Protecting Your Facility Against Major Windstorms

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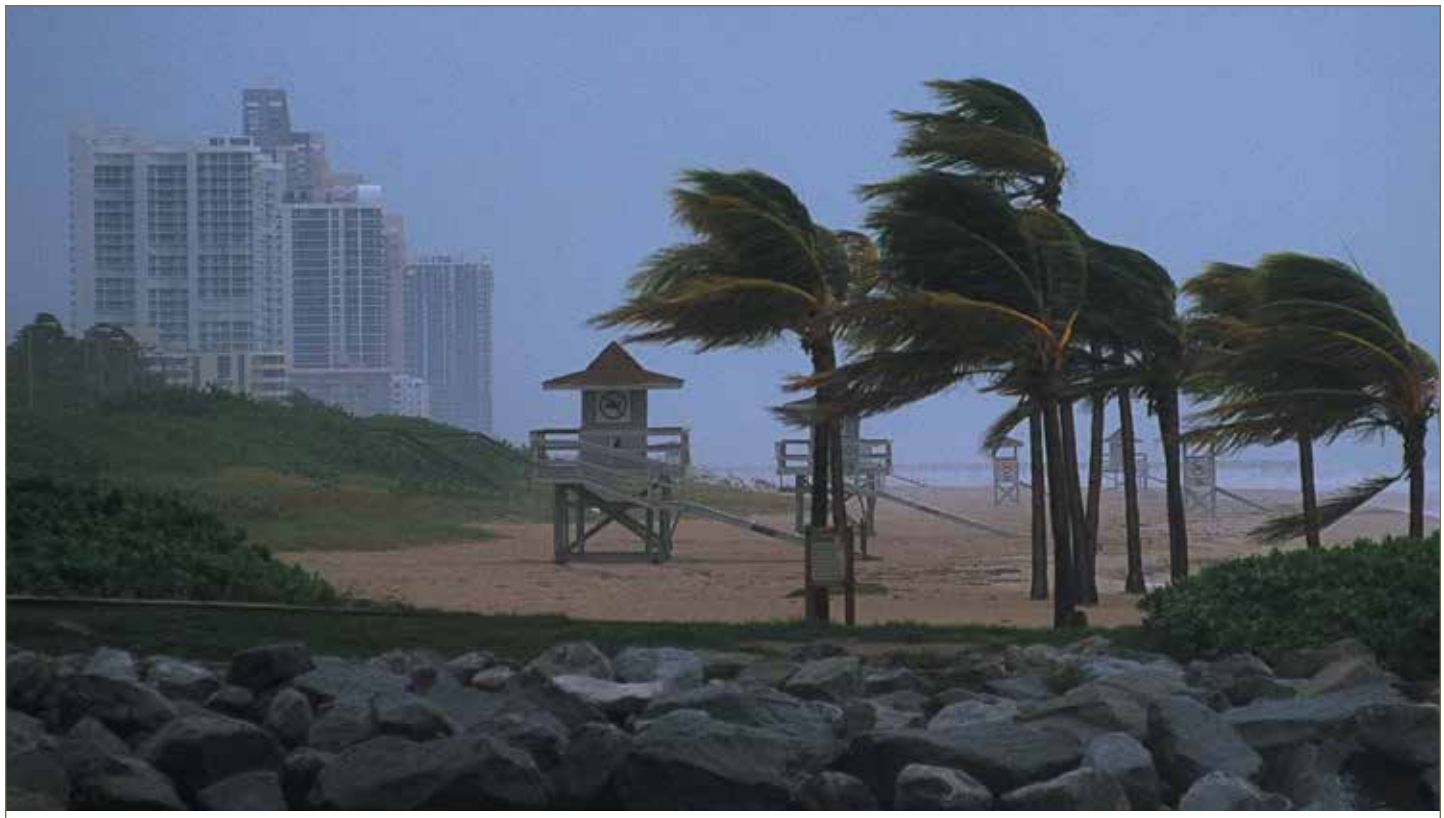

Over the many years that FM Global has analyzed windstorm damage to buildings, including damage caused by severe windstorms in the past decade or so, one fact is clear: Buildings designed, built and maintained according to FM Global's recommended guidelines have withstood high winds with minimal damage. Significant loss has been limited mostly to buildings that did not meet FM Global standards. Another factor: FM Global guidelines are likely to exceed the requirements of local building codes.

By Any Name, A Formidable Hazard

No peril can match that of a severe windstorm in its ability to cause widespread devastation. Such storms include hurricanes, typhoons and cyclones—depending on the part of the world they affect—and their fierce winds have been among the most significant contributors to FM Global client losses, for an a nnual average of US$210 million gross in the last 25 years. Ten percent of all damage sustained by FM Global clients during this period was related to wind.

Approximately 50 percent of these losses resulted from severe hurricanes and tropical storms, including the four significant hurricanes that struck Florida, USA, in 2004—an industry record-breaking hurricane season. With proper knowledge and preparation, however, you can minimize extensive wind damage and the risk it represents to your business—even in the most severe storms.

Understanding Wind

Before you can secure your facility against the impact of windstorms, you would do well to 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 rapidly. For example, a constant breeze of 20 mph (32 kph) exerts a pressure of 1 psf (48 Pa). When wind speed is increased four times to 80 mph (129 kph), pressure increases 16 times to about 16 psf (766 Pa). The stronger winds from a hurricane, combined with gusting effects and the extra force at the roof perimeter and corners, cause pressure to quickly multiply.

Remember that wind speeds are not necessarily uniform over a given area. If you think you've survived a major hurricane, find out the top wind speed at your facility. The diameter 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

It is important to know which basis is being applied in reports on the intensity of a windstorm. 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.

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

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 likely 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, costs and business strategy. Where possible, choose a built-up area, away from flat, unobstructed terrain. FM Global engineers can help you factor in ground roughness as you determine how much wind resistance you need for a new or renovated building.

Vulnerable Occupancies

FM Global has found that, at some facilities, rain entering the building—not wind striking it— accounted for most of the damage. Rain pouring in through the roof or broken windows will damage products, metallic surfaces prone to rust, electronic instrumentation and chemicals. Items stored directly on the floor are especially vulnerable.

Recommendations:

Place extra emphasis on a properly designed and maintained building, especially the roof, according to FM Global Property Loss Prevention Data Sheets and the *Approval Guide*, a publication of FM Approvals. Store products off the floor on pallets, and keep ample waterproof tarpaulins on hand to cover vulnerable equipment, material in process and finished goods.

Design and Installation Deficiencies

Most design and installation deficiencies are in the roof, leading to problems with flashing, roof covering, insulation and even the deck itself. Such deficiencies allow rainwater to enter buildings and destroy equipment, furnishings and interior finish. Frequent damage has been the result of unreinforced masonry parapet walls and decorative facades; these structures can blowover and destroy the rooftop or anything else they strike.

Recommendations:

Follow recommended design and installation guidelines in the data sheets, select products from the *Approval Guide*, and ask your FM Global engineer to review construction plans. Avoid unreinforced parapets and decorative facades. 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 your original specifications.

Glass Windows and Other Openings

Glass wall panels and plate-glass windows are vulnerable to breakage by wind-borne debris and the direct force of wind. Tree branches, outdoor furniture, building materials, gravel and roof tiles can become missiles that will break glass. If a large opening results, wind and soaking rain will cause significant damage in the building. In coastal areas, wind-driven saltwater spray may cause additional damage to sensitive equipment. In locations with a year-round warm climate, buildings with open sides, windows and doorways will be more vulnerable to damage by high winds and rain. Unless the facility is promptly secured after a storm, broken windows at ground level also will provide easy access for looting and vandalism.

Recommendations:

Before a storm, remove outdoor furniture, trash containers and other relatively lightweight objects that could become windblown missiles. Shield windows with hurricane shutters or plywood. Close and latch exterior doors and windows, and brace large doors at shipping and receiving docks. Indoors, relocate equipment away from windows, where practical, or cover it with waterproof tarpaulins. If smaller items are on the floor, place them on pallets, racks or shelving.

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.

Consider replacing large windows with smaller ones, filling the remainder of the window space with wall construction equal to the rest of the building. Replace standard glass windows with a laminated glazing system that meets test criteria for missile resistance. In new buildings, increase use of blank wall construction and narrow profile windows.

When a hurricane is approaching, latch all doors securely. If you have a doorway you no longer need, and eliminating it will not compromise emergency exiting, remove the door and fill in the opening with construction equal to that in the rest of the building. In a building with open doorways and sides, use a design with increased resistance to uplift. Long term, when you purchase doors, opt for sturdy products and rugged framing that will resist wind forces well. Tightly install windows, doors, air conditioners, vents and similar penetrations through the building's skin. Maintain well-sealed joints, replacing caulk and joint-covering trim as needed.

Vulnerable Roof Features

When wind strikes a flat or near-flat commercial roof and sweeps over it, a negative or reduced pressure results, especially along the windward edge or corners of the roof the wind strikes first. (FM Global research and other studies of loss experience clearly show wind forces are greater along the periphery of the roof than in the field, or center, and at a maximum at corners.) The pressure within the building remains positive, which leads to an upward force against the roof assembly. In addition, wind that enters the building creates an additional positive force that acts upward against the roof system and outward against leeward walls.

The combination of negative pressure over the roof and positive pressure beneath it results in uplift pressure that may peel off components of the roof or lift the entire roof assembly off its supporting framing.

Extensive damage to roofs is caused by winds of lesser velocities if the design, installation or maintenance is deficient. Depending on wind speed, the damage may include gravel blown off a roof, covering peeled off, insulation ripped off the deck, metal panels pulled over their fasteners, and even sections of the deck lifted off the framing. In many cases, a common denominator is loosened flashing, which allows the wind to pry into the exposed edges of the roof covering and insulation. If the roof looks to be in bad condition, it won't hold up to hurricane winds.

Many older steel deck roofs have insulation that is only adhered to the steel deck and are very vulnerable to windstorm damage. In fact, this type of roof system is no longer FM Approved for any location. However, newer steel deck roofs with mechanically fastened insulation (you can see the fasteners from inside the building) also can be vulnerable if not correctly installed with the

proper type and number of fasteners. Additional fasteners are required in the perimeter and corners due to the higher uplift pressures in these areas. FM Global also has found clay and concrete roof tiles that were inadequately fastened. In other cases, facilities used only mortar without any fasteners. Loosely or inadequately attached tiles were blown off the roof, becoming missiles that broke windows and damaged wall surfaces.

Roof gravel is another source of missile damage. Gravel generally provides a benefit in resistance to wear and ultraviolet radiation, but loose gravel is easily blown off the roof by high winds, and will mar building surfaces and break window and door glazing.

Recommendations:
The best protection is provided by poured reinforced concrete, proven to be highly resistant to high winds. Other types of FM Approved roof systems listed in the *Approval Guide* also can provide effective protection.

Especially 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 adhesive for tiles in the field of the roof; use three fasteners 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 and then remove whatever remains loose.

If you have any doubt about a roof's resistance to wind forces, contact your local FM Global office to discuss having the roof deck and roof cover securement analyzed or having a contractor conduct an uplift test. In fact, to make sure you're getting the roof you paid for, FM Global now recommends an uplift test be conducted before accepting new roofs (for roof types that can be tested) where the basic wind speed is equal to or greater than 100 mph (161 kph). See Data Sheet 1-52, *Field Uplift Tests*, for applicability and testing details.

Other Vulnerable Construction Features

Exterior Insulation and Finish Systems (EIFS) are used extensively in newer construction at resorts and hotels. Many times, large pieces of the EIFS assembly are blown off, bringing hurricane winds and rain directly into hotel rooms and offices. The removed EIFS pieces then become flying missiles, breaking large windows of nearby buildings. This was seen extensively during the 2004 hurricane season, even where the gypsum board appeared "well-secured" to the steel studs with a 6-in. (152-mm) screw spacing. (EIFS

The lightweight concrete on this metal roof was severely damaged by a tropical storm.

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

Panels of this standing-seam deck were torn off; leaving the fasteners still attached to the roof framing.

is multilayered, usually consisting of gypsum board attached to the exterior of metal studs, then covered with expanded or extruded polystyrene, which, in turn, is faced with a thin layer of glass-fiber-reinforced polymer-modified plaster or thin sections of brick.) Similar damage has occurred to plaster-on-metal-lath construction, widely used at resort buildings for balcony dividers (privacy screens), which breaks away under high winds, turning pieces into destructive missiles. Skimpy attachment of steel studs to the building frame and corrosion of studs over time appear to be responsible for such damage.

Recommendations:

It is critical to properly maintain the water tightness of EIFS systems because water penetration will greatly weaken the EIFS system. The sealant or caulking of EIFS cladding, especially around the windows, should be inspected every five years and repaired or replaced every 15 years or when necessary. The walls also should be inspected for visual signs of delamination or deterioration, which may include bowing or a loose feel when pushed in. 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 wind-borne debris ratings. EIFS is not recommended by FM Global for use in high-wind areas. You also should consider if you, your employees, your guests (especially hotels) and your business are safe behind the selected wall assembly, with wall studs and tree branches flying outside during a hurricane. Damage and restoration time will vary greatly depending on the system chosen. Will your customers be waiting for you?

Flashing: The Key Component

The most important component of a roof system is the flashing. It acts as a termination along the edge of a roof where it meets the wall. If high winds loosen perimeter flashing, further damage to the rest of the roof—roof covering, insulation and even the

deck—is inevitable. Inadequately designed and installed flashing will likely lead to additional damage from water leakage.

Recommendations:
Probably the single most cost-effective measure against wind damage to a roof is to ensure flashing is properly secured. It is vitally important to attach perimeter flashing well enough to prevent it from being pulled loose by wind. When installing new perimeter flashing, be sure to continuously attach its lower part to a hook strip that is firmly secured to the building. For wood nailers and cant strips, give preference to high-quality preservative-treated lumber, and anchor it securely to the main structure. (See the *Approval Guide* and details illustrated in Data Sheet 1-49, *Perimeter Flashing*.)

When inspecting existing flashing, just pull out on the lower edge. If it feels loose, resecure it with appropriate weather-resistant fasteners driven through washers. For further advice, contact your FM Global engineer.

Fix It Right

After a severe windstorm, you are likely to face some degree of damage and the need to make repairs. You may need to reinforce the fastening of the deck to its supporting structure, or replace sections of deck before a new covering is placed over it. In other cases, only sections of covering and insulation will need to be replaced. Even when storm damage is not a consideration, you will need to perform periodic maintenance—spot repairs or more extensive reroofing—on an aging roof. For proper repair and reroofing, follow the appropriate data sheet (for installation guidelines) and the *Approval Guide* (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 follows a severe windstorm. Subtropical and coastal regions most often 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, it is best to discuss all plans for roofing work with your FM Global engineer.

Steel framing, precast concrete wall panels and masonry block walls are all vulnerable while they are being erected.

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 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 blowoff, delaying construction and possibly causing damage to nearby structures.

The Human Factor

The scope of preparation depends largely on the potential strength of windstorms likely to strike in 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 that the forecast concentrates on. It's recommended preparations take no longer than 12 hours to complete because, many times, 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 give you time to make appropriate preparations.

Organize Staff

If the path of a severe windstorm suggests it may bear down on your location, be sure your 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 passes. 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 cooling towers (see Data Sheet 1-6, *Cooling Towers*), antenna towers and signs (Data Sheet 1-8, *Antenna Towers and Signs*), cranes (Data Sheet 1-62/17-16, *Cranes*) and chimneys (Data Sheet 1-13, *Chimneys*). Wind loads should be per Data Sheet 1-28, *Design Wind Loads*. Make building repairs as time permits, giving flashing priority status. Have plywood or hurricane shutters ready to mount over windows by attaching them to hardware previously installed. (Note: FM Global does not consider window taping to offer significant protection.)

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 repairs after a storm, renovations when needed and assessment of the roof's ability to withstand strong winds, keep up-to-date building plans and specifications securely filed.

Maintain Communications

You will need reliable communications between ERT personnel and any operating personnel remaining at your facility during a 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 e-mail, 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 how dependent you are on electricity. Plan to purchase or rent portable generators ahead of time. Make sure the equipment will start and you have an adequate fuel supply. Have portable lanterns and flashlights with fresh batteries ready. You may need to shut down computer systems and some industrial processes in an orderly fashion as the storm gets closer, to avoid damage caused by erratic supply, surges and abrupt loss. For those computer or production operations that cannot tolerate a shutdown, however, prepare an uninterruptible power supply.

At the same time, you may need to shut down some nonessential circuits 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.

Protect the 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 a 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.

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

You may need to take other emergency flood damage mitigation measures, depending on the facility's location.

For long-term planning, talk to your FM Global engineer about the threat of flood waters or surface runoff to your facility. Refer to Data Sheet 9-2, *Surface Water*, and 9-13, *Evaluation of Flood Exposure*, for appropriate measures inside and outside buildings.

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

Although severe windstorms cannot be prevented, the severity of windstorm damage can.

Cost-effective loss prevention guide. lines, appropriately applied to your facility, are available from your FM Global engineer. When you follow them, you will greatly minimize or even prevent windstorm damage to your facilities. Although severe windstorms cannot be prevented— nor their courses changed, nor their strength diminished—our knowledge of how to minimize damage by these and lesser storms continues to expand.

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- Toll-free: (1)877 364 6726
  (Canada and the United States)
- Phone: +1 (1)401 477 7744
- Fax: +1 (1)401 477 7010
- Email: customerservices@fmglobal.com