to numerous hazards. From a risk assessment standpoint, a building's roof is a single point failure mode potential. Utilizing the approach outlined in this technical resource will equip the user to address PV system securement in both construction and retrofit circumstance.

Rooftop PV System Securement – General Guidelines

Tokio Marine America (TMA) HPR Property Loss Control recommends following Factory Mutual (FM) datasheets for best protection against Natural Hazards. These windstorm guidelines adhere to the technical advice detailed in the referenced documents. Whether considering new construction, major renovations, maintenance related roof replacement or repairs or updating your risk management plan, follow the TMA HPR Loss Control "**WIND"** advice as a best practice.

- **W**herever your facility is located, all new important structures should be designed to meet applicable standards
- **I**nvestigate all existing important structures for conformance to appropriate standards
- **N**ecessary retrofit upgrades should be strategically considered following the advice of your Account Team
- **D**ecide in advance to meet these guidelines by inclusion in corporate design specifications

TMA HPR Loss Control Plan Review services are available to assist with your project

Equipment installed on roofs generally needs to be secured to the structure in a manner *equivalent to* or *exceeding* the strength of the structure itself. If this is not the case, rooftop equipment will become dislodged at a lower wind speed than the roof and roof cover. When rooftop PV equipment becomes dislodged, its components can damage the roof cover and the damaged system may result in a fire involving roof above-deck components. This may also cause premature failure of the roof cover or structure during high wind exposure. Securing rooftop equipment protects the building, roof cover and its contents from unexpected additional damage.

While mechanically secured, this system lacks fasteners at every seam

Rooftop PV Equipment Securement - Best Practices

Advanced planning during the design and installation of new roof mounted PV systems is the key method to help prevent wind uplift damage to a PV system mounted on a roof. All new installations should adhere to the technical guidance in this guideline and the applicable resources. Existing systems are difficult to modify once installed without significant cost associated with a revised design and re-installation. However, in consultation with your TMA HPR Property Account Team, existing systems should be considered for practical retrofits to limit the potential for severe property damage and business interruption.

- **Ballasted PV solar panel systems:** PV solar panels systems that are not mechanically secured to the structure should only be installed as follows:

This installation violates several "best practices" making it more vulnerable to wind damage

  - o Do not install a ballasted PV solar panel system on a roof where a ballasted roof cover would not be permitted due to the exposure (e.g. ≥ 110 mph).
  - o Ballasted PV solar panel systems should only be installed on roofs with a slope not exceeding ½ in. per foot.
  - o Do not consider installing a PV solar panel system over a roof cover with aggregate such as pea gravel or stone ballast.
  - o A ballasted roof cover that utilizes a complete paver block surface such as an 'inverted membrane' roof cover may be suitable for the installation of a ballasted PV solar panel system.
  - o Utilize concrete paver blocks that meet the specifications of ASTM C1491 and tested in accordance with ASTM C1262.
  - o Concrete paver blocks used for ballast should be well secured using slotted or flanged pedestals or paver trays.
  - o A PV solar panel system should not be installed above single ply, mechanically secured roof covers such as TPO, EPDM, PVC, etc.
  - o In lower wind speed zones, entirely ballasted systems are tolerable.
    - Install ballasted systems in the 'field' of the roof away from the edges and corners.
    - Increase the ballast rate prescriptively by 50 % for all PV solar panels along all edges of the arrays including edges located in the middle of the roof.
  - o All related equipment such as combiner and junction boxes, conduits, etc. should be mechanically attached to the structure. The dead weight of this related equipment is not sufficient to withstand wind forces even when the array itself may be.
  - o The manufacturer's windstorm testing should be completed using a Boundary Layer Wind Tunnel (BLWT) test that better simulates wind flow towards a building.
    - A manufacturer's windstorm test conducted using an Aerospace Wind Tunnel (AWT) or computational fluid dynamics modeling is not considered acceptable.
  - o Installation of a ballasted PV solar panel system should be designed to meet the requirements of the referenced guidelines.

- **Mechanically Secured PV Solar Panel Systems**: Complete or partial mechanical securement alone or in combination with ballast offers far superior protection against wind forces. When a fully ballasted arrangement does not offer sufficient protection based upon the above guidelines, utilize the options below for best protection.
  - o Install an entirely mechanically secured PV Solar Panel System utilizing the services of a licensed structural engineer. The system should be designed using the effective wind area for each anchor per the referenced documents.

Secure panels within the array perimeter zone using anchors designed using the services of a licensed structural engineer. The perimeter zone is two times the height of the building as measured from the edge of the roof. All panels within the interior zones may be ballasted.

- Provide additional setback for the array from the edge of the roof to reduce the effective wind load on the array to permit more feasible ballast or anchor design. This approach may be especially appropriate in high basic wind speed zones where it may be very difficult to effectively secure panels in the corner and perimeter zones.

- **PV Solar Panel Systems on Standing Seam Roofs (SSR):** Install rigid PV solar panels on a standing seam roof (SSR) using external seam clamps (ESC's).

PV solar panels are highly susceptible to hail

- An ESC should be installed at every seam to ensure that the installation will match the load path of the SSR as designed by the manufacturer.
- Ideally, the ESC's utilized should be approved for the SSR on which they are used when available.
- The ESC's should be torqued per the SSR manufacturer's instructions and inspected prior to acceptance and periodically during system inspections.

- **Hail Hazards:** The PV solar panels chosen should specifically be rated for the hail exposure present at the location of installation. When the hail exposure exceeds the rating of the PV solar panels installed, all of the panels are likely to be damaged when the predicted hail event occurs.

Summary of the Risk

The risk of damage to your facility during a windstorm is significant and may result from many factors. Windstorms, hail and other natural perils have the potential to severely damage rooftop mounted PV Solar Panel Systems. There is also the added potential for a fire originating within damaged equipment following the storm. The best risk management approach is to ensure adequate protection during the design process because retrofits may be costly. Prior to considering adding a rooftop mounted PV Solar Panel System, begin outside on the roof with a windstorm risk engineering assessment. The most effective means to protect the assets located both within and on your facility is to take the necessary steps during new construction, re-roofing and renovations to ensure your investments are well protected when nature strikes.

Summary of the Risk Reference Documents

FM Data Sheet 1-15 "Roof Mounted Solar PV Panels"

FM Data Sheet 1-28 "Wind Design"

FM Data Sheet 1-31 "Panel Roof Systems"

FEMA Document "Rooftop Solar Panel Attachment: Design, Installation, and Maintenance"