Warehouses

Preventing Avoidable Loss From Severe Convective Storms

Severe convective storms

—including strong thunderstorms, derechos, and tornadoes—occur across the United States and cause billions of dollars in losses annually.

Learn how these storms affect warehouses and how you can help policyholders prevent avoidable damage.

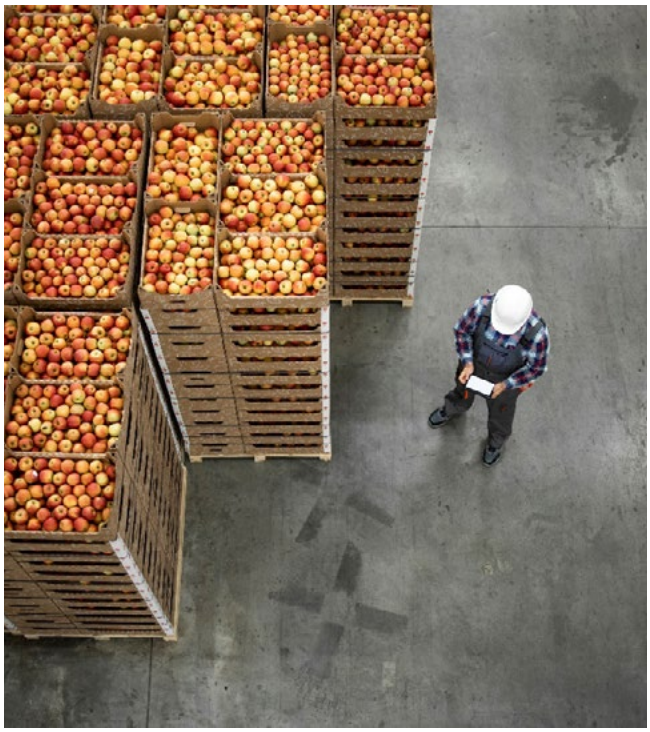
Understanding Warehouses

Warehouses serve a wide range of purposes, which often determine their construction and what you need to look for during an inspection.

WAREHOUSE TYPES

- **General.** Provides space for bulk, rack, and bin storage, aisle space, receiving and shipping space, packing and crating space, and office and toilet space.
- **Temperature-controlled.** Temperature is controlled within a range of several degrees. For example, in 90-degree weather, the inside may be maintained at 80 degrees. Normally, these facilities range between 55 and 80 degrees.
- **Humidity-controlled.** Constructed with vapor barriers and contains equipment to maintain humidity at desired levels to deter mold and mildew, which are especially damaging to wood, fabric, and a range of other products and materials.
- **Climate-controlled.** Both temperature and humidity are maintained to an exacting standard.

WAREHOUSE TYPES continued



Cold storage of perishable goods.

- **Automated.** Relatively new to the scene, these must be designed appropriately with added load-bearing beams and heavy-duty flooring to support heavy robotic equipment. Sensitive electrical equipment used often requires a climate-controlled environment to operate at peak performance.
- **Cold storage.** Preserves the quality of perishable goods and general supply materials that require refrigeration. Includes freeze and chill space, processing facilities, and mechanical areas. Known to utilize metal insulated sandwich panels for their exterior walls and roofs. A panel is comprised of an insulation core (expanded polystyrene, mineral wool, or polyisocyanurate) and exterior sheet metal.
- **Flex space.** A relatively new trend, these allow for multiple small businesses to reside in the same building, which enables tenants to optimize the space they need without designing a whole facility for each purpose.

Automated warehouse with robotic equipment.

Warehouse Structure

Like other commercial buildings, warehouses vary in size, finish, and structural systems. To maximize the use of interior space, warehouses require large spanning bays which entail substantial structural framing. To accommodate this, certain structural systems are more prevalent including:

- Structural roofing deck (steel, lightweight insulating concrete, gypsum, etc.) on steel-framing members with:
  - Concrete tilt-up panel walls
  - Cast-in-place walls
  - Concrete masonry block walls

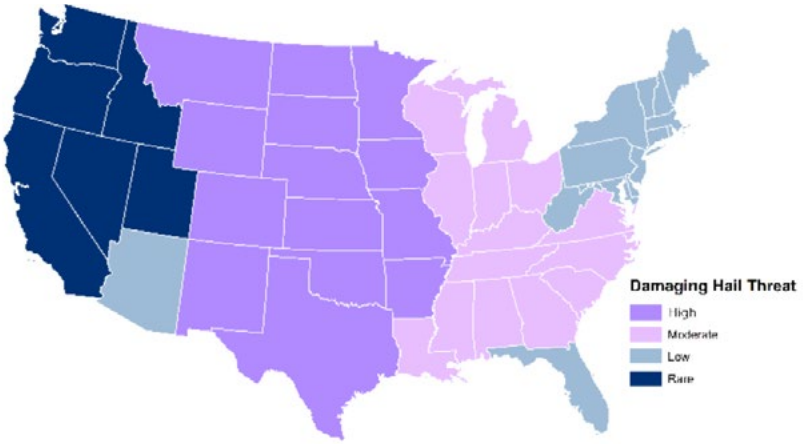
- Cast-in-place concrete roof deck, framing members, columns, and walls
- All-metal building with structural system, roof, and walls made of steel/metal panels
- Metal insulated sandwich panels for exterior walls and roofs (refrigerated warehouses); the panel is comprised of an insulation core (expanded polystyrene, mineral wool, or polyisocyanurate) and exterior sheet metal

Understanding Warehouse Risks

Warehouses serve a wide range of purposes, which often determine their construction and what you need to look for during an inspection.

Weather Conditions Caused by Severe Convective Storms

Severe convective storms can cause damage from a multitude of weather phenomena like tornadoes, lightning, wind, hail, and even flooding. These conditions can occur across the United States at any time of year, and they cause billions of dollars in losses annually. Despite advances in detection and forecasting, severe convective storms are becoming more frequent and costly.



Tornado Tracks Across the US from 1950 to 2019

Building Codes

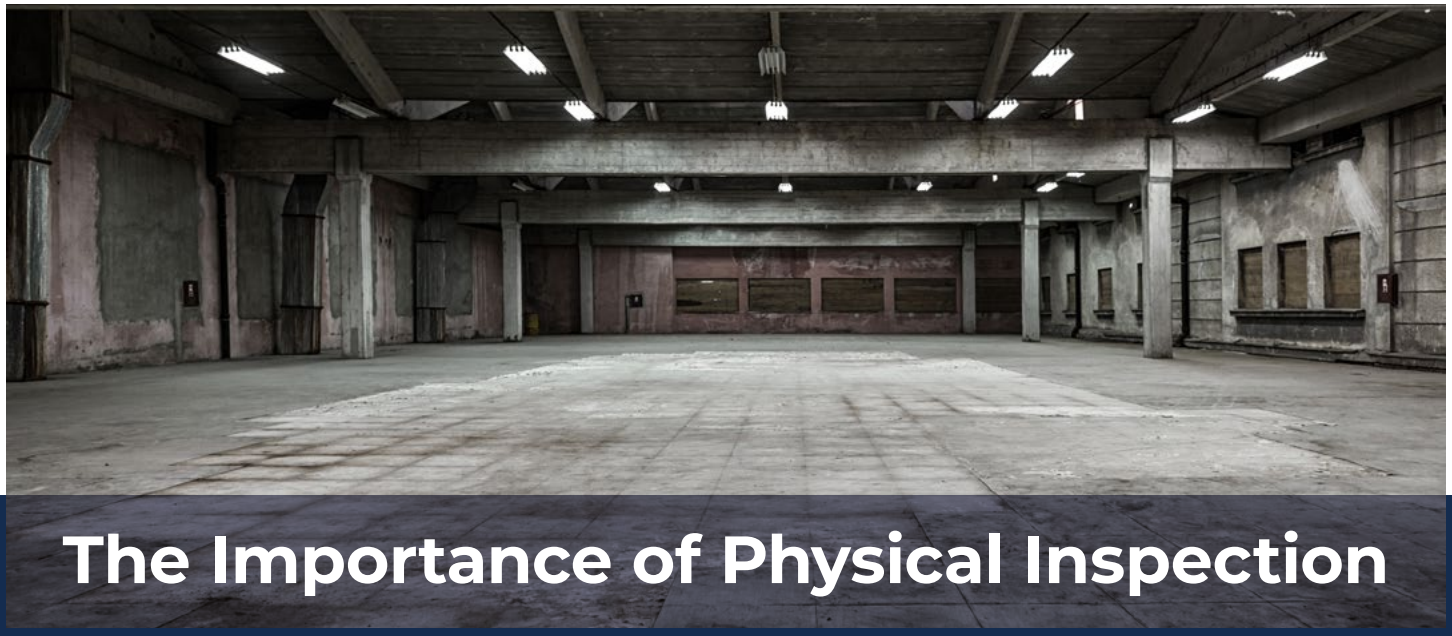
Building codes are continually evolving to minimize damage from severe weather, especially when it comes to wind, and IBHS strongly supports adoption of modern building codes. Unfortunately, inconsistencies in codes range by state, county, city, and municipality across the United States, and enforcement of these codes varies as well.

Additionally, older warehouses may have been constructed before local building codes were enacted. Identifying the building code used in construction can shed light on vulnerabilities the structure may have and what mitigation steps should be implemented. This will ensure the building meets modern building codes so that it performs well when exposed to a severe storm.

Age

The varying structural systems of warehouses can all perform well if they are adequately designed, installed properly, and maintained. However, all materials are subject to aging, the unique environment in which they are installed, and the inherent risk of damage due to unsafe operations (i.e., accidents such as a forklift backing into a column or wall). This stress and strain on the materials yields unique warning signs that should be closely monitored because they may lead to a weakened structure susceptible to severe weather. For example, concrete can show many signs of aging and deterioration such as cracking, spalling, and rusted exposed rebar. Steel connections and structural members can show signs of deterioration through rusting or deformation.

Preventing avoidable loss through inspection and maintenance can help to prolong the life span of building components and ensure they are performing properly. By identifying problems early, warehouse owners can take corrective action before a problem is critical.



The Importance of Physical Inspection

Site Visits

Conducting a physical inspection of the facility is the best way to understand its condition, identify building component problems, take corrective actions, and prevent avoidable damage. Since buildings are continuously subjected to Mother Nature and aging, conducting periodic inspections is recommended.

Consider more frequent inspections if the structure has multiple risks/exposures such as:

- Geographic location with multiple environmental factors (e.g., severe weather areas, areas that get snow/ice and salt, proximity to salt water/spray)
- Damage from tenants (accidents such as a forklift backing into a column or wall, etc.)
- Storage of corrosive materials
- Advanced age
- Remodeling, upgrading, etc. (adding solar panels, changing footprint, changing anything structural to the inside)
- Recent severe storm
- Poor maintenance

Before a Site Visit

Prior to a site visit, ask the warehouse owner for full access to the building, including the roof. Also request the following information that will better prepare you for the onsite inspection:

- Age of the building
- Type of construction materials (roof, siding)
- Maintenance history
- Building inspection records
- Structural/architectural drawings
- Photo documentation

Additionally, gather satellite and street imaging (if available) to get a better sense of the building and site; note items such as garage bays, site sloping, and building construction that will need to be inspected.

Vulnerable Warehouse Components

Inspecting the following components is key to understanding warehouse vulnerabilities.

Roofing Systems

The roof is a warehouse's first line of defense against the elements. Roofs are susceptible to high wind damage and water leaks, which can lead to extensive damage of the roofing system itself, building structural components, wall components and more. Water leaks through the subsequent damage can also travel long distances from where they originate, leaving electrical, robotics, machinery, and inventory vulnerable.

KEY INSPECTION ITEMS

- Gain access to the roof and inspect for tears, bubbles, and deterioration of roof covers to identify areas that may have water leaks. From below, look at the underside of exposed decks.
- For metal decks, look for rust and corrosion along the deck and structural metal frames.
- For concrete decks, look for cracking, spalling, and rusted exposed rebar.
- For other types of roof decks, look for water stains or deterioration of the deck. Locate any penetrations—like skylights, roof-mounted equipment, and vents—and inspect for leaks.
- Note any excess debris, inspect for loose or missing roofing materials, and look for any tools or materials that may have been left after a contractor has worked on the roof.
- Look for water streaks along the perimeter walls just below the deck. Inspect ceilings to identify any water marks from leaks. Pay particular attention to the area around the perimeter of the roof where it meets the walls.

RECOMMENDATIONS FOR OWNER

- If any issues with the roof cover are identified during inspection, hire a licensed and insured roofing contractor to remediate.
- If there are any noted issues to the roofing deck or framing members, hire a licensed professional structural engineer.
- If there are signs of water penetrations, hire a contractor to locate the source, conduct moisture surveys, and remediate if necessary.
- When re-roofing, use products that have been tested and approved by a certified testing facility.

  Low-sloped roof covers should have one or more of the following product approvals:
  - Florida Product Approval (FPA)
  - FM Approved
  - ICC-Evaluation Services (ICC-ES)
  - Miami-Dade Approved
  - Texas Department of Insurance (TDI)
  - UL Rated
- In hail-prone regions, re-roof with impact-resistant products. Use products with an FM impact rating of Severe Hail (SH) or Very Severe Hail (VSH).

Physical inspection of Metal Edge Flashing

Metal Edge Flashing, Gutters, Downspouts & Drains

Metal edge flashing can be found along the roof edge of a warehouse where the roof meets an exterior wall. Securement of the edge flashing is critical to keeping the roof cover intact during high winds. Loose flashing will allow wind and rain to get underneath the roof cover where wind action will add to uplift pressure on the roof system. This is a common failure point that can result in partial or total loss of a roof cover system. A roof cover system can also peel away from the edge if the flashing fails, leading to water entry that will create moisture problems within the roof cover system.

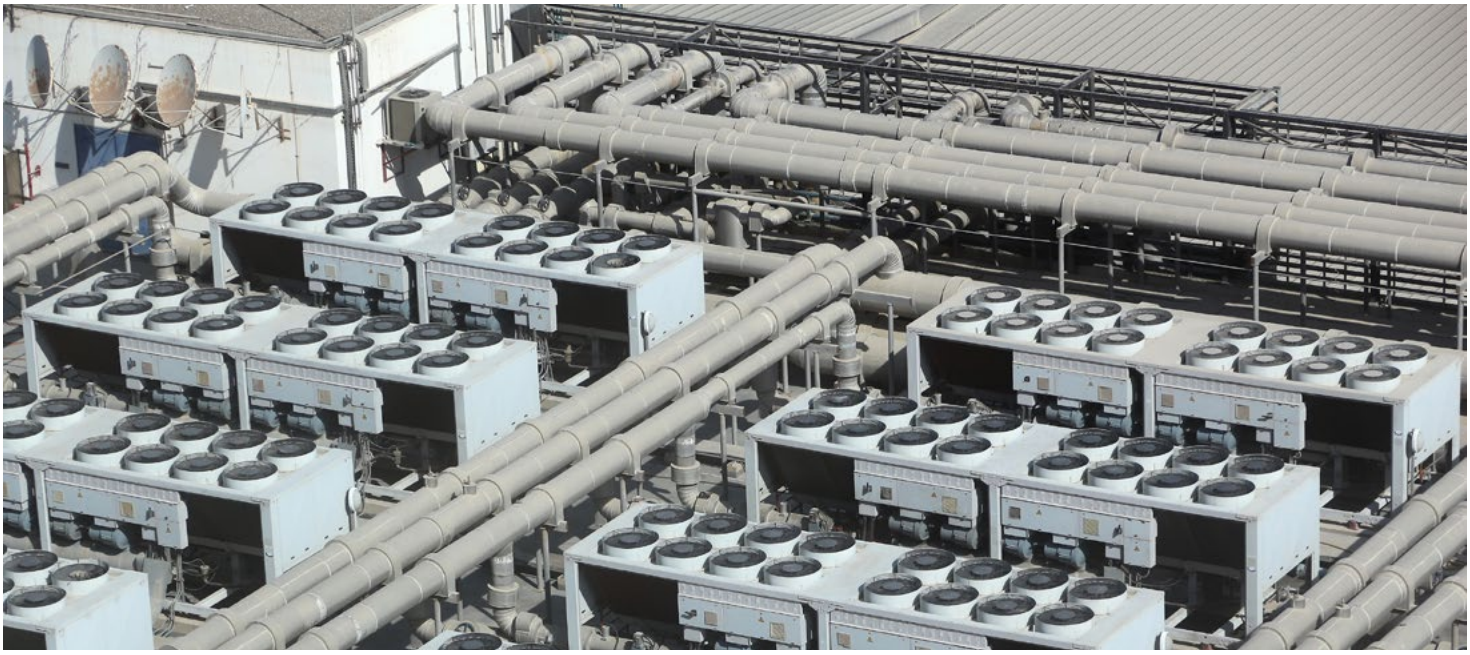
Gutters, downspouts, and drains remove water from the roof and surrounding properties. They tend to collect dirt and debris and need to be periodically cleaned to maintain proper operations.

KEY INSPECTION ITEMS

- Gain access to the edge of the roof (using appropriate safety precautions and PPE) and physically inspect the flashing:
  - Grasp the bottom edge of the flashing and gently pull up and out (away from the wall) at three or four points along the edge of each wall, including corner areas (Figures 4 and 5). This offers the most insight into the strength, installation, and quality of the metal edge flashing.
- Inspect gutters, internal roof drains, and downspouts.
  - Gutters and internal roof drains should be free of dirt and debris.
  - Determine whether drains have any signs of ponding or backed-up water, which can identify a larger issue.
  - Gutters should be properly attached to the building utilizing straps that are properly connected to the outside flange of the gutter and fastened to the building.
  - Downspouts should direct rainwater away from the foundation of the building, helping to preserve the integrity of the foundation and prevent flooding.
- Loading dock designs often slope down toward the building, which can direct water toward drains. These drains are susceptible to dirt and trash buildup, which can prevent them from operating properly. Inspect drains for any blockage or water retention.

RECOMMENDATIONS FOR OWNER

- For small areas of flashing that are not securely crimped to the metal cleat, the flashing should be re-crimped.
- Seams and gaps in flashing should be repaired.
- Repairing the fascia with exposed fasteners is a cost-effective option in lieu of replacing the entire edge flashing system.
  - Perimeter flashing should be secured with mechanical fasteners and metal-backed EPDM washers. Fasteners should engage a structural substrate. Additional fasteners should be placed approximately 12 in. o.c. and securement must be in the lower section of the flashing with a penetration depth of at least 1 in. If securing to concrete, use self-tapping stainless steel concrete screws. If necessary, pre-drill and include metal anchors. For securement to metal and wood, use stainless steel sheet metal screws and stainless steel wood screws, respectively. Where applicable, provide filler for large gaps between the flashing and wall.
- If a flashing replacement is needed, replace the entire flashing system during a major roof repair, re-cover, or replacement, as it will be most cost-effective then. Roof edge flashing, coping, and counterflashing should be designed and tested in accordance with ANSI/SPRI/FM 4435/ES-1 for ASCE 7 design wind pressures.
- Remove all dirt and debris from gutters and internal drains.
- If gutters and downspouts are not properly attached to the structure, hire a licensed contractor to reattach or install additional gutter straps.
- Loading docks should be properly mitigated for water removal. If proper drainage is not installed or water is not being removed quickly enough, a gutter cleaning service or plumbing engineer should be hired to do an analysis. Consider additional drains, gutters, downspouts, or a larger water removal system.



Roof-Mounted Equipment

During a convective storm, unsecured mechanical equipment, refrigeration units and piping on the roof are subject to sliding, lifting, detaching, and overturning. This can cause significant damage to a roof cover and subsequent water intrusion. Additionally, HVAC units can be severely damaged by hail, leading to inefficient performance, energy loss, and potential business downtime.

KEY INSPECTION ITEMS

- Ensure all equipment is securely fastened to a curb that is attached to the roofing structure. Inspect equipment for any loose or missing connections.
- Inspect for loose flashing around roof-mounted equipment, curbs, skylights, and roof hatches, which could lead to failures of the unit's structure and water intrusion.
- Inspect for debris accumulation around and under roof-mounted equipment, which can cause water to pond and cause costly damage to the roof and interior.
- Ensure service panels have all fasteners in place so panels do not become dislodged.
- Ensure all piping is properly attached to stands that are secured to the roofing structure.

RECOMMENDATIONS FOR OWNER

- For poorly connected equipment, fastening to curb should meet the recommendations in Table 1.0 of FEMA- Attachment of Rooftop Equipment in High-Wind Regions.
- If roof-mounted mechanical equipment, refrigeration units, and their attachments need to be replaced, they should be designed in accordance with ASCE 7.
- If the warehouse is in a hail-prone area:
  - Hire a qualified professional to install "hail guards" on the mechanical units. These specially designed protection systems cover the unit's vulnerable parts and are a cost-effective way to reduce damage.

Walls, Windows & Personnel Doors

A warehouse's exterior walls, and sometimes exterior cladding, can become susceptible to wind and water intrusion if not properly installed and/or maintained. When not properly installed with adequate high-wind fastening, the magnitude of damage can vary from minor cosmetic issues to full system loss due to high winds. In extreme situations, the wall system begins to tear away from the structure and can become wind-borne debris. Adequate connection of the exterior wall will vary based on the materials and geographic location. For instance, all metal buildings connect exterior wall panels using a clip system or through fasteners; in high-wind-prone regions, these connections should be spaced closer together. Similarly, for metal insulated sandwich panels, connections will be spaced closer at the corners of the buildings.

It is common to see water intrusion through wall penetrations, including window glazing, door thresholds, and other wall transitions from one material to another. Water intrusion that is not addressed will lead to deterioration of the materials it encounters.

KEY INSPECTION ITEMS

- All wall types
  - Look for signs of excessive aging, cracks, and punctures in any finishing wall system.
  - Pay close attention to any areas where there are sealants at transition points such as joints, corners, ridges, windows, doors, and wall penetrations.
  - Look for water stains on the inside perimeter walls and around doors and windows of the building.
  - At the base of the wall where it transitions to the foundation, inspect for moisture penetration and water intrusion resulting from improper flashing and sealing.
- Concrete/brick masonry
  - Look for honeycombing, spalling, missing concrete, or exposed rebar in concrete wall systems.
  - Inspect brick masonry for missing or cracked mortar. Check for damaged masonry units that could be caused from general warehouse operations.
- Metal panel construction
- Inspect for signs of rusting panels, fasteners, and connections.
  - For systems with clipped connections, inspect clips for signs of rusting or deterioration. Rust on these connections can indicate a larger moisture problem and may need additional attention from a professional. Confirm all mechanical fasteners are installed and tightened.

RECOMMENDATIONS FOR OWNER

- If there are any signs of cracking, spalling/missing concrete, exposed rebar or damaged masonry units, hire a licensed professional engineer to conduct a structural inspection and provide mitigation recommendations.
- Replace all rusted or missing connections.
- If replacing the exterior walls, replace with systems designed to modern building codes. They should be designed for the site-specific wind pressure as defined by ASCE 7 with a minimum exposure category of "C" or "D."

Large Commercial Doors

Large commercial doors seen in loading docks are a damage amplifier when subjected to high winds. Commercial doors have large surface areas and when they are damaged, they often cause a cascade of structural damage to the roof and walls of the facility. Warehouses, particularly those for the movement and storage of products, usually have a significant number of these doors, leaving the entire facility vulnerable to structural damage in high winds. If there's a weak link, the wind's inward and outward forces will always find it and cause a door failure. There are 3 primary concerns:

1. Rollers popping out of their track
2. The track pulling away from the wall
3. The door deteriorating/aging (rusting)

KEY INSPECTION ITEMS

- Look for a certification label on each door that identifies the design parameters such as wind speed, pressure rating, and/or approval rating.
  - On the label, a pressure rating is preferred since design pressure varies depending on location, terrain exposure, and building size. A pressure rating on the certification label is a good indicator that the manufacturer is trustworthy and typically means the door has been tested to pass 1.5 times its design load.
- Closely examine the door, track, and attachment details.
  - Make sure all track connections to the building's structure are tightly secured.
  - Check whether the track can be twisted by pulling and rotating. If so, this could lead to the rollers popping out.
  - Check the "give" in the door-to-track connection. If it is flimsy, the door is at risk for failure.
  - Verify there are door seals and there are no large gaps when the door is in the down position.
  - Confirm whether reinforced struts and sturdier rollers/hinges/braces were used.

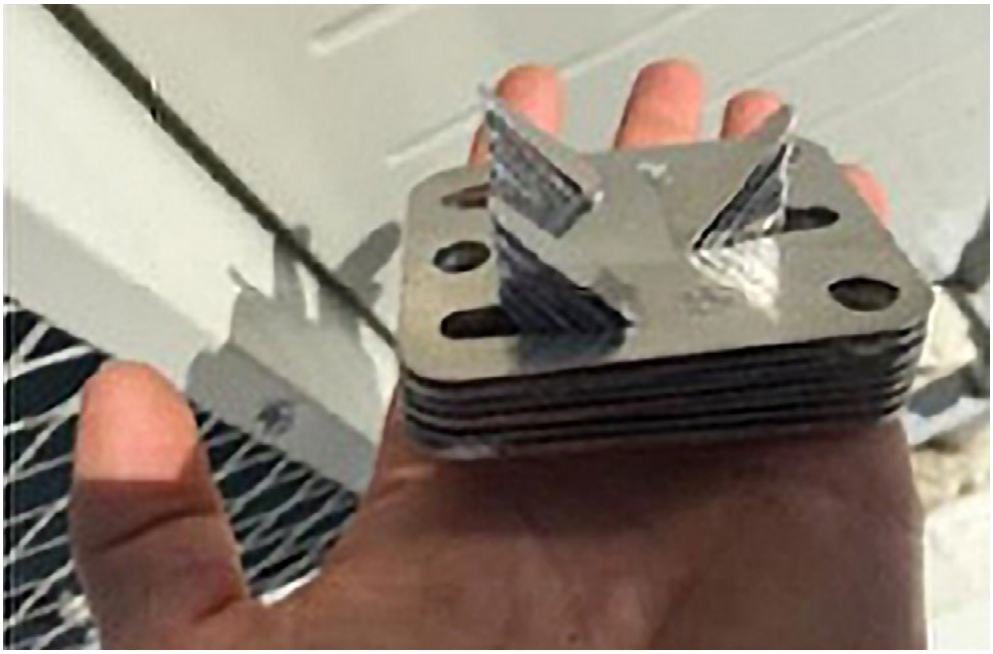
RECOMMENDATIONS FOR OWNER

- Hire a licensed contractor to install additional reinforcing struts to existing large commercial doors.
- If replacing or installing new doors, have a licensed and verified contractor install wind-rated doors for the site-specific design pressures and minimum exposure category "C" or "D."

Closed Loop Connector

Lightning Protection Systems

Lightning protection systems can serve as defense against dangerous lighting strikes to your warehouse. However, if they are not properly attached, they are not capable of providing the intended protection; this also can cause damage to other structures or roof components during high winds.



3-Prong Connector

KEY INSPECTION ITEM

- Check the lightning protection system by gently pulling on the securements and conductor poles.

RECOMMENDATIONS FOR OWNER

- If the cables, fasteners, or conductor poles are loose or disconnected, hire a licensed contractor to reattach them.
- If replacement or a new cable connector is required, install with a closed loop connector rather than a conventional 3-prong connector (see Figure 6). If the metal conductor cable becomes loose from its securement, it can be dragged or slammed against the roof membrane.
- If replacement is needed, the new system should be designed and installed for wind resistance in accordance with FEMA – Rooftop Attached Lightning Protections Systems in High-Wind Regions.

Roof-Mounted Photovoltaic (PV) Units

PV arrays can be secured to the roof by two methods: ballasting and mechanical attachment. When subjected to high winds, ballasted systems can shift and overturn if not properly weighted, causing tears in the roof cover that leads to water intrusion. It is best practice to mechanically attach all PV units to the roofing structure to reduce the possibility of damage to the unit itself and the roofing components.

Additionally, being located on the roof, PV units can be directly exposed to hail. Installing a hail-rated system can help reduce damage to the panel itself.

KEY INSPECTION ITEMS

- Inspect and photograph PV system and roof cover.
- Inspect for loose or disconnected conduit, wiring, or electrical connections.
- Check for overly tight cables and any signs of fraying or damage to cables or conduit, which could result in an electrical short or broken connection.
- Check for loose connections from the PV array to the stand.
- Look for signs of movement of PV system and components, particularly changes in proximity to other roof-mounted equipment to determine if collision has or could occur.

RECOMMENDATIONS FOR OWNER

- Hire a licensed contractor to:
  - Reconnect loose or disconnected conduit.
  - Loosen excessively tight electrical cables to prevent electrical shorts.
  - Mitigate improper mechanical connections between the PV array and stand.
- When installing a new PV system:
  - Warehouses have large interior spans and additional weight must be considered. This typically leads to larger framing members and thicker concrete roofing structure deck, columns, and/or walls.
  - PV systems and attachments should be designed using wind loads and hail resistance in accordance with local codes.
  - When installing PV panels on a low-sloped roof, designers must ensure the row spacing between the panels is wide enough for maintenance crews to service damaged panels. If the panels are installed too close together, perimeter panels may need to be removed to access interior ones.

For additional commercial property protection guidance IBHS.org.