White Paper

Acid Based Corrosion in Antifreeze Fire Protection Systems (August 2015)

By Andrew Loeffelman

Engineered Corrosion Solutions™

Complete Corrosion Control.

Engineered Corrosion Solutions, LLC
11336 Lackland Road
St. Louis, MO 63146
314-432-1377
ecscorrosion.com

ECS Engineered Corrosion Solutions
ecscorrosion.com

Oxygen corrosion is the primary cause of degradation of fire sprinkler piping in water based fire sprinkler systems, however, there is another phenomenon that leads to pinhole leaks in antifreeze systems – acid corrosion. Acid corrosion is found in both antifreeze systems and the adjacent fire protection systems that supply fresh water to antifreeze systems and causes a very aggressive, highly localized attack of the sprinkler piping.

Degradation Process

Acid corrosion in antifreeze systems is due to the breakdown of two primary chemicals found in antifreeze – *propylene glycol* and *ethylene glycol*. While propylene glycol is required by NFPA to be used in antifreeze and ethylene glycol is not, ethylene glycol is present in common antifreeze mixtures and will contribute to the production of acidic byproducts. In the presence of heat and oxygen, both of these chemicals break down to form acidic byproducts (acetic, lactic, formic, etc.), most of which are highly corrosive to the mild steel in fire sprinkler piping. This process is called thermal oxidation.

Antifreeze chemicals and/or organic acids have been found to "creep" into adjacent wet pipe fire protection systems that supply anti-freeze systems with fresh water for mixing purposes. Once the chemicals and acids enter the wet pipe system, the solutions mix and significant leaks develop. This is concerning for cross-contamination issues because these systems are assumed to contain water without chemical additives. There are several ways that these chemicals can leak into an adjacent system:

- Relief orifices in check valve clappers
- Antifreeze fill cups located upstream of antifreeze isolation check valves
- Corroded check valves
- Impaired backflow devices

Leaks from acid corrosion can occur in a very short amount of time and is further accelerated if fresh antifreeze is not replenished frequently in the antifreeze system. The recent findings of acid corrosion combined with other known issues of antifreeze, such as low flash points when sprayed as a mist, further call into question the continued use of antifreeze systems currently protecting buildings.

Characteristics of Acid Corrosion

While both acid corrosion and oxygen corrosion can cause pinhole leaks in sprinkler piping, this is virtually the only characteristic they have in common. Rather than causing widespread large pitting of pipe walls as oxygen corrosion does, acid corrosion causes very aggressive, highly localized attack of the sprinkler piping. The result is pipe walls that have an abundance of tiny sharp-edged pits or pinholes, leaving the rest of the inner pipe surface area virtually unaffected.

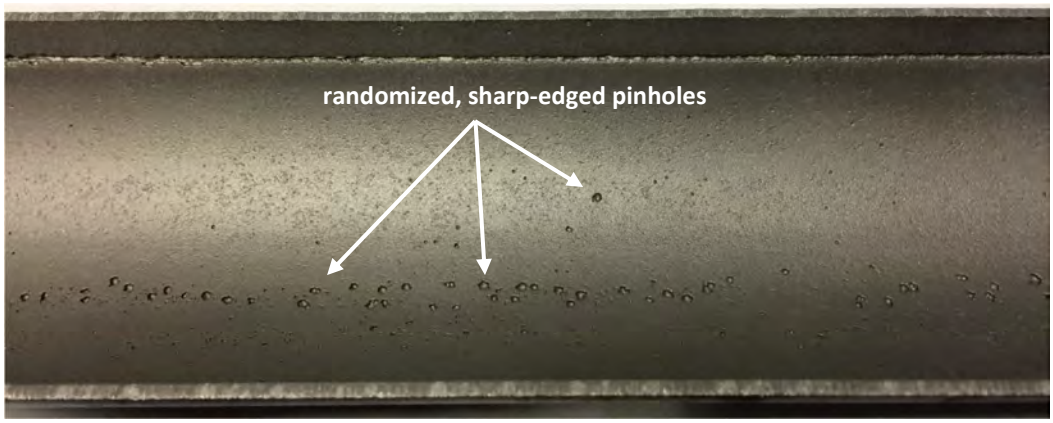

Figure 1: Section of wet system main adjacent to antifreeze system

Antifreeze Risks

There are many risks associated with the use of antifreeze in fire protection systems. One of the most alarming concerns with acid corrosion in fire sprinkler systems is the inability to predict where these pinhole leaks will occur. Because the area of attack is localized to a very small, concentrated area leaks caused by acid corrosion are sporadic and unpredictable – replacing what one would assume is the damaged section of pipe will likely not solve the problem as leaks are also forming elsewhere throughout the system piping. A significant leak can form with little to no warning and the integrity of the system is compromised

There is also a considerable health hazard from the degradation of antifreeze solutions as it causes extremely low pH values in the sprinkler system water, creating a highly acidic environment. While the normal pH range from the municipal water supply feeding a sprinkler system is 6.5 – 8.5, antifreeze systems have been measured with pH values below 4.0. Every time the system is drained and/or leaks occur, extreme caution must be exercised to prevent bodily injury to skin and eyes.

Another major concern is rapid attack of the weld seam in the piping. Because sprinkler piping is generally not heat treated, acid will preferentially attack the anodic weld seam in sprinkler piping and can completely dissolve it in a short period of time. Owners are left with few options as the leak frequency of these systems increase to the point where is becomes challenging to keep up with repairs and the disruption of building operations.

Mitigation Options

The alternatives to antifreeze in new and existing sub-freezing fire sprinkler system installations are limited.

<u>New Installations:</u>

1) Install a dry or preaction sprinkler system
2) Condition the space so a wet sprinkler system can be used

Because NFPA requires the use of listed antifreeze solutions in all new installations (post-September 30, 2012), these are the only options for installations in sub-freezing conditions. The use of a **nitrogen generation system** with a dry or preaction sprinkler system ensures that oxygen corrosion will not cause leaks in system piping.

Existing Installations:

1) Drain and thoroughly flush both antifreeze system and adjacent wet pipe system and return to normal operating conditions
2) Convert the system to a dry or preaction sprinkler system

Flushing of the systems both dilutes and removes organic acids that corrode system piping. Performing **wet pipe nitrogen inerting** to remove oxygen in the systems will prevent antifreeze from degrading and creating more acidic byproducts.

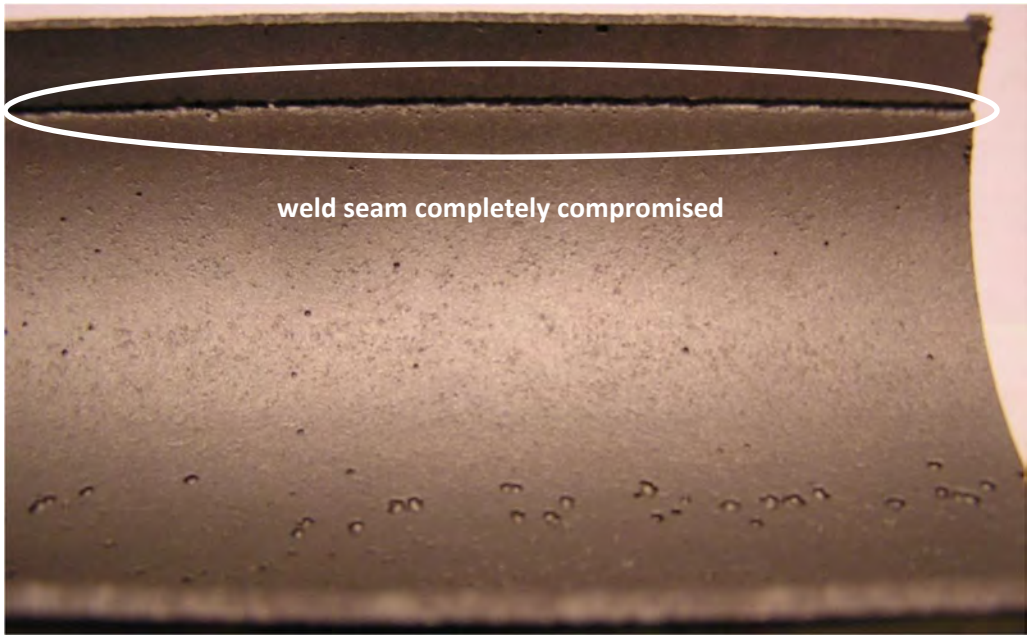

Figure 2: Close-up of weld seam attack by acid corrosion

Conclusions

It is clear that the use of antifreeze in fire sprinkler systems is a misapplication of the chemical. While antifreeze may perform its intended function adequately in other applications, the chemical should not be used in fire sprinkler systems where material deterioration and personal safety is compromised through its use. For systems protecting unconditioned space a dry pipe sprinkler system combined with a nitrogen generator provides the safest, longest lasting fire protection system. In existing systems where it is cost prohibitive or not feasible to condition the space or convert to a dry pipe system, Wet Pipe Nitrogen Inerting (WPNI) is the only solution that prevents further degradation of system piping and antifreeze chemicals.

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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.

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