Corrosion in Fire Sprinkler Systems – Increasing Your Liability, Increasing Your Costs, and Shortening System Life

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Academic facilities are required by codes to have fire sprinkler systems. These life safety systems increase the evacuation time for occupants in the event of a fire and protect the buildings and facilities from fire damage. They protect the lives of students residing in dormitories and occupants in classrooms, laboratories, athletic facilities, administration buildings, and parking structures. The vast majority of these systems utilize metallic piping which is subject to corrosion due to the presence of water and oxygen in the metallic piping. Corrosion and its deposits in the piping restrict water flow, create blockages, and leads to leaks. This increases liability in the event of a fire, causes property damage, and results in costly repairs and downtime. A report by FM Global states, "corrosion damage / products and mineral deposits can impair the effectiveness of sprinkler systems and leave facilities vulnerable to uncontrolled fire loss." [1]

Building owners and facility managers typically expect fire sprinkler systems to last 40 – 50 years or the useful life of the building. However, corrosion issues cause typical wet systems to start failing in 15-25 years and typical dry systems in 8-12 years.[2] A VdS study showed that 35% of wet systems at age 25 years required pipe replacement due to corrosion damage with 3% of those systems requiring total system replacement. This same study showed that 73% of dry systems at age 12 ½ years required pipe replacement due to corrosion damage with 22% of those systems requiring total system replacement.[3] What causes these systems to fail so prematurely? The answer is threefold: oxygen, water, and metal. When these three components are combined, corrosion will occur. These components make up the ingredients for oxygen corrosion, also known as generalized corrosion or rust. Only if one of more of these components is limited or eliminated will the corrosion process slow or halt.

To understand how corrosion can occur, one must understand how these systems operate. Wet sprinkler systems are filled with water, and when a fire opens a sprinkler, the water present exits to extinguish the fire. In a dry sprinkler system, compressed air fills the piping and upon opening of a sprinkler due to fire, the pressure in the piping drops until the water pressure at the alarm valve overcomes the air pressure causing water to enter sprinkler piping and flow to the point of the fire to extinguish the fire. To ensure a dry system is installed properly, they are filled with pressurized water to hydrostatically test the system. These systems are then drained and filled with pressurized gas, most commonly compressed air, to keep the water from entering the piping.

The problem for most fire sprinkler systems is that all three of the components for oxygen corrosion exist in fire sprinkler system piping. The vast majority of sprinkler piping is black steel or galvanized steel piping. This is the source of metal for the oxygen corrosion process. The problem for wet systems is that when they are filled with water, air in the piping becomes trapped at high points during the fill process. Piping can be filled with as much as 50% - 70% trapped air. This trapped air is the oxygen source for the corrosion process. Dry systems always have some residual

Dry sprinkler system, 5 years old

Sprinkler from wet sprinkler system, completely blocked by corrosion deposits.

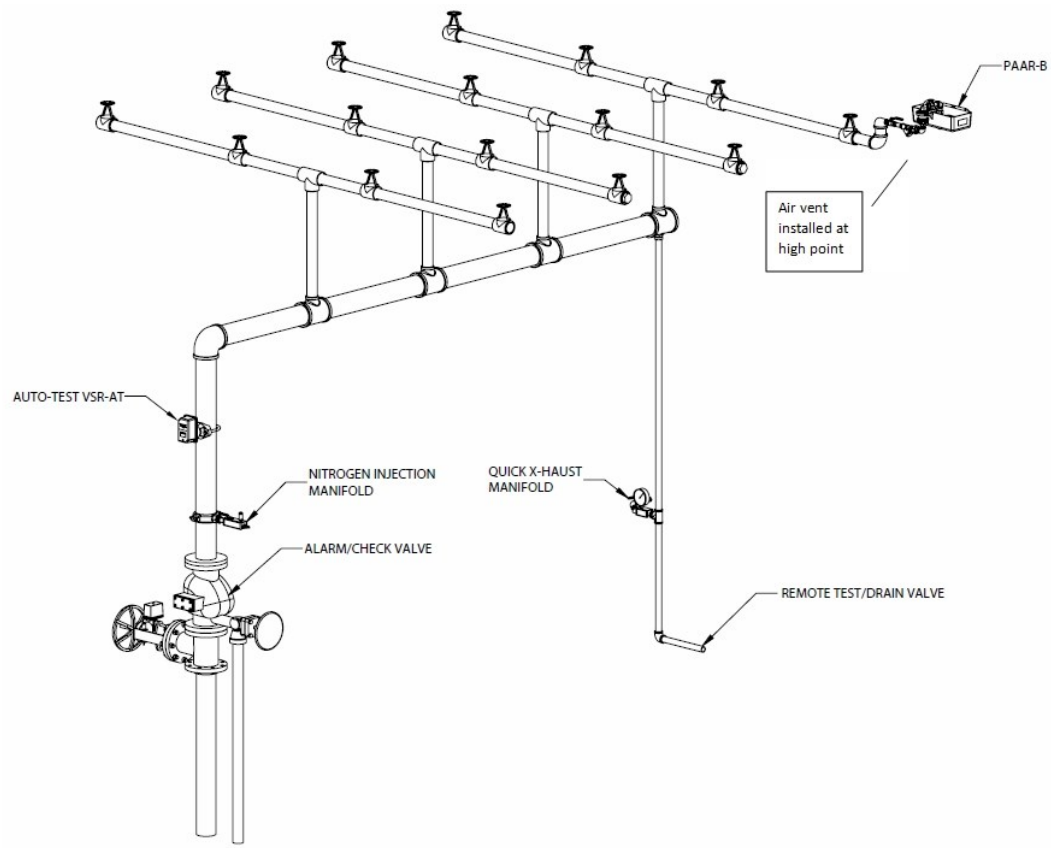
Dry sprinkler system with pinhole leaks.

water after they are hydrostatically tested. In addition, ambient humidity is pumped into the piping by the compressor which maintains the supervisory air pressure. The residual water and condensing humidity are the source of water for corrosion in dry systems, and the compressed air is the source of oxygen.

With the ingredients for corrosion present for oxygen corrosion in both wet and dry systems, corrosion will occur and eventually cause leaks. A typical pipe leak can cost $800 - $1200 to repair exposed piping. Only a handful of leak repairs are enough to exceed fire sprinkler maintenance budgets, that is, if your organization even budgets for this type of maintenance. It is very common for fire sprinkler maintenance costs to not be specified in operating and maintenance budgets. It is even more common for fire sprinkler systems to not be proactively maintained and for building owners and facility managers to act only after leaks occur.

Fortunately, piping failures, business down time, and costly leaks due to corrosion are preventable. Proven treatment protocols increase wet system life by a factor of 3 and dry systems by more than a factor of 5, dramatically cutting maintenance and costs over the life of the system.[4] Given the initial investment of $1 - $2 per square foot to install a sprinkler system in a facility, life extension of 3 to 5 times with the elimination of pipe leak repairs leads to protection of that investment and the lowest total cost of ownership of the fire sprinkler systems. With those life extension factors, both wet and dry system lives reach 40, 50, or more years.

How do you extend the life of your sprinkler systems 3 to 5 times? The answer is by controlling the oxygen levels in the piping. For wet systems, if there is no trapped air in the piping, the only oxygen present is the dissolved oxygen, roughly 10ppm (parts per million). That small amount of oxygen will react with water and metal and, once consumed, the piping system will be inert and corrosion halts. As long as new sources of oxygen are not introduced, corrosion remains halted. The primary issue that wet systems face is that air will be trapped in portions of the piping due to their inherent design. Installation of automatic air vents at appropriate high points in the piping will eliminate much of the trapped air as the system fills with water. While vents will address most of the trapped air pockets, it is unlikely that they will eliminate all trapped air. This remaining trapped air can be addressed with a process known as wet inerting. Wet inerting is a process in which the piping is pre-filled with nitrogen, (an inert gas), to achieve at least 98% nitrogen levels throughout the piping. As water fills the piping, the majority of the trapped nitrogen will be pushed out through the automatic vents and any trapped gas remaining in the piping will not cause corrosion.



For dry systems, there will always be some water in the piping regardless of the pitching and low point drains. Again, controlling the oxygen levels in the dry system is the key. By using at least 98% nitrogen instead of compressed air as the supervisory gas within the piping, the system piping will last at least 5.3 times longer.[5] Not only will the oxygen be virtually eliminated from the piping, ambient humidity will no longer be pumped into the piping as system leaks deplete the pressure. This controls two components of the oxygen corrosion process. Installing a nitrogen generator on the dry system instead of an air compressor is the proper way to supply the continual need for nitrogen. A typical nitrogen generator utilizes a separation process to strip the oxygen from the ambient air and produces nitrogen in excess of 99% concentrations.

On academic campuses, nitrogen generators have many applications. The most common application is their use in parking structures' dry systems. Attic dry systems typically found in dormitories benefit two ways from their application. First, the nitrogen controls the corrosion process. Additionally, because ambient humidity is not pumped into the piping, issues with freeze ups breaking piping are eliminated. This eliminates the costs and issues with water damage in the dormitory and the relocation process of students. Other areas on campuses where dry systems will benefit from the use of nitrogen generators are outdoor stadiums, data centers, laboratories, and loading docks.

While nitrogen generators are expensive pieces of equipment, systems implemented with them that utilize black steel piping are actually less expensive to install than the combination of galvanized piping with a standard air compressor. Black steel piping is roughly 30% less expensive than the same galvanized piping and when coupled with nitrogen, the black steel / nitrogen system will last at least 5.3 times longer than a galvanized / compressor system. For example, an assisted living facility had two, 425 gallon dry systems. When looking at materials and equipment only, the costs for the systems to being implemented with black steel piping and a nitrogen generator and with galvanized piping and a compressor are as follows:

Item	Cost
Black Steel + Fittings	$61,122.98
N2 Generator Equipment	$12,000.00
Total Cost	**$73,112.98**

Item	Cost
Galvanized Pipe + Fittings	$76,553.82
Compressor Equipment	$1,150.00
Total Cost	**$77,703.82**

Academic facilities invest substantial amounts of money in the fire sprinkler systems that protect their students, faculty, and structures. Those systems are subject to damage and corrosion which lead to costly issues and risk. By applying corrosion prevention protocols to these systems, system life can be increased while total lifetime costs are minimized. An upcoming free webinar will cover in detail the causes of corrosion and the means for mitigating corrosion in fire sprinkler systems. This webinar will arm attendees with knowledge to guide your organizations down the path of fewer problems, lower costs of constructing and maintaining fire sprinkler systems, and less risk of liability. Additionally, this knowledge will allow you to ask the right questions of your fire sprinkler contractor to ensure you are working with a partner for your life safety systems.

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[1] Su, Paul and Fuller, David B., "Corrosion and Corrosion Mitigation in Fire Protection Systems," FM Global, 2nd Edition, July 2014.
[2] European Fire Sprinkler Network, EFSN, "Corrosion in Sprinkler Systems", February 2013.
[3] European Fire Sprinkler Network, EFSN, "Corrosion in Sprinkler Systems", February 2013.
[4] Tihen, Josh, "Corrosion Inhibition of Dry and Pre-Action Fire Suppression Systems Using Nitrogen Gas", March 2014.
[5] Tihen, Josh, "Corrosion Inhibition of Dry and Pre-Action Fire Suppression Systems Using Nitrogen Gas", March 2014.

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