WINTER WEATHER

1 Introduction

The Insurance Institute for Business & Home Safety's (IBHS) Commercial Risk Engineering Bulletins address specific natural hazard risks and conclude with recommendations for reducing damage particular to that risk. Incorporating the selected materials, design features and maintenance items from this bulletin will reduce the vulnerability of buildings exposure to winter weather.

The methods prescribed in this bulletin are to be applied in conjunction with federal, state, and local codes, ordinances and regulations. In case of a conflict between provisions, use whichever regulation is more stringent.

2 Risk Overview

Severe winter weather is a large cause of insured catastrophe losses and is a risk for many regions of the country, including portions of the typically warmer southern United States. It causes structural damage to buildings from excessive snow loads, water damage from frozen pipes, and generates dangerous ice dams on the roof. Depending on your business's specific location, it could have a greater risk of exposure to these elements. This risk engineering bulletin provides practical protection for commercial structures to reduce the damaging effects of this hazard.

2.1 Exposure

The map in Figure 1 is based on the winter design temperature map in the 2018 International Building Code (IBC). All areas in the continental United States north of the 32°F line are covered by the recommendations in this bulletin.

Additionally, there is a greater potential for damage from ice dams in areas prone to snowfall accumulations greater than 12 inches. For site-specific snow accumulations contact the local building department.

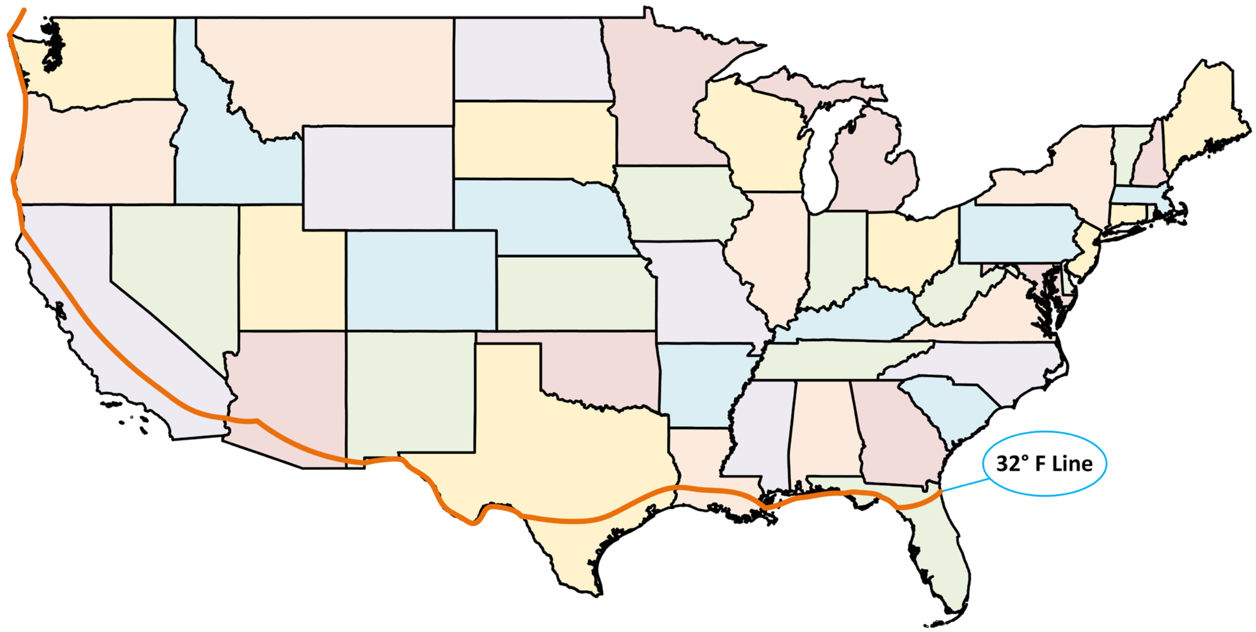

Figure 1. Winter Weather Zone for This Bulletin

3 Background

3.1 Snow and Other Loads

Weight of Snow

When it comes to the weight of snow, the type of snow is as important as the depth of the snow. Fresh powder type snow is typically lighter than wet packed snow and ice is heavier than snow. During the winter months, a roof system can be exposed to all three combinations over several months.

The following conditions add about 5 lbs per square foot on a roof:

- 10–12 inches of new snow
- 3–5 inches of packed/old snow
- 1-inch of ice

So, the total amount of accumulated snow and ice is what matters in evaluating snow load risk. For example, the accumulated weight of two feet of old snow and two feet of new snow could be as high as 60 lbs per square foot of roof space, which could stress the limits of even the most conservatively designed roof.

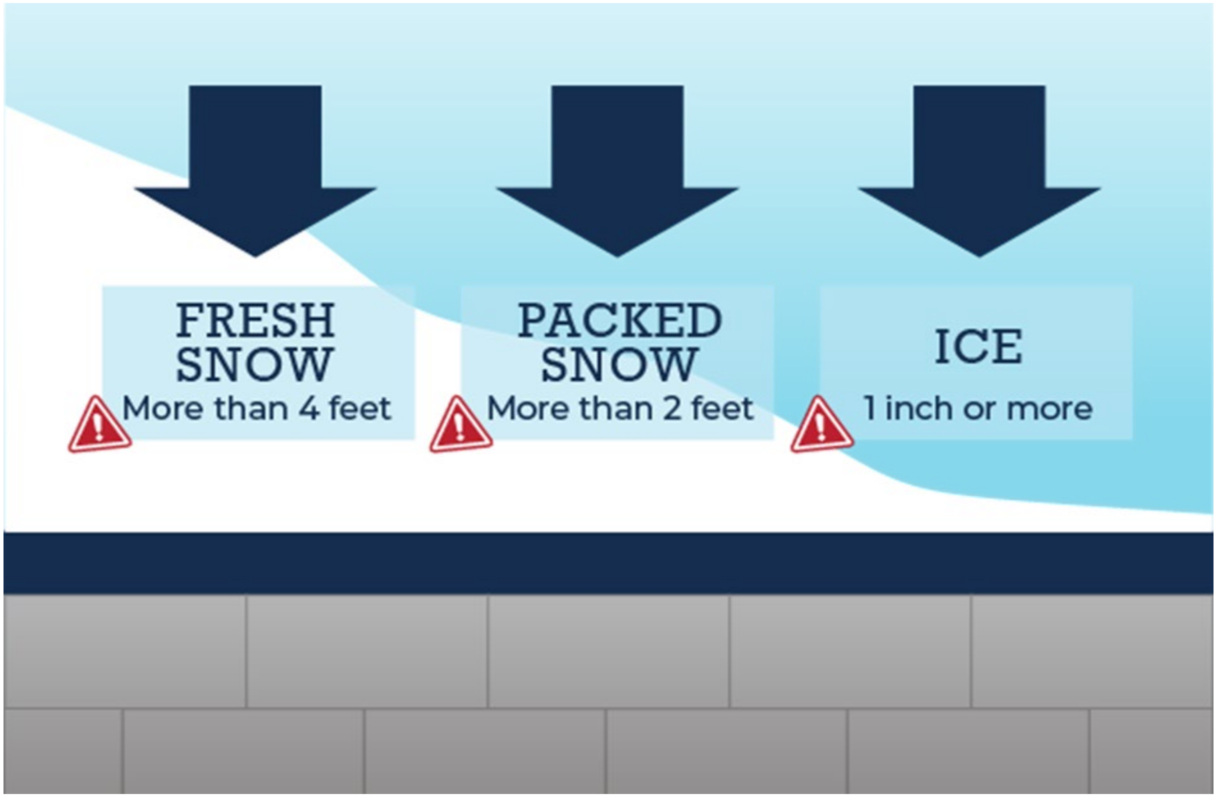

Figure 2. Snow and Ice Equivalent

During and after a snow storm it is important to understand the total weight of snow there is on a roof. When it is safe to do so, conduct a visual assessment of the snow and note the type of snow. If you have an accumulation of snow and/or ice on your roof similar to Figure 2 or if the load you estimate (based on the depth of accumulations) exceeds 20–25 pounds per square foot (psf), you should have the snow removed from your roof.

When designing a commercial building or structure, engineers must consider all the loads snow can produce. The American Society of Civil Engineers (ASCE) standard, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (ASCE 7), outlines the minimum loading produced by snow and ice loads that must be incorporated into the design of the roofing system and related structural components.

Snow Drifts and Sliding Snow

When snow and wind play a role in winter storms it is likely to see greater snow accumulations, known as snow drifts, in certain areas. The roof's geometry and its mounted equipment contribute to this accumulation of snow.

Low sloped roofs (≤10°) are subject to variable snow depth across its surface and tend to see significant snow drifts around mechanical units, photovoltaic units, adjacent taller buildings, and parapets (see Figure 3). The snow drifts in these locations can add significant loads to the roof and structure.

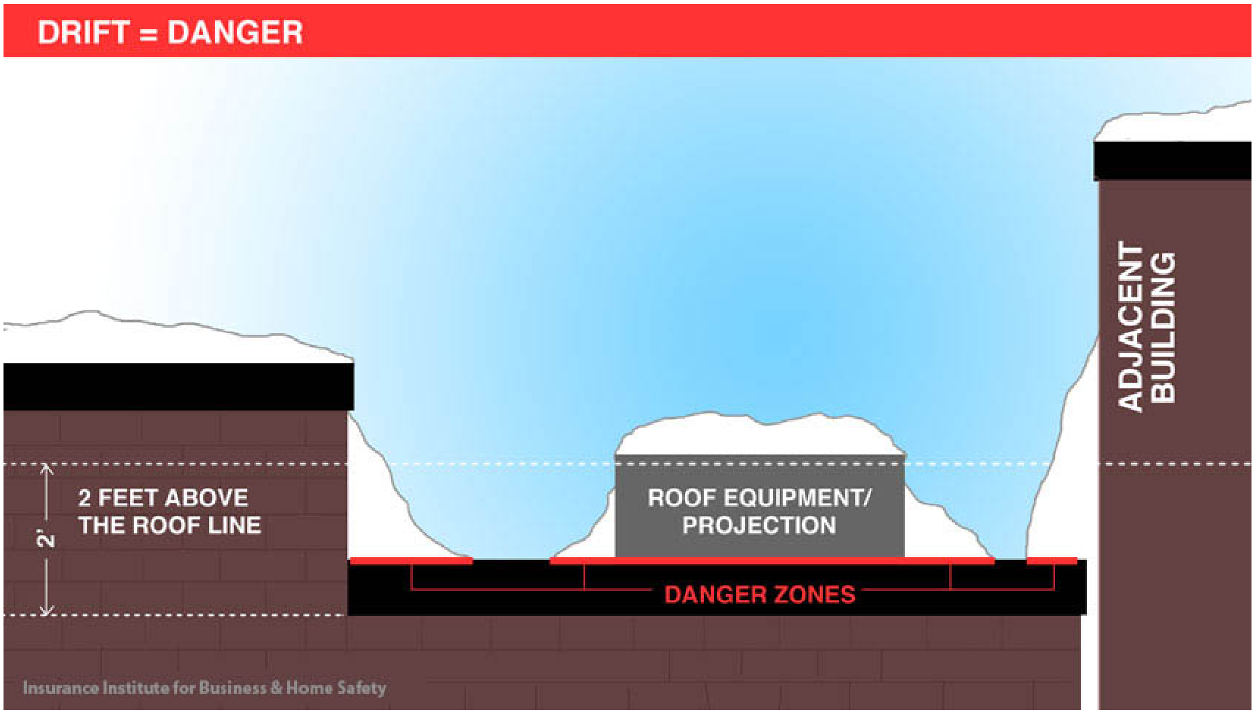

Figure 3. Snow Drift- Roof Geometry and Mechanical Equipment

In some cases, steep sloped roofs (>10°) can also see snow drifts at roof geometry changes and mounted equipment. For example, snow drifts can form on a steep slope roof where the roof deck and chimney meet.

Additionally, steep sloped and curved roofs are subjected to sliding snow if snow cleats are not installed. This sliding snow can fall to a lower roof and overload the structural deck or members which can lead to failure.

Modern building codes account for the additional weight of snow drifts and sliding snow. However, older buildings are more vulnerable to failure in these areas.

Heavy Rain on Snow

Modern building codes account for the additional weight of moderate rain on top of existing snow for commercial building design. While long periods of heavy rain could wash away the snow on the roof, it is possible to have short-term heavy rain that does not wash away the snow. This situation greatly increases the total load on the roof and can lead to roof damage or failure.

Melting Snow and Refreezing

When snow melts, due to weather conditions or from the internal temperature of the building, there is a possibility for that meltwater to re-freeze. Such conditions can be seen during a sunny afternoon where part of the snow melts and then below freezing temperatures at night freezes the water. This situation creates dynamic and heavy loads on portions of the roof which could lead to overloading and failure. Additionally, this phenomenon can produce ice dams.

3.2 Ice Dams

Ice dams are ridges of ice that form at the edge of a steep sloped roof or around drains on a low sloped roof and prevent meltwater from draining off of the roof. The water that backs up behind this ice dam can leak into the building and cause damage to the roof, insulation, ceilings, walls and other areas. Additionally, when the roof doesn't drain properly, snow, ice and water remain trapped on the roof, adding loads that put your roof at greater risk of failure.

Steep Sloped

Ice dams form on steep slope roofs when there is a layer of snow on the roof and heat within the building rises into the attic and warms the roof. The snow on the roof melts, and water runs under the snow down to the roof edge. The lower edge of the roof tends to be coldest because it typically has an overhang that extends past the warm interior of the building and does not get as much of the structure's heat. At the lower edge, the water refreezes under the snow and forms a thin layer of ice. When that happens repeatedly, the thin layer builds up and an ice dam is created. Over time, the ice dam expands to the point where it holds back a pool of water on the roof. The growth of the dam can force that water under the roof coverings such as shingles, creating a significant amount of damage and loss.

Icicles hanging from gutters are a tell-tale sign of ice dams.

Low Sloped

Ice dams form on low slope roofs when there is a layer of snow on the roof that begins to melt, and the meltwater drains to the internal drains and where it can refreeze. The danger here is from ice forming around roof drains, in effect creating a dam around the drain that prevents additional water from draining off the roof. Usually these roofs slope slightly down toward the roof drain. When water can't drain, it freezes and ice builds up. One inch of ice weights about as much as one foot of snow, so the weight of ice and snow on the roof can become a problem overloading the structural roof deck and framing members.

When there is a suspended ceiling where the area below the roof may be heated and cooled, there is no need to insulate above the suspended ceiling or seal the ceilings penetrations. The roofing system above the structural deck includes insulation boards which help block the transfer of heat from the interior of the building. This transfer of heat from below would typically cause the snow above to melt and refreeze but the incorporation of insulation boards in the roofing system minimizes this effect.

3.3 Frozen Pipes

Pipe Burst

Burst pipes are the leading cause of property damage from winter weather. Ice forming in a pipe does not typically cause a break where the ice blockage occurs. It's not the radial expansion of ice against the wall of the pipe that causes the break. Rather, following a complete ice blockage in a pipe, continued freezing and expansion inside the pipe causes water pressure to increase downstream between the ice blockage and a closed valve or faucet at the end. It's this increase in water pressure that leads to pipe failure. Usually the pipe bursts where little or no ice has formed. Upstream from the ice blockage the water can always retreat towards its source, so there is no pressure build-up to cause a break. Pipes that are adequately protected along their entire length by placement within the building's insulation, insulation on the pipe itself, or heating are safe.

Vacant commercial properties have a greater exposure to pipe bursts due to significant interior temperature swings and lack of tenants. Significant loss can occur if a pipe busts and the domestic water lines are not monitored by an automatic excess flow valve.

Regional Differences

Generally, commercial properties in northern climates are built with the water pipes located on the inside of the building insulation, which protects the pipes from subfreezing weather. However, extremely cold weather and penetrations in the building that allow a flow of cold air to meet pipes can lead to freezing and bursting.

Water pipes in commercial buildings in southern climates often are more vulnerable to winter cold spells. The pipes are more likely to be located in unprotected areas outside of the building insulation, and business owners tend to be less aware of freezing problems, which may occur only once or twice a season. Pipes in attics, crawl spaces and outside walls are all vulnerable to freezing, especially if there are cracks or openings that allow cold, outside air to flow across the pipes.

Unsealed penetrations in an outside wall can provide access for cold air to reach pipes. The size of pipes, their composition (e.g., copper or PVC), the absence of heat, lack of pipe insulation and exposure to a flow of subfreezing air all influence the potential for a pipe to burst.

Fire Protection Sprinkler Systems

For the purpose of this engineering bulletin, two types of fire protection systems are addressed, a wet system and a dry system.

Additional systems and guidance are provided in the National Fire Protection Agency (NFPA) 25 *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems* and NFPA 13 *Fire Sprinkler Systems*.

- In a wet fire protection system, the pipes are filled with water. When a sprinkler head is activated, the water supply is immediate. This is the fastest acting fire control and suppression system. However, because the pipes contain water, they are susceptible to freezing temperatures.
- A dry fire protection system has pressurized air that holds water back from the main line. When a sprinkler is activated, the air is released and the water is discharged over the fire.

Wet Systems

Building heat should be maintained above 40° F to prevent the potential of pipes freezing. Wet systems are typically not installed in locations where the temperature drops below freezing. There are some cases where the pipes may run into an unheated area of the building that could allow for freezing.

Parking garages are another example of locations where freezing can occur. It is not recommended to install a wet system in areas where the temperature could drop below freezing. However, an antifreeze solution or dry system may be used. The use of antifreeze solutions must conform with state and local health requirements. Regular maintenance including annual solution testing is required to maintain a proper concentration of antifreeze. If not, this may lead to the sprinkler system bursting with costly consequences.

Dry Systems

Dry /pre-action systems are often found in locations where the temperature drops below freezing. Regular maintenance is required when temperatures start to drop. A fire protection professional will check and drain all low parts of the system where drains are installed to dispose of any condensation. They should also check to make sure the pitch of all pipes is maintained to allow for condensation to flow to the installed drains.

3.4 Back-up Power Generators

Generators are an integral part of the preparedness planning process for businesses of every size and can greatly reduce business disruption when normal power is interrupted. This can be especially crucial when temperatures are below freezing leaving the building vulnerable to internal temperature drops. This could cause significant issues with water in pipes freezing as addressed in section 3.3. Backup power can help maintain a consistent building temperature.

Using a generator does pose certain risks that must be addressed for safe operation, including fire, damage to electrical equipment, and even injury or death to those operating the generator or working in the building where it is being used. Proper ventilation is a critical element for reducing the risk of carbon monoxide poisoning from a generator's engine exhaust.

In addition to safety concerns, proper maintenance is critical to avoid the failure of a generator when it's needed most. The time to maintain a generator is well before a major storm or disaster strikes (when professional assistance may be unavailable, power lines are down, and access roads are blocked). To gain the greatest business continuity benefits, while minimizing associated risks, it's important to purchase a generator that is properly designed and sized for your business needs.

After a generator is purchased and properly installed, put procedures in place to ensure regular maintenance and that all safe operating practices are followed. Business and building owners should always operate and maintain generators in accordance with the manufacturers' recommendations.

4 Recommendations for Winter Weather

4.1 Snow Loads

Weight of Snow

- To include a factor of safety, the ground snow loads (p_g) used to design the building should be 1.2 times the ground snow loads (p_g) shown in ASCE 7 (or the locally adopted ground snow loads in case study areas).
- Flat roof snow loads should be calculated in accordance with ASCE 7-16 section 7.3 using the additional ground snow load safety factor of 1.2.
- Steep slope roof snow loads should be calculated in accordance with ASCE 7-16 section 7.4 using the additional ground snow load safety factor of 1.2.
- During design or re-roofing, structural framing members should be designed or verified per a structural engineer using the most stringent loading combinations specified in ASCE 7.
- Existing roofs should be evaluated for increased snow loads caused by additions or alterations. If a higher roof is constructed within 20 feet, a structural engineer should verify the roof’s capacity with the additional snow load produced per section 7.2 of ASCE 7-16.
- For existing buildings, hire a structural engineer to verify snow load threshold of the roofing system. After a winter weather event, conduct an assessment (visual and/or measurements) of the snow and ice equivalent as described in Figure 2. Compare the estimated loads to the loads determined by the structural engineer.
- After a winter weather event, conduct a visual assessment of the roof deck and framing members from below, looking for any signs of excessive deflections (sagging), moisture, deterioration, rotting or rusting, or any other damage. Consider hiring a licensed structural engineer to conduct an assessment, or if a self-assessment identifies any concerns.
- Under safe operating conditions, remove excessive snow. If self-removal is not a safe option, hire a professional.

Snow Drifts and Sliding Snow

- Snow drift loads should be calculated per ASCE 7 using the prescribed additional ground snow load factor of 1.2.
- Additional snow drift loads should be accounted for on both low and steep sloped roofs at all changes of elevations; this includes but is not limited to mechanical units, photovoltaics, elevator caps, communication equipment and chimneys.
- For existing roofs, hire a structural engineer to calculate the weight of snow drifts and verify that the drift prone regions are adequately supported by the structural framing.
- Per ASCE 7-16 section 7.10, rain loads on snow drifts should be considered.

- After a significant winter weather event, conduct an assessment (visual and/or measurements) of the snow drift and determine its weight as described in Figure 2. Compare the estimated loads to the snow drift loads determined by the structural engineer.
- Install snow guards or snow cleats to reduce snow sliding on steep sloped roofs. Refer to the manufacturer's guidance for sizing and spacing depending on the commercial building's site-specific conditions.
- Under safe operating conditions, remove excessive snow. If self-removal is not a safe option, hire a professional.

Heavy Rain on Snow

- Buildings with low sloped roofs and bays susceptible to water ponding should be adequately evaluated by a licensed engineer for the additional loads and mitigated if necessary.

Melting Snow and Refreezing

- Remove all debris and other items from roof drainage systems that prevent drainage of water from the roof during the melting process.
- If large temperature swings are in the forecast, consider hiring a contractor to remove excess snow from the roof to minimize the quantity of ice produced during the re-freeze stage.
- See section 4.2 "Ice Dams" for more recommendations.

4.2 Ice Dams

- Remove or relocate heat sources that are installed in open areas directly under the roof.
- Use professionally installed, high quality self-regulating heating cables on eaves, gutters, downspouts, or around roof drains on low sloped roofs. Make sure the heating cables are UL Listed, FM Approved, or Canadian Standards Association (CSA) Certified. These cables won't remove the ice dam but create channels that allow water to drain off.
  - Install in a zig-zag pattern near gutters on low sloped roofs
  - Connect to drains and drainage system to create a pathway for meltwater to follow

Steep Sloped Roof

- Apply waterproof membrane on roof deck at roof edge (ice and water barrier).
- An additional moisture barrier should be applied to the roof deck of steep sloped roofs along the eaves of the roof to prevent intrusion caused by ice dams. This moisture barrier shall extend from the roof edge to at least 2 ft, towards the interior of the building, beyond the exterior wall enclosing conditioned space.

- Add insulation in unheated attic space, particularly around lights, fans and other openings between the occupied area and the attic.
- If you have penetrations into the attic, such as vents, seal and insulate them so that daylight cannot be seen and airflow is minimal.
- Seal 24 inches from the exterior wall between roof covering and the attic to prevent leakage.

Low Sloped Roof

All drains shall be capable of removing excess water from the roof and shall be free from any debris that may allow for water to back up onto the roof. Contact a qualified licensed contractor to verify that the drainage capacity is adequate.

4.3 Frozen Pipes

Pipe Burst

- Seal all cracks, holes, windows, doors, and other openings on exterior walls with caulk or insulation to prevent cold air from penetrating wall cavity.
- Insulate and seal attic penetrations such as partition walls, vents, plumbing stacks, and electric and mechanical chases.
- For small commercial properties, let all faucets drip during extreme cold weather to prevent freezing of the water inside the pipe, and if freezing does occur, to relieve pressure buildup in the pipes between the ice blockage and the faucet.
- Install a monitoring system that provides notifications if the building's temperature dips below a pre-determined number.
- Pipes in attics and crawl spaces should be protected with insulation or heat. Pipe insulation is available in fiberglass or foam sleeves. Home centers and hardware stores have sleeves providing 1/8 to 5/8 inches of insulation; specialty dealers have products that provide up to 2 inches of insulation.
- Heating cables and tapes are effective in freeze protection. Select a heating cable with the UL label and a built-in thermostat that turns the heat on when needed (without a thermostat, the cable must be plugged in each time and might be forgotten). Follow the manufacturer's instructions closely.
- Exterior pipes should be drained or enclosed in 2-inch fiberglass insulation sleeves
- Pipes leading to the exterior should be shut off and drained at the start of the winter. If these exterior faucets do not have a shut-off valve inside the building, have one installed by a plumber.
- Install an automatic excess flow valve on the main incoming domestic water line to monitor and provide early detection of a broken pipe or valve. Excessive flow valves automatically shut and stop the flow of water when preset normal flow settings are exceeded.

- Use wireless sensors to monitor leaks near water sources such as water tanks, commercial appliances, and the like.
- Install UL-approved gas or electric unit heaters in unheated sprinkler control valve/fire pump rooms.

For vacant properties take the following special precautions:

- Adjust the temperature to a minimum of 55°F and monitor to ensure the internal temperature does not go below 40°F. Insulate pipes that enter through exterior walls to help prevent pipes from freezing and possibly rupturing.
- Shut off the domestic water and drain the water lines. The domestic water lines are separate from the fire protection lines. This will prevent the potential for water leaks that could result in extensive interior water damage. In cold climates, this will prevent the pipes from freezing and possibly rupturing if building heat is lost.
- If the domestic water lines are not shut off, inspect for leaks and turn off the water supply line to individual fixtures such as sinks and toilets. Consider installing a monitored electronic leak detection system for the main domestic water line.

Regional Differences

Pipes should not be installed in unprotected areas outside of the building insulation unless specifically designed for such installation.

Fire Protection Sprinkler Systems

The recommendations provided in this section follow the general guidance and parameters of NFPA 13 and NFPA 25.

- Maintain building heat above 40° F.
- Ensure heat is provided to sprinkler control rooms.
- Monitor sprinkler systems using a central station to provide early detection of a pipe failure.
- Valve enclosures for pre-action and deluge valves should be inspected daily during cold weather to verify a minimum temperature of 40°F.
- Pre-action and deluge valves in areas subject to freezing should be trip tested in the spring to allow time before the onset of cold weather for all water or condensation that has entered the system to drain to low points or back to the valve.
- Auxiliary drains in pre-action and deluge systems should be operated after each system operation, before the onset of freezing conditions, and thereafter as needed.
- Verify that windows, skylights, doors, ventilators, other openings and closures, concealed spaces, unused attics, stair towers, roof houses, and low spaces under buildings do not expose water-filled piping to freezing.

Wet Fire Protection Sprinkler Systems

- If a wet system is installed in areas exposed to cold temperatures, contact a licensed and qualified fire protection contractor to discuss the option of converting to an anti-freeze (if state and local health regulations permit) or a dry system. If the local municipality allows, the addition of anti-freeze (with proper maintenance) could help protect the suppression system from freezing.
- At locations where the system was known to have been damaged by freezing or where other extensive damage might have occurred, a full hydrostatic test should be performed in accordance with NFPA 13 to determine the system's integrity.

Dry Fire Protection Sprinkler Systems

- Dry fire protection systems should be installed in areas outside of the building insulation or in areas that could be exposed to freezing temperatures.
- All pipes should be properly sloped to allow condensation to flow to installed drains.
- All low point drains in above ground piping should be opened, the pipes drained, the valves closed, and plugs replaced quarterly.
- Auxiliary drains in dry pipe sprinkler systems should be drained after each operation of the system, before the onset of freezing weather conditions, and thereafter as needed.

4.4 Back Up Power (Electrical Connections and Generators)

- Backup electrical power should be available that is capable of powering critical electrical and mechanical systems that maintain vital business operations.
  - In cases where life support functions are vital (e.g., nursing homes, rehab centers, assisted/independent living facilities, or hospitals), HVAC should be considered a critical system for business operations.
  - For properties where life support functions are not critical, generators should be provided to maintain an interior temperature sufficient to minimize a commercial property's exposure to freezing temperatures.
- Backup generator electrical connections should be installed with a transfer switch or docking station (sometimes referred to as a storm switch) connecting backup power to critical electrical and mechanical systems. All connections should be located above the 500-year flood level if known, or 3 ft above the known base flood elevation (BFE) or design flood elevation (DFE) for the property.

Portable Generators

- Portable generators should be operated outside in a well-ventilated area. A garage or docking bay may not provide enough ventilation. Use extreme caution when determining where to operate the generator.
- Portable generators should never be run unattended and should be checked periodically (review manufacturer recommendations).

- Portable generators should not be fueled while hot.
- Do not let snow accumulate on top of a portable generator.
- Set up a maintenance schedule to include periodic test runs for the unit.

Permanent Generators

- Permanent generators are more self-sufficient but should be monitored periodically throughout their operation.
- Permanent generators should have a proper maintenance plan that includes weekly, monthly, and annual checks. See the manufacturer's specifications for more information.
- Run the unit weekly on its maintenance plan to ensure that it is properly functioning in case of an emergency. Individual units may have a timer that allows a programmed test to be scheduled. Qualified personnel should oversee these scheduled weekly tests.
- Check the generator enclosure for loose debris or other conditions that could cause the unit to not function properly.