Investigation of Inadvertent Automatic Fire Sprinkler System Discharges
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Recent changes to national and international building codes include requirements for the installation of automatic fire sprinkler systems in a large number of new buildings, including single-family homes. As more buildings are equipped with automatic fire sprinkler systems, the likelihood of an inadvertent discharge (the accidental release of water from the system when there is not a fire) increases. Proper investigation of these failures is critical to determining the root cause.

Automatic fire sprinkler systems are often considered the most important component of a building’s fire protection strategy. When properly designed, installed and maintained, an automatic fire sprinkler system can control a fire and significantly reduce deaths, injuries and property damage. Generally, automatic fire sprinkler systems are considered both reliable and effective.\textsuperscript{1,2,3} Research shows that between 2003 and 2007, sprinklers operated in 93\% of all fires large enough to cause activation and were effective in 97\% of the fires in which they operated.\textsuperscript{4} However, when an automatic fire sprinkler system is not properly designed, installed and maintained, the system can fail to perform as intended, resulting in significant losses\textsuperscript{5} (in both property and life) or the system can inadvertently discharge, resulting in expensive water damage to the building and its contents, as well as costly business interruption.

Inadvertent discharge of an automatic fire sprinkler system is not a trivial issue. Historical loss data estimates that approximately 120 automatic fire sprinkler systems inadvertently activated per day in 2003.\textsuperscript{6} Discharge of a sprinkler system in the absence of a fire event may lend credence to the myth that automatic fire sprinkler systems are not reliable.

Details relating to how automatic fire sprinklers inadvertently discharge have been outlined previously.\textsuperscript{7} This article expands upon those causes of inadvertent discharge to incorporate other automatic fire sprinkler system components, such as fittings and pipe sections, examines historical loss data, and discusses what steps should be followed when performing a root cause analysis of the failure.

**Historical Inadvertent Activation Loss Data**
Common types of inadvertent activations include the activation of a sprinkler head resulting in water flow, the failing of a valve or air compressor resulting in a dry-pipe system filling, but not flowing water, and a leak or break in a sprinkler head, sprinkler pipe or fitting resulting in water flow.

Historically, the National Fire Protection Association (NFPA) has tracked and published data summarizing inadvertent automatic fire sprinkler system activations in the United States. The most recent data, compiled and published from 2003, estimated 44,000 inadvertent automatic fire sprinkler system activations (approximately 120 per day) that year. A review of the data reveals that four major occupancy groups accounted for nearly all of the reported losses:\textsuperscript{8}

1. Commercial properties: public assemblies, stores, offices (36\%)
2. Manufacturing facilities (15\%)
3. Homes: one- or two-family dwellings, apartments (11\%)
4. Warehouses, excluding cold storage (9\%)
5. Other (28\%)
An additional NFPA study examined only a small fraction of the losses in 2003 (approximately 3%) and found that water could have discharged in roughly 50% of the reported inadvertent automatic fire sprinkler system activations, as shown in Table 1.9

Table 1. Non-Fire Sprinkler Activations by Likelihood of Water Release and Major Property Use Group

<table>
<thead>
<tr>
<th>Type of Activation (Based on:)</th>
<th>Commercial properties (726 incidents)</th>
<th>Manufacturing facilities (206 incidents)</th>
<th>Homes (292 incidents)</th>
<th>Warehouses excluding cold storage (165 incidents)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No Water Released</strong></td>
<td>50%</td>
<td>55%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Definitely no water released except dry pipe system charging or release to drain or outside</td>
<td>(45%)</td>
<td>(48%)</td>
<td>(46%)</td>
<td>(44%)</td>
</tr>
<tr>
<td>Activation with no mention of water flow outside system</td>
<td>(5%)</td>
<td>(7%)</td>
<td>(4%)</td>
<td>(6%)</td>
</tr>
<tr>
<td><strong>Possibly Water Released</strong></td>
<td>50%</td>
<td>45%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Break or damage to component</td>
<td>(29%)</td>
<td>(30%)</td>
<td>(27%)</td>
<td>(38%)</td>
</tr>
<tr>
<td>Activation with mention of water flow release outside system</td>
<td>(8%)</td>
<td>(4%)</td>
<td>(14%)</td>
<td>(5%)</td>
</tr>
<tr>
<td>Leak</td>
<td>(5%)</td>
<td>(2%)</td>
<td>(2%)</td>
<td>(1%)</td>
</tr>
<tr>
<td>Freezing</td>
<td>(7%)</td>
<td>(6%)</td>
<td>(6%)</td>
<td>(6%)</td>
</tr>
<tr>
<td>Nearby heat</td>
<td>(2%)</td>
<td>(2%)</td>
<td>(1%)</td>
<td>(1%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Confirmed water release outside system</td>
<td>16%</td>
<td>7%</td>
<td>21%</td>
<td>12%</td>
</tr>
</tbody>
</table>

Source: Analysis of uncoded narratives from reported incidents in Austin (TX), Minnesota, and Massachusetts.

2003 was the last year the NFPA tracked inadvertent discharges, shortly thereafter data collection was halted, “because the complete file grew too large for practical storage for release in and after 2004.”10
It is likely that the increased use of automatic sprinkler systems, as required by new building and fire codes, will lead to more inadvertent discharges. Therefore, proper investigation of these losses to determine the root cause of the failure allows for corrective action to be taken and important lessons to be learned, which can reduce the likelihood of future losses in the incident building and others.

The Basics of Losses
Previous discussions on inadvertent discharges identified and described six primary reasons an automatic fire sprinkler will discharge in the absence of a fire: overheating; freezing; mechanical damage; corrosion; deliberate sabotage; or manufacturing defect.11

1. Overheating – Automatic fire sprinklers respond to heat and cannot differentiate between “good heat” (i.e. a fire) and “bad heat.” “Bad heat” can be attributed to unit heaters, mechanical equipment, electrical equipment, or skylights. Temporary heat-producing sources, such as construction lighting or heaters have also been known to activate sprinklers. Overheating typically causes only the sprinkler head to fail, not nearby fittings and piping.

2. Freezing – Although special types of automatic fire sprinkler systems are available for use in areas subject to freezing, most sprinkler systems are wet pipe systems, meaning that the pipes are normally filled with water. If even a small portion of an automatic fire sprinkler system is exposed to freezing temperatures, water in the pipes can turn to ice, expanding in volume and producing thousands of pounds of pressure. Such pressures can break pipes and fittings, but can also force open the valve caps of sprinkler heads, resulting in an apparent accidental discharge or leakage when the system thaws.

3. Mechanical Damage – The frame, the seat, and the operating mechanism (typically a solder link or glass bulb) of a sprinkler head are joined together and activate when released by heat. Mechanical impact to sprinkler heads can result in damage and separation of those parts, resulting in accidental discharge. Mechanical impact upon pipes and fittings feeding sprinkler heads can also result in unwanted water flow.

4. Corrosion – Corrosion can result in a weakening of parts over time, resulting in the accidental discharge of the system. Older sprinkler heads are at a high risk for corrosion, as are newer sprinkler heads installed in a harsh environment. Pipes and fittings exposed to harsh environments before or after installation can also corrode and fail prematurely.

5. Deliberate Sabotage – Deliberate acts of sabotage and vandalism, possibly motivated by insurance fraud, can affect automatic fire sprinklers and associated components.

6. Manufacturing Defect – The likelihood of an automatic fire sprinkler activating in the absence of a fire is historically low: approximately one per year per sixteen million sprinklers in use.12 Although very rare, the possibility of a manufacturing defect in a sprinkler head, fitting, or pipe should be considered when all other potential reasons for inadvertent discharge have been eliminated.

Investigation Basics
The first step in investigating an inadvertent automatic fire sprinkler system discharge is to collect all the pieces of the failed sprinkler head, fitting, or pipe.

Sprinkler heads are manufactured in a variety of styles and configurations, therefore, it is essential to know what to look for and collect, given the type of sprinkler head involved in the loss. Accessing manufacturer design specification sheets is one way to identify items for collection. Another alternative is to examine similar sprinkler heads installed in the area or, if
possible, an exemplar sprinkler head in the spare sprinkler head box, often installed near the main sprinkler riser.

Following discharge, the sprinkler head frame and deflector, unless severely impacted, will remain in its original location. However, the activation element, caps, and seals will be discharged from their original location.

When investigating a broken fitting or pipe, it is critical to collect all the broken pieces of that component to assist in the failure analysis. Where components have fractured, care should be exercised in protecting the fracture surfaces and not causing any additional damage. The fracture surface is often the most critical piece of evidence in determining why a component failed.

Regardless of what component failed or what caused the failure, early response to the loss and examination of the area prior to cleanup is the most successful means to collect all necessary pieces. Careful examination of the surrounding area for small parts is essential. When possible, discussions with first responders and/or cleanup crews may facilitate locating the pieces discharged from the sprinkler head or separated from the component.

Following this, careful documentation of the scene is required. Data to collect may include:

• Design and installation documents related to the automatic fire sprinkler system.
• Information pertaining to the components installed within the system, such as sprinkler head model, activation temperature, manufacturer, and year of production; the pipe material, diameter, year of production, and manufacturer; the fitting material, style, size, manufacturer, and year of production.
• Dimensions of the space where the failure occurred.
• Location of heat sources, including heaters, HVAC supply vents, skylights, heat producing lighting, and/or electrical equipment.
• Communication paths with the external environments, including windows, doors, passive venting, etc.
• Weather data preceding and including the day of the loss.
• Status of the building HVAC systems and set points.
• Human access to the scene, including status and records from electronic monitoring, surveillance video, and/or electronic access systems, if provided.
• Alarm data from the fire alarm control panel or offsite monitoring company.
• Facility operations, including equipment relocations, employee activities, and storage configurations.
• Chemicals, processes, or other environmental conditions capable of causing corrosion.

After the scene investigation, further analysis of failed components through microscopy can shed light on the cause of the failure (i.e., bad heat, mechanical, sabotage, corrosion, defect). Analyzing the history of the sprinkler head and associated piping or fittings from manufacture through installation can also be relevant to the investigation.

For recently installed automatic fire sprinkler systems, this includes shipping, storage, and installation conditions that could include contamination or exposure to non-compatible chemicals, gases, or liquids. In addition, while the components await installation onsite, they can be damaged through rough handling.

For components that have been in service, common root causes of an inadvertent discharge include damage from equipment, exposure to freezing or overheating conditions, exposure to corrosive environments, sabotage, and other unintended use factors, such as hanging of items from sprinkler heads. As such, thorough documentation of the automatic fire sprinkler system and its surrounding environment is a necessary part of the overall investigation.
Many times the investigation is performed after the failed component has been repaired and the exact location of the failure is not obvious. In these instances, it is important to interview the building owner and any witnesses with knowledge of the failure or the system. Collecting and reviewing the alarm data from the fire control panel or from the offsite monitoring company can also provide guidance as to where the failure may have occurred. Other clues regarding where the failure occurred include:

- A new or different model sprinkler head, fitting, or pipe section when compared to others in the area;
- Evidence of water damage to the surrounding structure or contents;
- Evidence of new repairs to the surrounding structure; and
- The type, amount, and color of the pipe dope or sealant tape used at fittings, which, if different when compared to other fittings in the same area or building, could indicate that a new component was recently installed.

After completing the site investigation, collecting pertinent data and analyzing the failed component, the investigator can begin to rule out causes of the failure on the path towards determining the root cause of the loss.

Conclusions

Almost all new buildings require the installation of an automatic fire sprinkler system, including single-family homes. As more buildings are equipped with automatic fire sprinkler systems, the likelihood of an inadvertent discharge increases. In fact, the NFPA halted the tracking of inadvertent discharges in 2003, because the complete file grew too large for practical storage and release.

Inadvertent discharges can cause considerable property damage and business interruption, as well as reinforce the myth that automatic fire sprinkler systems are not reliable. Proper investigation of an inadvertent discharge of an automatic fire sprinkler system involves prompt and thorough collection of component pieces and data to determine the root cause of the failure. An understanding of the likely causes of inadvertent discharge will help prevent future occurrences and ensure that automatic fire sprinkler systems are ready and able when needed to protect lives and property from a fire.

1 Koffel 2005
2 Budnick 2001
3 Hall 2010: p. i
4 Hall 2010: p. i
5 Long et al. 2010
6 Hall 2010, p 48
7 Fleming 2000
8 Hall 2010, p 48
9 Hall 2010, p 48
10 Hall 2010, p 49
11 Fleming 2000
12 Fleming 2000
Bibliography