PROTECTING YOUR FACILITY AGAINST MAJOR WINDSTORMS

FM Global®

FM Global has many years of loss experience and has analyzed windstorm damage from severe windstorms to insured client facilities and buildings. This analysis has shown that buildings and structures designed, built and maintained in accordance with FM Global's recommended standards have significantly less damage than buildings and structures designed to lesser standards. Designing to FM Global standards has resulted in more resilient facilities.

BY ANY NAME, A FORMIDABLE HAZARD

No peril can match that of a severe windstorm for its ability to cause widespread devastation in a geographic area. Severe windstorms can be called hurricanes, typhoons or cyclones, depending in which part of the world they occur. Whatever they are called, they have been one of the major contributors to FM Global client losses and have accounted for an annual average of US$620 million gross over the last 20 years.

The majority of these wind-related losses occurred as a result of major severe storms such as Hurricane Maria in 2017 and Hurricane Michael in 2018. However, in storm after storm, designing buildings to FM Global standards, along with proper knowledge and preparation, can significantly minimize the property damage and the risk to business from downtime.

UNDERSTANDING WIND

Before you can secure your facility against the impact of windstorms, you should arm yourself with information about wind in general. The following sections offer some background.

SPEED AND FORCE

As wind speed increases, the wind's force accelerates exponentially. For example, a constant breeze of 20 mph (32 km/h) exerts a pressure of 1 psf (48 Pa). When wind speed is increased four times to 80 mph (129 km/h), pressure increases 16 times to about 16 psf (766 Pa). The strong winds from a hurricane, combined with short duration wind gusts, increase the pressures on a roof in the perimeters and corners.

Remember that wind speeds are not necessarily uniform over a given area. The radius of the damaging winds of a hurricane, typhoon or cyclone is typically 50 to 100 miles (100 to 200 km), with the storm area from 100 to 300 miles wide (200 to 500 km). Within these areas, the wind speeds vary significantly, with the most intense and damaging winds usually within 30 miles (48 km) of the eye and concentrated at an area known as the Radius of Maximum Winds (RMW). As a result, the range reported at a local weather station may be different from the speed at your facility. So if a Category 4 hurricane strikes your area, your facility may experience only Category 1 winds.

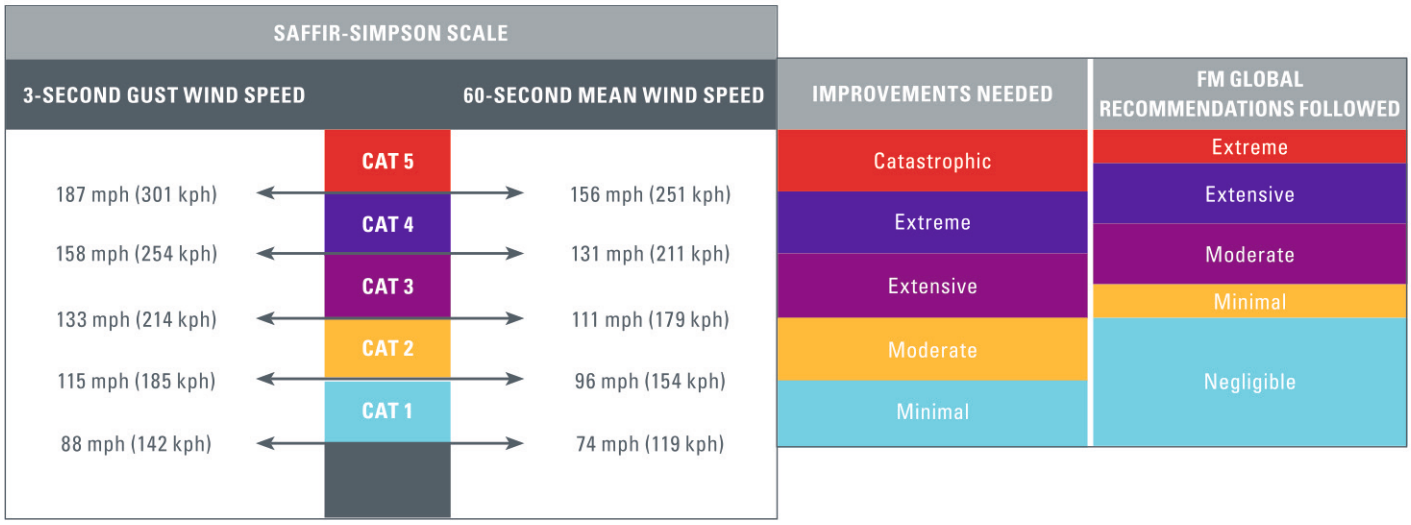
DIRECTION

Tropical cyclones spin around a central low-pressure core, with the direction of circulation governed by the rotation of the earth. Storms in the Northern Hemisphere spin counterclockwise, and storms in the Southern Hemisphere spin clockwise. In the Northern Hemisphere, the winds on the eastern side of the storm are typically strongest, whereas the western side of the storm presents the strongest winds in the Southern Hemisphere.

INTENSITY

Knowing which basis is being applied in windstorm intensity reports is important. Wind speed can be measured by various averaging times, such as the three-second gust and 60-second mean. The comparison in the Saffir-Simpson Hurricane Intensity Chart shows the relationship between these two measurements. The right side of the chart shows the expected damage at a given site with and without FM Global recommended improvements.

For example, a wind speed at the threshold of a Category 3 hurricane is 133 mph (214 km/h) using a three-second gust wind speed compared with 111 mph (179 km/h) using a 60-second mean wind speed.



This glass wall facade was destroyed by high winds, leaving the building interior vulnerable to wind and rain damage.

The damaged roof covering on this seaport building is mostly along the edge where wind forces are at a maximum.

An inadequately designed parapet wall with masonry blocks was blown off at the roof line.

LOSS PREVENTION GUIDELINES

VULNERABLE LOCATIONS

Buildings located next to open terrain where the wind can blow unimpeded— such as near fields, large bodies of water, parking lots and airport runways—are more likely than buildings near wooded areas or within a dense city center to be damaged when the wind strikes with full force. FM Global testing and modeling have shown that wind also can accelerate around hills, berms and escarpments.

RECOMMENDATIONS:

The location of a facility is dictated primarily by availability, cost and business strategy. FM Global engineers can help determine how much wind resistance is needed for a new or renovated building, factoring in ground roughness.

VULNERABLE OCCUPANCIES

Loss experience shows that in some cases, rain entering a building accounts for much of the damage when compared to the effects of wind. Rain pouring in through the roof or broken windows will damage products, metallic surfaces prone to rust, electronic instrumentation and susceptible building finishes. Items stored directly on the floor are especially vulnerable.

RECOMMENDATIONS:

Ensure new and existing buildings and structures have the proper wind design in accordance with FM Global Property Loss Prevention Data Sheets and use FM Approved products such as roof and wall systems. Also, have a strong wind emergency plan that includes both contingencies for damaged product and equipment and a business continuity plan.

DESIGN AND INSTALLATION DEFICIENCIES

Deficiencies often occur in the design of roof coverings, roof decks, perimeter edge flashing, wall systems, and openings' protection (windows, skylights, wall louvers, and overhead doors). Such deficiencies allow rainwater to enter buildings and destroy equipment, furnishings and interior finish. Frequent damage also occurs to inadequately secured rooftop equipment such as HVAC equipment (including both securement of equipment to curbs and curbs to the building structure), satellite dishes, raised equipment, antennas, and small vents and fans. Simple retrofits can be made by adding screws at the base for additional securement.

RECOMMENDATIONS:

Follow recommended design and installation guidelines in the data sheets, select products from the *Approval Guide* a publication of FM Approvals, consult with your FM Global engineer and utilize the FM Global project management and plan review services for all new projects. Also, consider replacing roofs that are nearing the end of their service life or have known deficiencies.

During construction projects, closely monitor contractors to ensure product selection and installation follow original specifications.

GLASS WINDOWS AND OTHER OPENINGS

Glass curtain walls and windows are exposed to large windborne debris and inward and outward wind pressures during a storm. Windborne debris such as sign posts, tree branches, building materials, and outdoor furniture and equipment can damage glass and create large openings for rain water to enter buildings. In coastal areas, building materials and equipment are especially susceptible to wind driven salt water spray. Damaged openings can also provide access for vandals.

RECOMMENDATIONS:

Prior to a storm, survey roofs and surrounding areas for potential windblown debris. Glass windows should either be protected with metal hurricane shutters or replaced with approved large missile impact glass that is properly rated for pressure. Plywood can be used post storm to cover any damaged openings. Sensitive equipment or valuable contents should be located away from glass openings. Stock or water sensitive equipment should also be raised above floor level.

Other considerations include replacing openings that are no longer needed with properly designed blank walls, ensuring that perimeters around glass openings are properly sealed and caulked, inspected/replaced regularly, and ensuring that other penetrations through walls are properly sealed.

DOCK AND ROLL-UP DOORS

Dock and roll-up doors are another type of opening that can allow water to enter a building if they are not constructed to resist windborne debris impact and pressure. Similar to windows, failure of these building components can create large openings in walls during a storm. These doors should either be braced with metal brackets on the inside and outside of the doors or replaced with approved, properly wind-rated (for impact and pressure) doors. Contact your FM Global engineer for the best solutions.

VULNERABLE ROOF AREAS AND COMPONENTS

When wind passes over a roof surface, a negative or suction pressure is developed. Positive pressures inside the building are also increased when wind is allowed to enter the building from failure of window or door assemblies.

Uplift pressures in the field of a roof area are increased further within the perimeters and corners of the roof. If securement of roof coverings and roof decks is deficient, failure of these components can result; and water is allowed to enter the building from above. Severe water damage will then occur to the buildings, equipment, and stock and supplies; and operations' downtime can last several months for clean-up and repairs.

Many different types of roof coverings and roof decks are available. There are also many different types of securement, including cold adhesives, asphalt adhesion, mechanical fasteners for roof coverings and welds, clips and fasteners for metal, wood and other types of roof decks.

Roof gravel is another type of windborne debris that breaks windows and doors. Roof gravel should be eliminated or fully embedded in hot asphalt when possible.

RECOMMENDATIONS:

Choose construction materials (such as reinforced concrete) that are more resistant to wind uplift forces than others. Also, choose FM Approved roof cover and deck assemblies with the proper wind ratings for the geographic location and building configurations at a given location. For existing constructions outside of FM Approvals (wood, cementitious wood fiber, gypsum decks, clay tiles or asphalt shingles), consult with your FM Global engineer.

In hurricane-prone areas, select clay or concrete tiles that have two or three starter holes. Drive fasteners through every hole provided on each tile. FM Global recommends at least two fasteners and a polyfoam adhesive for tiles in the field of the roof; use three fasteners and adhesive for tiles at the edge, in corners and along the ridge of peaked roofs. Screws provide greater uplift resistance than nails. Also, consider adding mortar in the openings at the edge of tiles installed along the first row at the eaves.

Where pea gravel has been used on a built-up roof, sweep back any loose stones, flood-coat the roof with hot asphalt or coal tar and then sweep the gravel over the hot coating. Allow to set; then remove any loose gravel.

In new construction, make sure the newly applied gravel is embedded in the asphalt; then remove whatever remains loose.

Uplift testing is another great tool for verifying the securement of a newly completed or existing roof installation. Visual construction observers are also an option during the installation of new roofs.

ROOF FLASHING

Roof cover flashing is the first point storm winds hit and is often not properly secured and easily susceptible to uplift and failure. Flashing terminates the edges of roof coverings; and when it fails, it can uplift even adequately secured coverings once the wind is allowed to get up and under the surface. This results in water damage and business interruption inside a building. Flashing is typically constructed by attaching a metal cap over a metal hook strip or anchors. Securement for flashing metal is often not visible, and deficiencies are not noticed unless seen during installation or discovered while trying to pull up on the flashing edge.

RECOMMENDATIONS:

Where deficient flashing securement is found, through fastening of the cap metal to the wood nailer or building behind the metal with neoprene or rubber washers to prevent water intrusion is recommended. FM Global engineers should be consulted on the best method and design for a given building.

This roof cover on a lightweight concrete deck was damaged when fasteners pulled out of the concrete.

An insulated steel-deck roof was blown off this building.

This standing seam roof uplifted when the metal panels detached from the metal clips.

EXTERIOR INSULATING FINISHING SYSTEMS (EIFS)

This common light weight wall and parapet construction system consists of an insulation substrate (often gypsum board) with layers of expanded or extruded polystyrene and fiber reinforced mesh and a hard plaster surface finish. This construction can either be installed on concrete walls or metal studs and is highly susceptible to damage from wind-borne debris and wind pressures. During severe storms, large holes in these assemblies are created from windborne debris. Wind pressures will also separate the assemblies from concrete or metal stud walls. Corrosion from water intrusion and (in coastal locations) salt water spray can affect metal studs. EIFS around the perimeters of window assemblies is often improperly sealed and caulked. Similar damage has occurred to plaster on metal lathe construction. Severe storms over the last 20 years have shown how susceptible this type of construction is to wind and rain. FM Approved wall systems designed to withstand the anticipated wind forces should therefore be used in place of EIFS.

RECOMMENDATIONS:

Properly maintaining the water tightness of EIFS systems is critical. The sealant or caulking of EIFS cladding, especially around the windows, should be inspected every year and repaired or replaced as needed. The walls also should be inspected for visual signs of delamination or deterioration, which may include bowing or a loose feel when pushed. Most of all, your wind emergency response plan should account for the loss of large sections of these walls.

Anchor exterior wall sections of plaster-on-metal-lath to studs on the main building structure. Interior partitions are best when built full-height from the floor up to the overhead floor slab or roof framing, and anchored at top and bottom. (Such a design also acts as a fire cutoff for the surrounding area as long as doors are closed.)

Reinforced concrete or reinforced-concrete block walls offer the best windstorm protection for new construction. Other wall assemblies should be evaluated for proper pressure and windborne debris ratings. EIFS is not recommended by FM Global, particularly for use in high wind areas.

FIX IT RIGHT

After a severe windstorm, assess the damage and need for repairs. The fastening of the deck to its supporting structure may need to be reinforced or sections of the deck replaced before a new covering is placed over it. In other cases, only sections of covering and insulation will need to be replaced. In all cases, periodic maintenance will need to be performed. The age of a roof assembly or deck should be considered when evaluating the need for maintenance or repairs. For proper repair and reroofing, follow the appropriate FM Global Property Loss Prevention Data Sheet (for installation guidelines) and RoofNav (for product selection). Ask your local FM Global office to review plans before you undertake any work.

Periodic inspections and routine maintenance will go far to minimize the need for major unexpected repairs that often follow a severe windstorm. Subtropical and coastal regions most subject to severe windstorms such as hurricanes often are exposed to saltwater spray from the ocean. Under such conditions and without appropriate attention, steel cladding and framework can be weakened by corrosion; and wood construction can rot from decay and insect infestation. Concrete and associated steel reinforcing bars (not epoxy-coated) in sea walls and oceanfront walkways are likely to deteriorate.

PROBABLY THE SINGLE MOST COST-EFFECTIVE MEASURE AGAINST WIND DAMAGE TO A ROOF IS TO ENSURE FLASHING IS PROPERLY SECURED.

Your own staff can handle some of these essential repair and maintenance tasks if the specified equipment and materials are used. Other work should be completed by a contractor. In any case, discuss all plans for roofing work with your FM Global engineer.

CONSTRUCTION IN PROGRESS

Wind is more likely to damage buildings under construction for a number of reasons. Steel framing, precast concrete wall panels and masonry block walls are all vulnerable while they are being erected and not fully attached to adjacent walls and the roof. A steel beam is usually attached to a column with a minimum number of bolts until the frame is completed and aligned. Precast and tilt-up concrete wall panels are supported only at the bottom until they are stabilized at the top by the structural roof. Concrete block walls are commonly erected to unsafe heights without lateral support; and they are easily blown over by moderate winds, especially when they have not yet been tied to structural steel framing.

For steel framing, provide cross-bracing between columns with cable. Concrete block walls should be braced at an incline from the ground up to the ceiling on both sides of the wall. Tilt-up concrete walls need similar lean-to pipe bracing on both sides until they are attached to the roof. On the rooftop, fasten deck panels, roof covering and flashing promptly and securely as construction progresses. If necessary, provide temporary ballast in the form of paver blocks along roof edges and corners. Rooftop equipment should be fastened securely to the roof. If high winds are forecast, remove building materials and tools from the rooftop. Otherwise, they may blow off, delaying construction and possibly causing damage to nearby structures.

STEEL FRAMING, PRECAST CONCRETE WALL PANELS AND MASONRY BLOCK WALLS ARE ALL VULNERABLE WHILE THEY ARE BEING ERECTED.

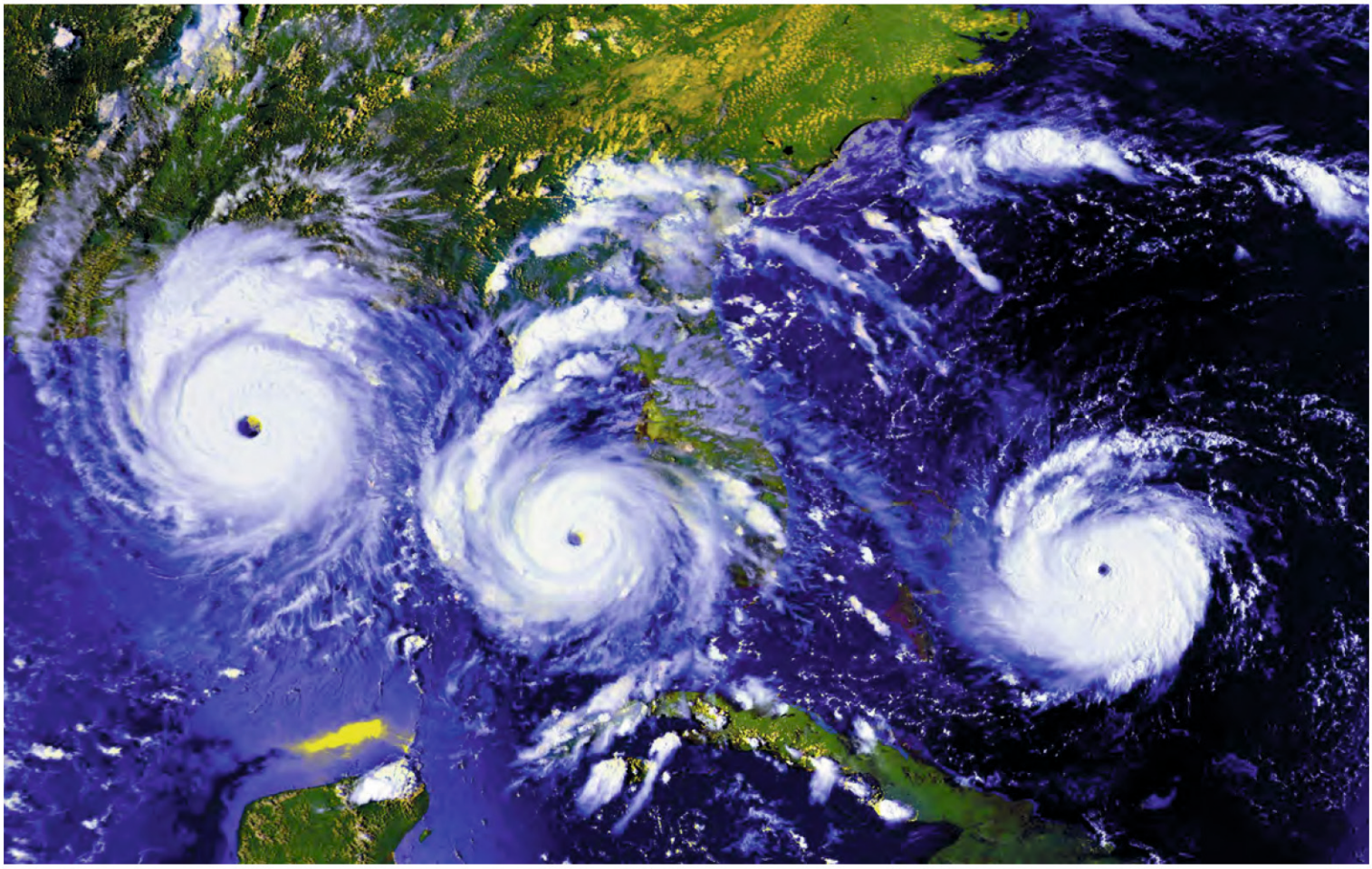
THE HUMAN FACTOR

The scope of preparation depends largely on the potential strength of windstorms likely to strike your facility's location. In areas prone to severe windstorms, tracking the storm's development and movement should provide time to make appropriate preparations if you have a proper wind emergency response plan in place. But remember, preparations must be completed before the onset of high winds, which will arrive well before the hurricane eye on which the forecast concentrates. Preparations should take no longer than 12 hours to complete. Often a storm's forward speed will increase, resulting in the onset of high winds earlier than expected.

IN AREAS PRONE TO SEVERE WINDSTORMS, TRACKING THE STORM'S DEVELOPMENT AND MOVEMENT SHOULD PROVIDE TIME TO MAKE APPROPRIATE PREPARATIONS.

ORGANIZE STAFF

If your location is in or near the path of a severe windstorm, be sure your wind emergency response team (ERT) is equipped to take action before the storm to minimize damage and to deal with potentially widespread and massive damage after the storm. To be fully prepared, the ERT roster should include alternate team members.



PREPARE THE BUILDING

Survey the condition of your buildings and ancillary structures such as roof-mounted equipment (see FM Global Property Loss Prevention Data Sheet 1-28, *Wind Design*), cooling towers (see FM Global Property Loss Prevention Data Sheet 1-6, *Cooling Towers*), antenna towers and signs (see FM Global Property Loss Prevention Data Sheet 1-8, *Antenna Towers and Signs*), cranes (see FM Global Property Loss Prevention Data Sheet 1-62/17-16, *Cranes*) and chimneys (see FM Global Property Loss Prevention Data Sheet 1-13, *Chimneys*). Wind loads should be per FM Global Property Loss Prevention Data Sheet 1-28, *Wind Design*. Make building repairs as time permits, giving flashing and roof-mounted equipment priority status. Have hurricane shutters ready to mount over windows by attaching them to hardware previously installed.

YOU WILL NEED RELIABLE COMMUNICATIONS BETWEEN ERT PERSONNEL AND ANY OPERATING PERSONNEL REMAINING AT YOUR FACILITY DURING A STORM.

Make sure roof drains, outdoor drains and ditches on and near the property are free of debris so they can handle the heavy rain that normally accompanies tropical storms.

To facilitate evaluations and repairs after a storm, provide full contact lists for employees and contractors, identify key utilities and contractors that will be needed following a storm, and consider keeping certain contractors on retainer for repairs on critical services and utilities. Also, ensure the safety plan for accessing a site post storm and conducting evaluations on utilities is up to date.

MAINTAIN COMMUNICATIONS

Reliable communication will be needed for ERT personnel and any operating personnel remaining at the facility during the storm, especially at a sprawling complex and between your facility and sister plants or public services. Look to redundant means of communication, such as internal and internet email, cellular phones, two-way radio, CB radio and even ham radio.

Under severe weather conditions, utility poles, satellite dishes and transmission towers may be damaged and unreliable; and phone lines may be constantly busy. Portable radios with fresh batteries will help you keep in touch with announcements from the weather service and local public authorities.

CHECK UTILITIES

Consider dependence on electricity. Plan to purchase or rent portable generators ahead of time. Make sure the equipment will start and has an adequate fuel supply. Have portable lanterns and flashlights with fresh batteries ready. Computer systems and some industrial processes may need to be shut down in an orderly fashion as the storm gets closer to avoid damage caused by erratic supply, surges and abrupt loss of power. For those computer or production operations that cannot tolerate a shutdown, prepare an uninterruptible power supply.

At the same time, some nonessential circuits may need to be shut down to avoid short-circuiting and ignition of any exposed combustible material. Piping that carries gas, liquid or process water may need to be shut off. Know where the shutoff valves are located.

INSPECT FIRE PROTECTION

Assign ERT personnel to check the fire protection system before, during and after a storm. Make sure sprinkler system control valves are open, and know which valve shuts off only that part of the system affected by broken piping. Shut off as little of the sprinkler system as necessary—shutting off too much of the system will leave your facility unprotected if a fire occurs—and contact your local FM Global office, taking necessary precautions by following the Red Tag Permit System, FM Global's sprinkler impairment program. Emergency power for electric-motor-driven fire pumps and ample fuel for internal, combustion-driven pumps should be available. Have special protection systems, such as carbon dioxide and foam, designed to switch over to battery backup in case of power loss. Similarly, have a backup for deep-well pumps to ensure the water supply continues for fire protection and critical processes.

PROTECT EQUIPMENT

With the possibility that water will leak into the building from rain and nearby overflowing streams or inadequate drainage of surrounding soil, ERT personnel must be ready to relocate equipment and storage— especially away from unprotected windows and ground-level doors— or cover it with waterproof tarpaulins. Have water vacuums, pumps, mops, buckets, water absorbents and dehumidifiers ready for cleanup and salvage after the storm.

Keeping good records and stockpiling critical spare parts for key machinery and equipment can make a difference in expediting repairs and returning to service.

Other emergency flood damage mitigation measures may need to be taken, depending on the facility's location. For long-term planning, talk to your FM Global engineer about the threat to your facility from flood waters or surface runoff.

For a more complete checklist of precautions to take before, during and after a windstorm, refer to the FM Global publication, *Emergency Checklist: Wind* (P9308).

ALTHOUGH SEVERE WINDSTORMS CANNOT BE PREVENTED, THE SEVERITY OF WINDSTORM DAMAGE CAN.

Cost-effective loss prevention guidelines, appropriately applied to your facility, are available from your FM Global engineer. When followed, windstorm damage to facilities will be minimized or even prevented. While severe storms cannot be prevented, the majority of loss and effects from these storms can be reduced with the above guidance. FM Global is committed to partnering with our clients to mitigate these effects and protect assets their business creates.

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