White Paper

Nitrogen Vs. Dry Air for the Management of Corrosion in Dry Pipe and Preaction Fire Sprinkler Systems

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Introduction

In order for corrosion to occur in steel and galvanized steel fire sprinkler systems three (3) elements are necessary. For some time that interdependence has been visualized by the familiar three-sided triangle:

- Steel or galvanized steel piping (metal)
- Liquid water present in the system piping
- Oxygen gas from the pressure maintenance air

Within the fire protection industry when speaking on the subject of corrosion, parallels have been drawn between the well known "fire triangle" which also involves three (3) necessary elements:

- Combustible fuel source
- Oxygen gas from the air
- Heat source

Within firefighting, control of the fire begins with the elimination or reduction in the supply of one of the three (3) necessary elements. Management of corrosion can be accomplished in much the same way by controlling or eliminating one of the three (3) necessary elements. A discussion about the most efficient means of managing corrosion must address the most practical and effective means for reducing or eliminating one of the three (3) necessary elements.

Corrosion Chemical Reactions

The electrochemical corrosion reaction that takes place within dry and preaction fire sprinkler systems is shown below wherein metallic iron (or zinc) reacts directly with dissolved oxygen gas that is present in water. A sheen of liquid water is all that is necessary for the corrosion reaction to occur if oxygen gas is present. As has been stated, it is likely that there will always be small pools of trapped water within the piping. In these reactions the amount of dissolved oxygen that is present always controls the rate of the reaction because iron is available in excess. Oxygen is known as the *rate limiting component*.

Oxygen Corrosion in Dry Pipe Main

$$Fe^{o} + \frac{1}{2} O_2 + H_2O \rightarrow Fe(OH)_2\downarrow$$

$$Zn^{o} + \frac{1}{2} O_2 + H_2O \rightarrow Zn(OH)_2\downarrow$$

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Iron is further oxidized to form hematite (Fe_2O_3) which is commonly referred to as rust.

Potential for Eliminating One of the Necessary Corrosion Elements

The discussion below evaluates the potential for eliminating one of the necessary elements within the corrosion triangle.

Element 1: Steel or galvanized steel piping

One approach to controlling corrosion in water-based fire sprinkler systems would be the elimination of steel or galvanized steel piping and components. There are several options for the replacement of steel or galvanized steel piping:

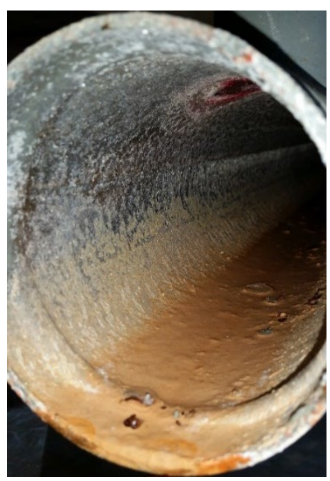
- The use of plastic or composite piping in place of steel or galvanized steel piping would eliminate corrosion risk. In fact, CPVC is used in some wet pipe fire sprinkler system applications and when used, there is absolutely no oxygen corrosion risk. However, the use of plastics or composites in dry or preaction systems is not permitted and it is only permitted in wet systems for specific light hazard or residential applications. It should also be noted that CPVC plastics bring a different set of risks associated with stress cracking. Even if plastics could be used in future installations, addressing corrosion risk in existing steel systems cannot be ignored.

- **Conclusion** – it is not possible or practical to eliminate steel or galvanized steel piping from dry and preaction fire sprinkler systems.

Element 2: Liquid water in the system piping

- Water is introduced into dry and preaction fire sprinkler systems in three (3) different ways:

    1. Initial hydrostatic testing of the fire sprinkler system piping involves completely filling the piping with water for pressure testing.
    2. Periodic trip testing of the fire sprinkler system introduces water to the piping.
    3. Condensate moisture (water) is introduced to the sprinkler system piping each time the pressure maintenance air compressor cycles on to maintain system pressure within the piping. When the compressor runs, it introduces warm, moist air to the system piping.



Trapped Water in Galvanized Dry Pipe Main

It is impossible to completely remove the water that has been introduced into system piping. Pitching the sprinkler piping as required along with the installation of multiple auxiliary drains cannot completely remove all residual trapped water.

There will always be small pools of trapped water within the system piping. A sheen of liquid water is all that is necessary to support the oxygen corrosion reaction.

- **Conclusion** – it is <u>not possible</u> or practical to completely remove water to the point where oxygen corrosion can be controlled.

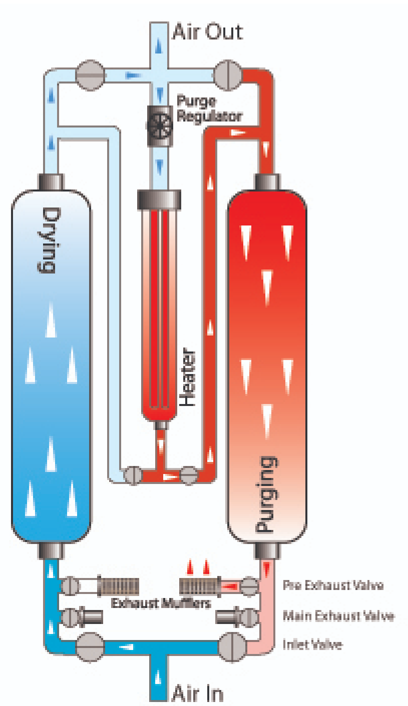
Element 3: Oxygen gas from the pressure maintenance air

Approximately 10 years ago, research began in the use of nitrogen gas as a replacement for pressure maintenance air in dry and preaction fire sprinkler systems. The process involves the incorporation of a nitrogen generator in place of the traditional air compressor to maintain the pressure within the dry and preaction fire sprinkler piping. When dry nitrogen gas is used for pressure maintenance, the periodic introduction of oxygen gas can be completely controlled.

- **Conclusion** – it <u>is possible</u> to eliminate or greatly reduce oxygen from dry and preaction fire sprinkler systems by using a nitrogen generator for pressure maintenance. If oxygen gas is eliminated from system piping, corrosion can be completely controlled.

Regenerative Desiccant Dryers for Corrosion Control

Within the fire protection industry regenerative desiccant dryers have been used to prevent the formation of ice plugs and frost accumulation when air compressors are used for pressure maintenance on dry and preaction fire sprinkler systems in freezer applications. When enough moisture is present in the pressure maintenance gas, ice forms within the fire sprinkler piping at the point of penetration into the freezer space. Regenerative desiccant dryers have been used to reduce the dew point of the pressure maintenance gas thereby reducing the potential for ice plugs.



Dessicant Air Dryer Towers

Recently it has been suggested that regenerative desiccant dryers can control corrosion in dry and preaction fire sprinkler systems[1] by eliminating the introduction of moisture in the pressure maintenance air. However, condensate moisture from the pressure maintenance compressor is only one (1) of three (3) sources of water that are found in all dry and preaction fire sprinkler systems. Water from the initial hydrostatic test of the system and water

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that is introduced during system trip testing cannot be completely removed from the piping.

It should be noted that any method or process that reduces the amount of water that is introduced to the dry or preaction piping will only reduce the *number of locations* where oxygen corrosion can take place. However, any water present within the system piping will activate the oxygen corrosion reaction. Reducing the amount of water will not reduce the total amount of oxygen corrosion that takes place.

In the corrosion reaction equation, the component that controls the amount of corrosion that takes place is the amount of oxygen. Each time an air compressor cycles on to maintain pressure it introduces warm, moist (condensate) oxygen into the system piping. When a regenerative desiccant dryer is used in conjunction with an air compressor it introduces warm, dry oxygen into system piping. Using a regenerative desiccant dryer will NOT stop oxygen corrosion because it cannot eliminate water from the system, and it cannot dry out or remove water from the system. A nitrogen generator eliminates one (1) of the necessary elements from the corrosion triangle i.e. oxygen, a regenerative desiccant dryer cannot remove oxygen from the pressure maintenance air.

Benefits of an FM Approved Nitrogen Generator

An FM Approved membrane type nitrogen generator is a much better solution for controlling corrosion when compared against a regenerative desiccant dryer. The benefits of using an FM Approved membrane type nitrogen generator for pressure maintenance gas in dry or preaction sprinkler installation include:

- Membrane type nitrogen generators prevent oxygen corrosion by reducing the oxygen content in the pressure maintenance gas to less than 2%. Dry air from a regenerative desiccant dryer contains 21% oxygen which is the primary cause of corrosion in fire sprinkler systems.
- The 98% nitrogen gas produced using a membrane type nitrogen generator has a much lower dew point of -70ºF to -90ºF than the dry air typically produced by a regenerative desiccant dryer at about -40ºF. Nitrogen generators produce much dryer gas than a regenerative desiccant dryer.
- Nitrogen generators cost less to operate because they run less frequently than a comparably

FM Approved Nitrogen Generator

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sized regenerative desiccant dryer which must constantly use dry air or heat to regenerate the desiccant bed.

- When maintained properly, membrane separators that are used in an FM Approved nitrogen generator can last up to 20 years according to the manufacturer[3], while the desiccant material must be replaced every 1-3 years in a typical regenerative desiccant dryer[4].
- FM Approved membrane type nitrogen generators cost approximately the same as regenerative desiccant dryers for equivalent size dry and preaction system installations.

Other operating factors that make regenerative desiccant dryers more expensive to install, operate and maintain compared to a membrane type nitrogen generator:

- Regenerative desiccant dryers require a break-in period[4] to create enough dry air capacity for initial introduction to the freezer. This represents another labor expense for the property owner while the contractor is present for this process. An FM Approved nitrogen generator instantly produces low dew point (-70°F) pressure maintenance nitrogen gas with no break-in period.
- During the initial commissioning with a regenerative desiccant dryer it is recommended to purge the moist air from the fire sprinkler system piping by manually opening a valve at the inspector's test connection for a 24-hour period. After 24 hours of purging moist air, the valve must be manually closed[4]. This again creates a labor expense for the property owner. An FM Approved membrane type nitrogen generator automatically removes the moist air and oxygen from the system piping as part of the normal operation using an integral venting device that is located on the system riser[5].
- As desiccant material breaks down in the desiccant beds they produce particulates that have the potential to clog valves and fittings downstream of the dryer[4].

Recommended annual maintenance of the regenerative desiccant dryer is complicated and time consuming. In addition to coalescing cartridge filter replacement, the desiccant beds of the dryer may require replacement. Once again, a break-in period is required before the dryer can be placed back in service. An FM Approved membrane type nitrogen generator requires simple annual replacement of the coalescing cartridge filters.

There are many potential operational pitfalls associated with a regenerative desiccant dryer that do not exist with an FM Approved membrane type nitrogen generator including:

- Failure to set up the cycle frequency on the desiccant towers properly to maintain low dew point dry air delivery.

- Failure to account for system pipe leakage can cause short cycling and lead to the delivery of high dew point air.
- Failure to perform break-in during initial commissioning can deliver high dew point air.
- Failure to perform the 24-hour purging of the system piping can lead to high dew point air within the system piping.
- Failure to change out degraded desiccant in a timely manner can result in the delivery of high dew point air.

Given the complexities involved with operating and maintaining a regenerative desiccant dryer coupled with the fact that they do not reduce the level of corrosion activity, they are not an alternative to the complete corrosion control that a nitrogen generator offers. FM Approved membrane type nitrogen generators offer superior moisture removal of the pressure maintenance gas while also providing proven corrosion control for the fire sprinkler system piping.

References

[1] General Air Products Dry Air Pac™ cut sheet.

[2] FM Global Research Technical Report ***Corrosion and Corrosion Mitigation in Fire Protection Systems*** – Paul Su and David Fuller, July 2014.

[3] Air Products ***PRISM Membrane*** technical literature.

[4] General Air Products DAP Series Installation and Operation Manual, Models DAP500, DAP1000 and DAP2000.

[5] Engineered Corrosion Solutions, ECS Protector Nitrogen Generation System Owner's Manual – covered by US Patents 9,144,700; 9,186,533; 9,526,933; 9,610,466.

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Engineered Corrosion Solutions, LLC is a corrosion management consulting firm that offers fire sprinkler system assessment and analysis coupled with design services and a full suite of corrosion management strategies that include equipment and integrated devices for controlling corrosion in water-based wet, dry, and preaction fire sprinkler systems. We understand the science of corrosion in fire sprinkler systems in a complete variety of different settings from parking structures to warehouses to clean rooms to data centers.

Engineered Corrosion Solutions, LLC offers proprietary dry pipe nitrogen inerting technology (DPNI) and wet pipe nitrogen inerting technology (WPNI), which includes the ECS Protector Nitrogen Generator, Pre-Engineered Skid Mounted Nitrogen Generator, Gas Analyzers, SMART Dry Vent, Two (2) Wet Pipe Nitrogen Inerting Vents and the industry's first real time in-situ corrosion monitoring device the ECS In-Line Corrosion Detector. Finally, we offer the first comprehensive remote corrosion monitoring system that provides live validation of the corrosion control strategy that is in place within your facility.

For complete information about the entire line of corrosion management products and services and the complete list of downloads of White Papers, FAQs, installation schematics and product spec sheets please visit the Engineered Corrosion Solutions website at ecscorrosion.com or contact us at (314) 432-1377 and one of our engineers will assist in personally answering any of your questions.

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