White Paper

Galvanized Pipe Failures in Dry Pipe Sprinkler Systems
(April 2016)

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Original article published in Fire Protection Contractor Magazine in May 2016.

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Introduction

Galvanized steel has been used in a variety of industries for many years because of its resistance to atmospheric corrosion. The galvanizing process involves the application of a thin layer of metallic zinc to the base metal which is typically mild steel. In almost every industrial application, galvanizing is used to protect mild steel from atmospheric corrosion by oxygen.

As far as corrosion control is concerned there are multiple mechanisms that protect the base metal from atmospheric corrosion. First, the zinc acts as a barrier which prevents water from contacting the iron in the mild steel base metal. Second, zinc is less noble than iron which means that zinc will corrode preferentially when coupled to iron and act as a "sacrificial anode" to protect the iron from corrosion. Finally, the zinc coating forms a passive film of zinc carbonate on the metal surface that can significantly reduce the rate of oxygen corrosion.

In theory, use of galvanized steel piping in dry pipe fire sprinkler system applications makes sense. The exterior of the tubing will not rust due to atmospheric oxygen corrosion because the zinc carbonate layer forms and protects the external surfaces and the essentially dry state of the interior piping should mean that corrosion is minimal. Unfortunately, the interior surfaces of dry and preaction fire sprinkler piping are rarely completely dry. The following discussion presents the primary reasons galvanized steel piping should not be used in fire sprinkler piping.

Ineffective Internal Corrosion Resistance

Galvanized steel pipe is NOT more corrosion resistant than black steel piping under normal use conditions in dry and preaction fire sprinkler applications. The atmosphere inside dry pipe fire sprinkler systems presents a persistently moist, oxygen rich environment which means that the galvanized coating corrodes at a very high rate.

If residual water is trapped inside the pipe the zinc layer will break down quickly and ultimately lead to a pin-hole leak. This problem is complicated further because the nature of the attack is localized. Once the zinc coating is breached and the underlying steel is exposed to water, oxygen corrosion will be concentrated at the point of the breach. Because of the highly localized nature of corrosion attack in galvanized steel piping, through-the-wall penetrations occur faster in galvanized steel corrosion than black steel exposed to the same conditions. Ultimately, a failure will occur at a point just beneath the trapped pool of water.

The formation of zinc carbonate requires that the metal surface be allowed to dry completely. This protective layer will never form in areas with residual water. Dry pipe fire sprinkler systems almost always contain water from multiple sources:

- Hydrostatic test
- Full flow trip test
- Poor design (insufficient system drains)
- Poor installation (insufficient pitch in the piping)
- Accidental trip of the fire sprinkler system
- Water vapor from the air compressor

Unnecessary Cost

The cost premium for installing galvanized pipe is approximately 30% higher than black steel piping for the same size sprinkler system. This cost premium can vary depending on size and design of the system and schedule of the piping, however, the cost of galvanized pipe will always be greater than black steel pipe.

Nitrogen gas has been used effectively to control oxygen corrosion in fire sprinkler system piping by removing oxygen from the system. If nitrogen gas is used to create an oxygen free atmosphere within the dry pipe system, black steel pipe used in actual conditions and galvanized steel pipe used in ideal conditions perform equally in terms of corrosion resistance. Because ideal conditions are nearly impossible to achieve, the additional cost for the galvanized steel pipe is not warranted.

Heavy Metal Pollution

Galvanized steel piping subjected to the corrosive conditions typically found in dry and preaction fire sprinkler systems produces discharge water that may be high in zinc levels. Although individual jurisdictions may vary in the methods and means by which sprinkler discharge water must be handled, most jurisdictions consider zinc a heavy metal contaminant. The allowable discharge limits for zinc containing waters can be as low as 1.0 mg/L (1 ppm). Zinc exhibits its greatest toxicity to fresh water fish and aquatic organisms, including those exposed to sprinkler water drained to storm sewers.

The analyses of deposit samples from galvanized dry pipe fire sprinkler systems indicate that the deposits inside the pipe can contain zinc at levels from 1% up to 96%. Water from galvanized dry pipe systems has been measured with as much as 1500 mg/L of zinc present in the water.

Conclusions

The use of galvanized steel piping within the fire sprinkler industry is a complete misapplication of the construction material. The dry conditions inside the piping that must exist in order for galvanized steel piping to be effective against oxygen corrosion are also ideal for the use of black steel piping. Empirical evidence suggests that under the same conditions inside the pipe, black steel will outperform galvanized steel because the corrosive attack in black steel piping is not as localized.

The original intent of installing galvanized steel as a means of improved corrosion protection in fire sprinkler systems was well intentioned, but poor field performance under typical conditions has shown that galvanized pipe is inappropriate for dry and preaction fire sprinkler systems. The fire sprinkler industry is starting to become aware of the problems associated with galvanized pipe as evidenced by the list below, but additional awareness is needed.

- NFPA 13 eliminates hydraulic advantage of galvanized pipe [2013 edition]
- FM Global publishes Research Technical Report that states “New dry or preaction systems can develop through-wall corrosion pinhole leakage within 2-3 years after initial installation, due to residual water causing corrosion in galvanized steel pipe” [July 2014]
- Government design standards prohibit use of galvanized pipe in dry and preaction fire sprinkler systems – Unified Facilities Criteria [Department of Defense, 2013] and Facilities Standards for the Public Buildings Service (P-100) [General Services Administration, 2015]

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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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