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

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• Objectives
  – Discuss the problems corrosion causes in fire sprinkler systems
  – Discuss life expectancy of fire sprinkler systems
  – Identify the causes of corrosion
  – Current state of corrosion technology
  – Mitigation: when / where to apply
  – Evaluate the economic impact decisions regarding corrosion has on fire sprinkler systems
• Why do we care about corrosion in fire sprinkler systems?
• Codes require them
• **COST!!** (Installation and Repair)
  – American Fire Sprinkler Association, AFSA
    – New construction $1-$2 / ft$^2$
    – Retrofits $2-$3 / ft$^2$
  – 100K ft$^2$ (9300m$^2$) = $100K-$200K new construction
  – 50K ft$^2$ (4650m$^2$) = $100K-$150K retrofits
  – Pinholes $800 - $1200 to as high as $5000
• What are the types of fire sprinkler systems?
  – Wet Systems: pressurized water throughout
  – Dry Systems: pressurized gas holds water at riser
  – Others: Pre-action, deluge, mist, foam, chemical...

• What is the purpose of a fire sprinkler system?
  – To permit occupants to exit structure
  – To control / extinguish a fire at the location where the fire is active
• How does it control / extinguish a fire?
  – Heat from the fire opens a sprinkler, water flows through piping and out of the open sprinkler
  – Only those sprinklers impacted by fire open

• Is it that simple?
  – Usually...
The biggest concern is that corrosion can cause a sprinkler system to fail.

50% Blockage
(California, 5 year old system)

Failed Sprinkler Head
(Illinois, 12 year old system)
Corrosion produces many issues in the fire sprinkler market

- Pinhole leaks
- Loss of property
- Loss of production
- Total system replacements
- Temporary shutdowns, often unplanned
- Limits effectiveness of fire sprinkler design
- Personal injury
What is the life expectancy of a fire sprinkler system?
VdS 20-year long survey of corrosion in sprinkler systems:

Class I - Little damage is found the pipe array should just be flushed.

Class II - Medium damage is found, so that some but not all pipes show increased damage, those pipes must be replaced.

Class III - Considerable corrosion and deposits the complete pipe array or parts of it must be replaced.
Wet Systems

- Fontana
- Class I
- Indianapolis
- Class II
- Wisconsin
- Class III
Classes of Corrosion

Dry Systems

- Cincinnati
  - Class I
- Minneapolis
  - Class II
- Illinois
  - Class III
## Results Summary

<table>
<thead>
<tr>
<th>System Type</th>
<th>Class I</th>
<th>Class II</th>
<th>Class III</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet Systems</td>
<td>65%</td>
<td>32%</td>
<td>3%</td>
<td>In <strong>25</strong> years, 35% have significant corrosion issues</td>
</tr>
<tr>
<td>Dry and Pre-Action Systems</td>
<td>27%</td>
<td>51%</td>
<td>22%</td>
<td>In only <strong>12\frac{1}{2}</strong> years, 73% have significant corrosion issues</td>
</tr>
</tbody>
</table>

**What is the life expectancy of a fire sprinkler system?**
There are 2 main types of corrosion in FSS

1) Generalized Corrosion (Rust)
2) Microbiologically Influenced Corrosion (MIC)
NFPA 13

24.1.5.1  Water supplies and environmental conditions shall be evaluated for the existence of microbes and conditions that contribute to microbiologically influenced corrosion (MIC). Where conditions are found that contribute to MIC, the owner(s) shall notify the sprinkler system installer and a plan shall be developed to treat the system...

NFPA 25

14.2.1.3  Tubercules or slime, if found, shall be tested for indications of microbiologically influenced corrosion (MIC).
FM Global study found **10-30%** of corrosion was influenced by MIC and **70-90%** of corrosion was generalized (oxygen) corrosion.
Dry and Pre-action

Corrosion flourishes in Dry and Pre-action systems because they are NEVER 100% DRY.

Trapped water from hydrostatic testing, combined with humid air supplied constantly by the air compressor creates a perfect storm.

Typical “Dry” System
Nitrogen Tests

Corrosion Comparison Tests
(0.010” Leak Diameter)
Nitrogen Tests

After 20 months

Compressed Air

98% Nitrogen

After 20 months
Nitrogen Tests

Corrosion Coupon Testing Manifold
After 12 Months

Steel Coupon
Compressed Air

Steel Coupon
98% Nitrogen

Galvanized Coupon
Compressed Air

Galvanized Coupon
98% Nitrogen
Nitrogen Tests

Life Expectancy Multiplier = 5.3
Localized Corrosion = Quick Failures

Galvanized Schedule 40 after only 3 1/2 years

Galvanized Schedule 10 after only 18 months
Installation Guidelines for Automatic Sprinklers 2-0
FM Global Property Loss Prevention Data Sheets

2.5.2.5 Protection of Sprinkler System Piping

See Data Sheet 7-14, *Protection for Flammable Liquid/Flammable Gas Processing Equipment*, for installation guidelines for sprinkler system piping in areas subject to potential explosion hazards. Do not hang anything, including conduit, cable trays, air piping, speakers, and signs, from sprinkler system piping.

Use internally galvanized, stainless steel, or similar corrosion-resistant pipe in all new dry-pipe, pre-action, refrigerated-area, deluge, and exposure-protection sprinkler systems. Do not use galvanized pipe in areas where the ambient temperature could exceed 130°F (54°C) unless the pipe is specifically FM Approved for use in such conditions.

**Exception:** Black steel pipe can be used in dry-pipe sprinkler systems equipped with closed-type sprinklers if the piping system is filled with an inert gas.
### Table 23.4.4.7.1 Hazen–Williams C Values

<table>
<thead>
<tr>
<th>Pipe or Tube</th>
<th>C Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unlined cast or ductile iron</td>
<td>100</td>
</tr>
<tr>
<td>Black steel (dry systems including preaction)</td>
<td>100</td>
</tr>
<tr>
<td>Black steel (wet systems including deluge)</td>
<td>120</td>
</tr>
<tr>
<td>Galvanized steel (dry systems including preaction)</td>
<td>100</td>
</tr>
<tr>
<td>Galvanized steel (wet systems including deluge)</td>
<td>120</td>
</tr>
<tr>
<td>Plastic (listed) all</td>
<td>150</td>
</tr>
<tr>
<td>Cement-lined cast- or ductile iron</td>
<td>140</td>
</tr>
<tr>
<td>Copper tube or stainless steel</td>
<td>150</td>
</tr>
<tr>
<td>Asbestos cement</td>
<td>140</td>
</tr>
<tr>
<td>Concrete</td>
<td>140</td>
</tr>
</tbody>
</table>

*The authority having jurisdiction is permitted to allow other C values.

23.4.2.1 Friction Loss Formula.

23.4.2.1.1 Pipe friction losses shall be determined on the basis of the Hazen–Williams formula, as follows:

\[
\Delta p = 4.52Q^{1.85} \frac{C^{1.85}}{d^{4.87}}
\]

where:
- \( \Delta p \) = frictional resistance (psi/ft of pipe)
- \( Q \) = flow (gpm)
- \( C \) = friction loss coefficient
- \( d \) = actual internal diameter of pipe (in.)

Source: NFPA 13, 2013
How do you supply nitrogen to a fire sprinkler system?

7.2.6.8 Nitrogen or Other Approved Gas.

7.2.6.8.1* Where nitrogen or other approved gas is used, the supply shall be from a reliable source.

7.2.6.8.2 Where stored nitrogen or other approved gas is used, the gas shall be introduced through a pressure regulator and shall be in accordance with 7.2.6.6.

7.2.6.8.3 A low pressure alarm shall be provided on gas storage containers to notify the need for refilling.

Generate it on-site!

Source: NFPA 13, 2013
Replace the Oxygen with Nitrogen.

Nitrogen is an INERT gas.

It does not react with metals. Thus, no oxidation or rust occurs!

The earth’s atmosphere is 78% nitrogen and 21% oxygen.

Strip the oxygen from air and leave pure nitrogen!
Nitrogen generators that provide on-site reliable nitrogen production.

- Meet NFPA 13, 30 minute fill time requirements
- Easy installation
- Sized to meet the needs of systems
- Cost effective
- Low maintenance
- Dependable
Purging Process – Getting Air Out

- Initial system fill with air
- Nitrogen level monitoring
- Stops purging when nitrogen levels reach target.
- BMS connectivity and notification
- Advance Purging – Designed for drying and freezer applications, reducing moisture and ice build-up.
- Manual options also available
Dry System Testing

Fig. 9

Dry Pipe System Waterflow And Air Supervisory Switch Selection Guide

- **PS40-1** Low Pressure (Set at 30 PSI)
- **PS40-2** Low and High Pressure (Set at 30 and 70 PSI)

**PS40 Should Be Installed In Line With “BVL” Valve For Test Purposes**

**WATERFLOW SWITCH**

**PS10-1** Single Contact
**PS10-2** Double Contacts

**AIR PRESSURE SUPERVISION**

**PS40-TM**

**BVL**
The number one enemy of a wet system is **TRAPPED AIR**, which can take up **70%** of the sprinkler system.
Trapped Air Causes:

• Increased Generalized Corrosion
• Supplies 99% of the oxygen for corrosion
• Better MIC environment
• Unnecessary False Flow Alarms

Why Is Trapped Air a Problem:

• System Design!
Minimizing air pockets in wet pipe system is recommended. An air release valve which is capable of venting trapped air in the pipe can mitigate this kind of corrosion.
Removing Trapped Oxygen

Automatic Air Vents AUTOMATICALLY vent the trapped air in the wet fire sprinkler system. This eliminates the corrosion oxygen trapped in the line.

The Only UL-Listed and FM approved air vents for fire sprinkler branch lines.
Trapped Air:

• In many sprinkler systems, it is unrealistic to remove all trapped air cost effectively.

• How can you remove more trapped air (oxygen)?

• Pre-fill the wet system with **Nitrogen** before filling with water – Wet Inerting!
On average, with systems with 99.9% nitrogen pockets increases the life expectancy of a wet fire sprinkler system up to 2.8X.
Economic Impact

• Use black steel instead of galvanized piping
  – Saves roughly **30%** on sprinkler piping

• Save existing systems from additional corrosion

• Use a lower supervisory pressure
  – Smaller compressor
  – Smaller membrane
  – Less expensive system

• Feed more than one system
  – “Plant Nitrogen”
  – Economies of scale

*Parking garage installation*
Nitrogen Generators

Cost Evaluation Using Nitrogen
Assisted living facility
Two, 425 gallon dry systems @ 40 psi
No labor, materials and equipment only

**Nitrogen**
- 1 nitrogen generator + purge valves
- Black steel pipe, Schedule 10
- Steel fittings

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Steel + Fittings</td>
<td>$61,122.98</td>
</tr>
<tr>
<td>N2 Generator Equipment</td>
<td>$12,000.00</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td><strong>$73,112.98</strong></td>
</tr>
</tbody>
</table>

**Compressed Air**
- 1 air compressor
- Galvanized pipe, Schedule 10
- Galvanized fittings

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Galvanized Pipe + Fittings</td>
<td>$76,553.82</td>
</tr>
<tr>
<td>Compressor Equipment</td>
<td>$1,150.00</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td><strong>$77,703.82</strong></td>
</tr>
</tbody>
</table>

Estimated life **53 years**

Estimated life **10 years**
Dry Systems

• Use nitrogen over compressed air
• Use black steel over galvanized
• Use lower supervisory pressure
• Limit addition of new water
• Implement a corrosion monitoring program
Wet Systems

• Design systems to vent trapped air
• Pre-fill with nitrogen gas
• Minimize fresh water ingress
• Test the water
• Implement a corrosion monitoring program
Recommendations

Keys for Tomorrow

- Identify expenditures on leak repairs
- Develop budgets for addressing existing systems
- Establish requirements for corrosion prevention in new systems
- Ally with fire sprinkler contractors experienced in fighting corrosion in fire sprinkler systems
- Look at long term cost benefits
Applications

• Parking structures
• Data centers
• Dormitory attic systems
• Sports stadiums
• Loading docks
• Laboratories
• Document archives
• Freezer systems
Questions?

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