

# Extended Abstract: Data-enabled Fire Sprinkler Systems

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## 1 Introduction

NFPA 25 establishes the minimum requirements for periodic inspections, testing and maintenance (ITM) of water-based fire protection systems [1]. Most ITM actions are performed every three months [2] which is not always enough to identify potential risks which could result in costly interruptions, system failures and unsafe building conditions. This is not a unique problem to the fire protection industry and other industries are adopting the Internet of Things as a possible solution.

The Internet of Things (IoT) is a system of interrelated computing devices along with mechanical and digital machines that have the ability to transfer data over a communications network [3]. Although IoT is being applied in different ways depending on the industry, each application often shares a common goal of using real-time data to increase operational efficiency and make data-driven proactive decisions [3]. Applying a similar concept to the fire sprinkler industry may be able to provide similar results and reduce the severity of customer pain felt during disruptive break/fix events.

Applying IoT to a fire sprinkler system can not only complement existing ITM procedures, but it could potentially allow for better quality of inspection, testing and maintenance through data analytics and continuous sampling. A solution was developed to connect and monitor core system vitals and provide users with real-time data. It was theorized that data-enabled fire sprinkler system can empower building owners and maintenance managers to take preemptive corrective actions by providing insight to historical and current system data along with automatic notifications for when the system is trending outside of acceptable bounds.

## 2 Applying IoT to Fire Sprinkler Systems

The high-level architecture that allows fire sprinkler systems to become an IoT system is broken down into four layers commonly used in industrial IoT applications (Figure 1):

1. Sensors - Convert pressure, temperature and condensate drain information into digital data.
2. Edge Devices – Pre-process the data from sensors and provide a connection to the Internet Gateway.
3. Internet Gateway – Aggregates the pre-processed data from all the edge devices at a site and routes that information to the Internet.
4. Cloud-Based Data Storage and Analytics Platform – Provides data storage, management and analysis.

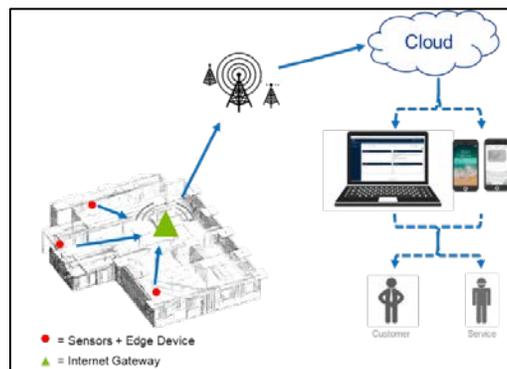


Figure 1 - High-level IoT architecture

Sensors and edge devices were developed to monitor wet, dry and pre-action sprinkler system pressures, temperatures and water presence within condensate drains. Statistical tools and algorithms were applied on the time-series data and behaviors and patterns that typically would have gone unnoticed were captured.

An online dashboard was created to allow users to interact with their proprietary sprinkler system data (Figure 2). Additionally, a rules engine was created to analyze data and send notifications to users via short message service (SMS) or email when measurements crossed a pre-determined or calculated threshold.



Figure 2 – Example of continuous data on a pre-action system as seen on the online user dashboard

### 3 Evaluation of Data-enabled Fire Sprinkler Systems

The method of validation used to understand the potential benefits and use cases of a data-enabled fire sprinkler system involved a controlled deployment of devices. This approach allowed the project team to work closely with end users and service providers to transform assumptions and uncertainties into knowledge.

Variations of the system were installed in 25 sites across the United States. Building types, geographical locations and customer needs were identified. The perspective of the building owner and the service company in the area were also taken into consideration.

During the initial discussions with building owners and maintenance managers, a set of common concerns were identified including false valve trips, water presence, freezing pipes, and system leaks. Using this input, a data-enabled approach that can continuously monitor fire sprinkler systems was hypothesized to provide a proactive solution to address these concerns. The feedback received from the data-enabled strategy and the impact it had on building operations was used to measure performance and whether the concept could be scalable to the broader fire protection industry.

### 4 Validated Use Cases

#### 4.1 Reduce Troubleshooting Time

A big box retailer in the Mid-Atlantic region of the United States reported a history of multiple false trips on a dry sprinkler system. For the store, these false trips caused business disruption, lost revenue and multiple fines by the local fire department. The service company was unable to identify any issues with the system each time they came out to reset the system after a false trip. The service company's reputation was starting to come into question by their customer and it was causing disruptions to their business, as well.

A valve monitoring kit was installed on the malfunctioning dry sprinkler system for diagnostics purposes. It monitored air pressure, water pressure, compressor activity and ambient temperature at the valve. The jockey pump pressure was set at 150 psi and air pressure was set to 39 psi. The dry valve in the system

had a 5.5 trip ratio. Therefore, at the initial system settings the air pressure would need to drop below 27 psi, or the water pressure would need to be more than 215 psi for the valve to trip.

Shortly after adding sensors and data-enabled capabilities to the sprinkler system, it was observed that system water pressure fluctuated with a pattern consistent to temperature changes exhibiting peaks around 5 to 6 p.m. daily. These fluctuations proved to be greater than the cycling of a jockey pump; the maximum observed water pressure was approximately 170 psi after one week (Figure 3). The action taken by the service technician was to increase the air pressure to 45 psi to decrease the probability of a false trip due to water pressure fluctuations.

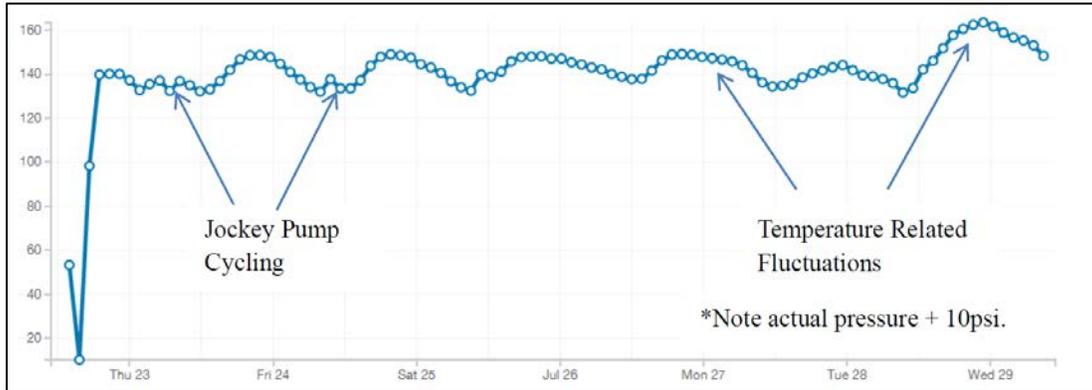


Figure 3 – Water pressure data

A few months later, the system had another false trip incident and the data revealed that the water pressure increased from 150 psi to 260 psi in less than 36 hours (Figure 4).



Figure 4 – Water pressure data vs. temperature data

Again, there appeared to be a correlation between water pressure and temperature. The accumulation of the water supply pressure resulted in inadequate air pressure to hold the valve closed. When the minimum

required air pressure exceeded the actual air pressure, the valve tripped. The installation of a pressure relief valve was recommended to permanently remedy this problem.

This problem was difficult to identify for the service company because when the system was reset the pressures observed were not out of the ordinary. A typical dry sprinkler system has alarms for low or high air pressure but does not monitor the water pressure. Since the air pressure was not low relative to its fixed set point, the low air alarm never sounded. As seen on this site, unexpected water accumulation can happen in relatively short periods of time throwing off the balance between air and water pressure. Without having continuous pressure data, it would have been difficult to diagnose the root cause of the false trips. Having continuous data allowed for quick diagnosis of the problem and provided the insight needed to determine a solution.

#### 4.2 Preventative Maintenance

While a data-enabled solution can assist in troubleshooting existing issues in a reactive manner, it can also be useful from a proactive standpoint to help provide insight to system maintenance. An assisted living company with locations across the Midwest and the Rocky Mountain Region of the United States was interested in reducing unplanned maintenance costs and emergencies at their various facilities. The potential costs incurred due to sprinkler system failures experienced at an assisted living facility can be attributed to evacuating patients, replacing equipment, requirements for fire watch and damage to reputation which can also affect future occupancy.

Valve monitoring kits were installed in multiple facilities to monitor air pressure, water pressure and compressor activity on dry sprinkler systems. It was noted that the compressor cycle run time at one of the facilities was approximately 22 minutes and the system leak-down time was 72 minutes, both of which are indicative of an air leak in the system (Figure 5). NFPA 13 states that 1.5 psi pressure loss per 24 hour period is acceptable [4] and the leakage rate for this system was 13 psi per hour, a cumulative of 312 psi per 24 hour period. Additionally, the excessive leakage was causing the compressor to cycle more frequently which could lead to premature failure.



Figure 5 – Compressor pressure data over time

Based on the data collected, it was recommended for the assisted living company to schedule a service call to investigate the source of the leak. If not addressed, these issues could have resulted in major inconvenience or damage if the compressor failed prematurely or if the leak worsened. Without real-time data spanning a breadth of time, an issue like a leak could be difficult to recognize and may not be observed in a conventional quarterly inspection.

#### 4.3 Cost and Efficiency Improvements

A higher education building in the New England Region of the United States had a previous problem with frozen pipes at a condensate drain of a dry sprinkler system. This caused significant damage to a new building at their campus. Their response to the problem was to hire a service company to come to the

campus on a weekly basis and empty all the condensate drains. Employing a service technician for one day every week was costly to the site and impacted the efficiency of the service provider's field staff.

The condensate drain monitoring kit was installed to monitor temperature and water presence at each condensate drain. Temperature thresholds were applied to both ambient temperature and pipe temperature to allow for notification of freezing risk at specific condensate drains.

It was observed that not all of the condensate drains accumulated water at the same rate and some of the condensate drains in the building were not at risk of freezing (Figure 6). The service company used the live temperature and water presence data to target specific condensate drains and increased their efficiency at the weekly visits.

LOW POINT MONITORING				
Name	Battery Status	Air Temperature	Pipe Temperature	Water Presence
LP-Executive Directors Office	 32 minutes ago	69.1 °F  OK 32 minutes ago	66.9 °F  OK 32 minutes ago	 32 minutes ago
LP-House Keeping Closet	 47 minutes ago	64 °F  OK 47 minutes ago	61.7 °F  OK 47 minutes ago	 48 minutes ago

Figure 6 – Snapshot of condensate drain visuals found on the user dashboard

## 5 Conclusion

The observations made during this study suggest that the application of real-time monitoring and data analytics can help provide new insights to building owners and maintenance managers. The information and conclusions that can be drawn from the data have the ability to empower sites to better understand and maintain their fire sprinkler systems. Having the means and methods to diagnose system issues ahead of time can lead to reduced downtime, lower repair costs and increased overall operational efficiencies.

The use of connected technologies in the fire protection industry is still in its infancy. These technologies currently serve as a complement to the ITM requirements detailed in NFPA 25. Through continued innovations, data-enabled IoT technology has the potential to propel the fire industry and relevant codes and standards towards a connected, proactive and safer future.

## 6 References

- [1] NFPA, "NFPA 25," in *Standard for the Inspection, Testing, and Maintenance of Water Based Fire Protection Systems*, Quincy, 2017, p. 1.1.
- [2] NFPA, "NFPA 25," in *Standard for Inspection, Testing and Maintenance of Water-Based Fire Protection Systems*, Quincy, 2017, p. Table 5.1.1.2.
- [3] J. Morgan, "A Simple Explanation Of 'The Internet Of Things'," *Forbes*, 13 5 2014. [Online]. Available: <https://www.forbes.com/sites/jacobmorgan/2014/05/13/simple-explanation-internet-things-that-anyone-can-understand/#bfdcc581d091>. [Accessed 28 8 2019].
- [4] NFPA, "NFPA 13," in *Standard for the Installation of Sprinkler Systems*, Quincy, 2010, p. 24.2.2.1.
- [5] Koorsen Fire & Security, "IoT in Fire Safety - An Exciting Future, but Approach with Caution," 2019.