Frozen Automatic Sprinkle Systems

Introduction

Fixed fire protection in the form of automatic sprinkler protection is a critical investment in the protection of the physical property of any business or organization from loss by fire. When this protection is impaired and not available to respond as designed the physical and business assets of the organization are at risk.

Automatic sprinkler systems are passive in nature as they are only called upon in the event of a fire emergency. This passive nature often results in systems not being routinely inspected, tested and maintained to assure their proper response as designed when called upon.

Inadequate or improper inspection, testing and maintenance of automatic sprinkler protection often result in sprinkler systems being impaired for various reasons. One of the most significant contributors to automatic sprinkler protection is frozen sprinkler system piping and/or the formation of ice plugs within sprinkler system piping both obstructing water distribution and discharge through sprinkler heads.

Recent surveys by two of the largest property underwriters revealed that of all systems surveyed protecting refrigerated warehouses 50% were totally impaired due to the formation of ice plugs. Several years ago this writer discovered 18 of 19 dry pipe sprinkler systems impaired due to frozen sprinkler system piping. The impaired sprinkler systems left 720,000 ft² of refrigerated food storage without protection at a grocery regional distribution center for several weeks.

The Problem

Automatic sprinkler systems can be complicated in design with their operation and requirements for inspection, testing and maintenance not fully understood. Over the past few years this lack of understanding has resulted in the discovery of hidden impairments (impairments not previously known) throughout the country to sprinkler systems due to the freezing of sprinkler system piping and/or the formation of ice plugs within piping both creating obstructions that impair the ability of the system to respond and function as designed.

The most significant contributing factors to impairments of automatic sprinkler systems due to freezing of automatic sprinkler system piping are as follows:

- Wet pipe sprinkler systems located in heated facilities in geographic areas subject to freezing temperatures where the heating was turned off or malfunctioned.
- Dry pipe sprinkler systems located in geographic areas subjected to freezing temperatures or protecting areas with freezing temperatures with accidental tripping without immediate action taken to drain and restore before systems freeze.
- Formation of ice plugs within dry pipe sprinkler systems protecting areas of low temperatures.

Wet pipe sprinkler systems consist of automatic sprinklers connected to piping system-containing water and connected to a water supply. Water is discharged from sprinklers opened when subjected to heat from a fire.

A dry pipe sprinkler system consists of automatic sprinklers connected to a piping system containing air or nitrogen under pressure. Upon release of the pressure from the piping by the operation sprinkler(s) subject to heat from a fire a valve is opened to allow water to flow into the system piping discharging from the actuated sprinkler heads. Dry pipe sprinkler system actuation may be arranged as non-interlock, single-interlock or double-interlock.
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The largest number of impairments due to frozen sprinkler piping and/or the formation of ice plugs have been found in refrigerated warehouses, which are areas for temperature-controlled atmospheres principally for storage of food type commodities.

Refrigerated storage areas are classified as follows:

- Coolers - 32º to 65ºF
- Chill Rooms - 16º to 35ºF
- Freezers - 5º to 10ºF
- Sharp or Flash Freezers - 35º to 0ºF

The degree of protection lost by a total impairment of an automatic sprinkler system is easily realized. However, a partially impaired system where only a portion of the system may be impaired including partial obstruction of a riser or feed main by ice plug(s) can be just as critical as a total impairment to the system.

With exception of older sprinkler systems designed on a schedule basis, sprinkler systems are hydraulically designed to deliver a specific amount of water at a predetermined pressure based on the commodities stored and their storage arrangements. Any obstruction within the piping at all will reduce the hydraulic capability of the system reducing its ability to provide the volume of water and pressure required of the system to control a fire.

Cold weather brings the potential of water freezing within wet pipe sprinkler systems. This usually occurs when the heat is turned off or malfunctions in the area(s) being protected. Other causes may include cold air coming in through broken windows and other structural deficiencies. These incidents not only occur in areas that are normally subjected to cold temperatures but in other areas when subjected to unexpected cold fronts. It is the areas that are subjected to the unexpected cold fronts that experience the majority of frozen sprinkler systems principally due to lack of emergency procedures to deal with the unexpected exposure.

Improper installation, testing and maintenance of dry pipe sprinkler systems can cause accidental trips of the systems resulting in frozen sprinkler system piping. Principal causes are accidental trips due to poor maintenance, inadequate system air supply, improper testing procedures, slow human response time and/or lack of proper system drainage. Ice plugs form in cold storage areas when air warmer than the refrigerated area within the sprinkler system supply piping enters the refrigerated area typically at the top of the sprinkler system riser and/or in close proximity to the evaporator coils where the piping is subjected to its coldest temperature.

Moisture present in the air condenses and accumulates in the interior of the piping. The ice accumulation will create a blockage within the piping preventing water from flowing to sprinkler heads.

Apart from of the cause or contributing factors, the impairment to automatic sprinkler systems creates the potential for a significant loss in the event of fire during the period of impairment, which may be extensive particularly if the impairment is of the unknown or hidden type. In addition, the cost to repair and restore the system(s) to service can be costly. The 18 sprinkler systems previously described as being impaired were required to be completely dismantled and taken outside of the buildings to thaw, which took several weeks. In addition, labor costs were high due to the limited amount of time a pipe fitting crew could spend in the freezers requiring the use of multiple crews on site at the same time.
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In addition to the buildings and their contents being left unprotected during the extent of an impairment to automatic sprinkler systems refrigerated warehouses present and additional concern of special note. Refrigerated warehouses use a refrigerant in mechanical compression systems to removal heat from the area served. Some of these systems use Anhydrous Ammonia as a refrigerant. These systems contain ammonia under pressure and have the potential not only of adverse affects on workers but can present a fire, explosion and contamination exposure. This exposure is significantly enhanced when automatic sprinkler protection is impaired at the time leak should occur with the system.

Prevention

**General Provisions** – Emergency Pre-planning Procedures should be written and implemented with support of management to prevent and/or reduce the potential and extent of impairments to fire protection installations including automatic sprinkler systems. Impairment handling procedure should include the following basic elements:

- Assign responsibilities for impairment supervision.
- Adopt a detailed system for supervision of impairments through restoration.
- Educate appropriate personnel as to the importance of impairment handling and the facility’s procedures.
- Maintain list of emergency contractor’s telephone numbers.

**Wet Pipe Systems Cold Weather Precautions** – As previously discussed the freezing of wet pipe systems is normally the result inadequate heat. The following procedures and safeguards will assist to prevent wet pipe systems from freezing during cold weather:

- Provide heating of adequate capacity to maintain the temperature at not less than 40°F near sprinkler piping during the severest potential cold weather exposure. Particular attention should be given to wet pipe sprinkler piping in attics, entries, penthouses, above ceilings, shipping docks and other areas outside of the principal area serviced by the system.
- Provide low building temperature supervision monitored by a UL Listed Central Station Supervisory Service agency.
- In the event heat must be shut off or interrupted for a period of time that may expose the sprinkler system piping to freezing it may be necessary for the system(s) to be drained. A fire watch should be established during the duration of the impairment.
- For areas of a system that have an antifreeze loop system, the antifreeze solution must be checked prior to cold weather season to ensure that it has the proper proportions of antifreeze and water and confirmation that the control valve is open.

**Dry Pipe Systems Not Protection Cold Storage Facilities Cold Weather Precautions** – Dry pipe sprinkler systems do not contain water and are less likely to freeze that wet pipe systems during cold weather exposure. However, certain precautions should be taken to ensure that freezing does not occur is such systems during cold weather exposure as follows:

- Drain any water or condensate from auxiliary drains and all other low points including drains under stairs and platforms.
- The dry pipe valve and the riser on the waterside of the dry pipe valve should be adequately protected against freezing. Heat the valve enclosure using electric heat strips under thermostatic controls so that 40°F can be maintained.
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- Provide low temperature supervision for the valve enclosure monitored by a UL Listed Central Station Supervisory Service agency.
- Check to assure that the system air pressure devices including compressors, regulators, etc. are functioning properly and that air pressure supervisory devices are functioning.
- Air supply system compressor intakes should be located in a cold, dry atmosphere. Avoid warm, damp areas since moisture introduced into the air condenses in the piping and collects at low points where it may freeze. Air dryers should be installed on the air intake.
- Repair, replace or reattach broken, missing or loose sprinkler hangers to ensure proper pitch of sprinkler system piping to facilitate good system drainage.

Dry Pipe Sprinkler Systems Protecting Refrigerated Storage Areas – All dry pipe sprinkler systems protecting refrigerated storage areas should be inspected and tested to assure proper operating status. Dry pipe systems should be trip tested on an annual basis and full flow tested every three years in accordance with NFPA 25, Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.

Where systems have been impaired in the past by the formation of ice plugs the following safeguards should be provided to prevent reoccurrence:

- Take dry pipe system air supply from within the freezer
- Maintain air supply dew point at 20°F (11.1°C) lower than the normal freezer temperature.
- Use approved air supply package for freezers or use a desiccant type regenerative air dryer.
- Supply air into sprinkler piping in freezer through duplex lines arranged for easy removal for inspection and removal of ice accumulations.
- Provide elbow at the top of the riser with plug to facilitate visual inspection of the piping at the point it enters the freezer.

General Preventive Measures for Dry Pipe Sprinkler Systems Protecting Refrigerated Storage Areas

- Inspect systems annually for ice plugs. Particular attention should be given where the piping enters the freezer and piping showing signs of frost near evaporator coils; moisture will migrate to the coldest part of the system.

Note: Factory Mutual Research has done extensive research in the area of using ultrasound technology to locate ice plugs. Their nondestructive testing laboratory has developed a method where this technology can be used to inspect the piping without the need for disassembling the entire system. The procedure uses high frequency sound pulses to detect solid ice or liquid. The equipment produces bursts of ultrahigh sound waves that are deflected off obstructing ice plugs and recorded on an oscilloscope.

- Trip test Dry Pipe Valves annually.
- Full trip test Dry Pipe Valves every three years.
- Provide trip test cut off valve on the system riser to facilitate tripping of the dry pipe valve to ensure water does not enter system interior piping.
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Action Plan When Sprinkler Systems Freeze

When impairment due to freezing of automatic sprinkler system piping is discovered immediately implement the Pre-emergency Impairment Plan and the following actions:

- Inform department heads in the areas where protection is out of service.
- Notify in-house fire brigade and/or emergency response team.
- Increase surveillance in the impaired area by provision of continuous fire watch patrols.
- Notify the Central Station or other agency supervising the fire alarm system.
- Notify your agent and the Crum & Forster Claim Department.
- Notify your local fire department that sprinkler protection is impaired and identify areas affected.
- Shut down hazardous processes or maintenance operations such as welding and other hot work activities.
- Prohibit smoking throughout the impaired area(s).
- Determine the cause of the impairment.
- Determine the extent of the impairment by identifying all frozen piping and/or location of ice plugs.
- If temporary heat is used use only portable units listed by UL or Approved by FM.
- Work continuously on the impaired equipment until it is restored to service.
- If only part of the system is impaired isolate the impaired portion and restore the remaining portion of the system to operating status.
- Supplement manual fire fighting facilities by the temporary addition of additional fire extinguishers and charged hose lines as applicable.
- If plugs and/or blind flanges are used during restoration to isolate system sections keep record/inventory of all plugs and flanges to be certain they are removed when repairs are completed.