Sprinkler Pipe Corrosion
in Wet, Dry and Preaction Fire Protection Systems

Presented by:
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WET, DRY AND PREACTION SPRINKLER PIPE CORROSION
# Corrosion Leads to Catastrophic/Pinhole Leaks

- Property/Equipment damage
- Costly ongoing repairs; pipe and/or system replacement
- Renders Fire Protection System (FPS) inoperable in event of fire
- Sprinkler head blockage
- Deteriorates system components such as gaskets and seals
Corrosion Occurs in Galvanized & Black Steel

A + B + C = Corrosion

- **Unprotected Metal (A)**
  - Uniform wall thinning corrosion mechanism in Black Steel
  - Localized pitting corrosion mechanism in Galvanized
- **Electrochemical Potential (B)**
  - Inexhaustible source of Oxygen in compressed supervisory air
- **Electrolyte (C)**
  - Residual water and moisture left behind after hydrotest

Nitrogen eliminates the Electrochemical potential (B), therefore the equation is not complete and Corrosion is Inhibited.
Example: Galvanic Corrosion

As-received

Cleaned

Wall thickness

0.111 inch
0.061 inch
0.142 inch

Courtesy of: CorrConsult
SPRINKLER PIPE TESTING
Nitrogen vs. Air

Ongoing, long term exposure tests conducted to compare the performance of Nitrogen vs. air

Sections of **Schedule 10** Black Steel and Galvanized Pipe

Individually subjected to compressed air and **supervisory Nitrogen**

Measure the corrosion rates and extrapolate

Sufficient data collected to project significant pipe service life extension as a result of Nitrogen supervision
BLACK STEEL
36-Month Test Results

<table>
<thead>
<tr>
<th>As Received</th>
<th>Cleaned</th>
</tr>
</thead>
<tbody>
<tr>
<td>![As Received Image 1]</td>
<td>![Cleaned Image 1]</td>
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<tr>
<td>![As Received Image 2]</td>
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<tr>
<td>![As Received Image 3]</td>
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<tr>
<td>![As Received Image 4]</td>
<td>![Cleaned Image 4]</td>
</tr>
</tbody>
</table>

**Compressed Air**
- 16.4 Years Pipe Service Life

**95% Nitrogen**
- 20.3 Years Pipe Service Life

**98% Nitrogen**
- 48 Years Pipe Service Life
GALVANIZED STEEL
36-Month Test Results

As Received | Cleaned
--- | ---

**Compressed Air**

7.1 Years Pipe Service Life

**95% Nitrogen**

10.4 Years Pipe Service Life

**98% Nitrogen**

92 Years Pipe Service Life

As Received Cleaned
### RESULTS
36-Month Test

<table>
<thead>
<tr>
<th>Pipe Material</th>
<th>Supervisory Gas</th>
<th>Exposure time (Days)</th>
<th>Uniform wall loss or Pit depth (inches)</th>
<th>Penetration Rate (mils/yr)</th>
<th>Average Penetration Rate (mils/yr)</th>
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<tbody>
<tr>
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<td>Compressed Air</td>
<td>497</td>
<td>0.009</td>
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<td>0.002</td>
<td>0.7</td>
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</table>
Sprinkler Pipe Testing Conclusions

As a result of 98% Nitrogen supervision instead of compressed air supervision:

- Potential extension of black steel pipe service life from 16 to 48 years
- Potential extension of galvanized steel service life from 7 to 92 years
- Significant cost savings can be realized by using black steel pipe in combination with Nitrogen supervision instead of galvanized steel pipe.
SPRINKLER PIPE ICE PLUGS
## Ice Plugs

<table>
<thead>
<tr>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accumulation of condensation leads to ice plugs</td>
</tr>
<tr>
<td>Compressed air exits the air compressor between 180°F and 250°F</td>
</tr>
<tr>
<td>Warm air cools too quickly and moisture develops on the low temperature piping</td>
</tr>
<tr>
<td>Even with regenerative dryer, moisture collects whenever dew point is greater than pipe temperature</td>
</tr>
<tr>
<td>Nitrogen is an inert gas with a true -40°F to -70°F dew point</td>
</tr>
<tr>
<td>Per FM Global, “It is recommended that a dew point 20°F lower than the freezer temperature be chosen.”</td>
</tr>
</tbody>
</table>

Photos courtesy of FM Global
DRY & PREACTION: NITROGEN GENERATION TECHNOLOGY
Membrane Technology

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Used to generate</td>
<td>Non-cryogenic (gaseous) nitrogen on-site</td>
</tr>
<tr>
<td>Material</td>
<td>A polymeric hollow fiber permeates oxygen, water vapor, and impurities out of side walls, allowing nitrogen to flow through its center</td>
</tr>
<tr>
<td>Lifespan</td>
<td>10 – 15+ year lifespan (when properly designed and maintained)</td>
</tr>
<tr>
<td>Requirements</td>
<td>Requires a minimum of 125 PSI of clean, dry compressed air</td>
</tr>
</tbody>
</table>
PSA Technology

Cost effective for larger applications

For applications requiring up to 99.995% Nitrogen purity

Carbon Molecular Sieve (CMS) adsorbs Oxygen and all other molecules under high pressure, allowing Nitrogen to pass through

20 – 25 year lifespan (when properly designed and maintained)

Vessels are filled with Carbon Molecular Sieve (CMS)

Under high pressure, CMS adsorbs impurities, allowing Nitrogen to pass through and into the Storage Tank

Once the CMS is saturated, the vessel is vented to atmosphere and impurities are released from the CMS

The CMS is now ready for the next N2 generating cycle
Type 1 Nitrogen Generator Installation Layout

- Air Compressor
- Nitrogen Generator
- Compressed Air Bypass Line
- Nitrogen Supply line out to Air Maintenance Devices (AMDs)
Type 2 Nitrogen Generator Install Layout

Note: Figures Not Drawn to Scale
Type 3 Nitrogen Generator Installation Layout

Air Compressor

Refrigerated Air Dryer

Nitrogen Generator

Compressed Air Bypass Line

Nitrogen Supply line out to Air Maintenance Devices (AMDS)

Note: Figures Not Drawn to Scale
TOTALPAC³

NEW N₂-Blast® INTEGRATED CORROSION INHIBITING SYSTEM for FIRE PROTECTION SYSTEMS
NEW N₂-Blast® INTEGRATED CORROSION INHIBITING SYSTEM for FIRE PROTECTION SYSTEMS

N₂-Blast® Option Components

A: Dry or preaction automatic sprinkler system
B: Air Style “A” Direct air compressor (shown) or Style “B” APMD available
C: Nitrogen generator
D: Nitrogen storage tank (28 gallons)
E: Maintenance Air Compressor - Maintains storage tank pressure

N2-Blast® Option Specifications

<table>
<thead>
<tr>
<th></th>
<th>FPS-250</th>
<th>FPS-750</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum System Capacity (Gal)</td>
<td>250</td>
<td>750</td>
</tr>
<tr>
<td>Electrical</td>
<td>120V/60Hz/1 Phase</td>
<td>120V/60Hz/1 Phase</td>
</tr>
<tr>
<td>Amperage</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>N₂ Receiver Tank Size</td>
<td>28 Gallons</td>
<td>28 Gallons</td>
</tr>
</tbody>
</table>
Building Monitoring System Integration

**Leak Detection System**

- Should be provided with every Nitrogen generator
- Alarms when the Nitrogen Generator senses a significant leak in FPS piping, which causes the equipment to run excessively
- Alarms if the equipment is not working properly
- Built within the Nitrogen Generator cabinet and includes dry contact for signal out to Building Monitoring System

**Air Bypass Alarm**

- Alarms if Nitrogen Generator is bypassed by air compressor or inadvertently powered “off”
- Ensures that Nitrogen, not air, is continually flowing to the Air Maintenance Device/s
- Built internal to the Nitrogen Generator and provides both a visual and audible alarm
- Includes a dry contact to wire into the Building Monitoring System
AutoPurge System

In order to effectively inhibit corrosion, high purity Nitrogen must be equally distributed throughout the entire FPS

- Provides a constant purge of Nitrogen within each FPS Zone
- Assists in drying out residual water and moisture left behind after hydrotest
- Proven through Computational Fluid Dynamics Modeling to be the most effective way to ensure high purity Nitrogen reaches all branches within the FPS

(1) to be installed on each Zone / System

Install on remote section of FPS

Easily tuned on site by the Sprinkler Contractor

Pneumatic, no power required
AutoPurge System Install

Installation Notes:

- Install 1" NPT Tee on a horizontal section of the Fire Protection Piping.
- Mount APS at a high point within the Fire Protection System as far from the pump room as possible.
- Ensure that the Tee's 90 degree outlet from the main is facing upward so that the main of the APS runs horizontally with the Fire Protection Piping.
- Close Ball Valve on AutoPurge System before hydrostatic testing

Note A: Plumb APS to drain in water sensitive areas
Note B: Close valve during hydrostatic testing
Tuning the AutoPurge System

<table>
<thead>
<tr>
<th>Gallons in Zone</th>
<th>APS 2 Flow Setting</th>
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</thead>
<tbody>
<tr>
<td>50</td>
<td>1/4</td>
</tr>
<tr>
<td>100</td>
<td>1/2</td>
</tr>
<tr>
<td>150</td>
<td>3/4</td>
</tr>
<tr>
<td>200</td>
<td>A</td>
</tr>
<tr>
<td>250</td>
<td>A+1/2</td>
</tr>
<tr>
<td>300</td>
<td>A+3/4</td>
</tr>
<tr>
<td>350</td>
<td>B</td>
</tr>
<tr>
<td>400</td>
<td>B+1/4</td>
</tr>
<tr>
<td>500</td>
<td>B+1/2</td>
</tr>
<tr>
<td>550</td>
<td>B+3/4</td>
</tr>
<tr>
<td>600</td>
<td>C</td>
</tr>
<tr>
<td>650</td>
<td>C+1/4</td>
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<tr>
<td>750</td>
<td>C+1/2</td>
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<tr>
<td>800</td>
<td>C+3/4</td>
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<tr>
<td>850</td>
<td>D</td>
</tr>
<tr>
<td>900</td>
<td>D+1/4</td>
</tr>
<tr>
<td>950</td>
<td>D+1/2</td>
</tr>
<tr>
<td>1000</td>
<td>D+3/4</td>
</tr>
<tr>
<td>1050</td>
<td>E</td>
</tr>
</tbody>
</table>

Set the APS Flow Setting once the FPS system is at supervisory pressure. Use the bleed screw below to relieve the water check feature if no flow occurs, see manual for instructions.

Warning: AutoPurge Systems should be valved off during all FPS pressure tests. This system allows a controlled purge of the FPS system and should be set to the proper APS Flow Setting only. Other settings may cause the FPS to alarm or malfunction.
**Initial fill with Compressed Air**

- Air Compressor
- Refrigerated Air Dryer
- Nitrogen Generator
- Open the Compressed Air Bypass Line
- Nitrogen Supply line out to Air Maintenance Devices (AMDs)

Note: Figures Not Drawn to Scale
System fill with compressed air

Dry or Preaction Riser

AutoPurge System™
System fill with compressed air

Dry or Preaction Riser
System fill with compressed air

Dry or Preaction Riser
System fill with compressed air

Dry or Preaction Riser

AutoPurge System™
System fill with compressed air

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Dry or Preaction Riser

AutoPurge System™
System fill with compressed air

Dry or Preaction Riser
Introducing 98%+ Nitrogen

- Air Compressor
- Refrigerated Air Dryer
- Nitrogen Generator
- Nitrogen Supply line out to Air Maintenance Devices (AMDs)

Note: Figures Not Drawn to Scale
Purge compressed air with Nitrogen

Dry or Preaction Riser
Purge compressed air with Nitrogen

Dry or Preaction Riser

AutoPurge System™
Purge compressed air with Nitrogen

Dry or Preaction Riser

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AutoPurge System™
Purge compressed air with Nitrogen

Dry or Preaction Riser

AutoPurge System™
Portable Nitrogen Purity Sensor

Designed for Building Management Personnel to periodically obtain a quick, visual display of the Oxygen content within the system.

- Ensures that the inner walls of the Sprinkler Piping are blanketed with 98%+ pure Nitrogen.
Nitrogen Monitoring Manifold

Provides the Building Manager with a true indication of the Nitrogen purity content within each FPS and ultimately minimizes power consumption

- LCD screen tracks the Nitrogen purity content within each specific Zone
- Samples the Nitrogen purity at remote points within the FPS
- Stops the purging process once Nitrogen purity has been achieved
- Limits the runtime of the Air Compressor and Nitrogen Generator
- 110V/60Hz/1Ph, 8 amp power required
## Preventative Maintenance

<table>
<thead>
<tr>
<th>Quarterly</th>
<th>Annually</th>
</tr>
</thead>
</table>
| • Air Compressor  
  • Check belt, wipe down surfaces, and inspect oil level  
• Nitrogen Generator & Related Accessories  
  • Clean strainer on each AutoPurge System  
  • Check that 98% or greater Nitrogen purity content is being maintained within each Zone  
• Monitor runtime (should be less than 3 hours per day)  
• Wipe down all surfaces  | • Air Compressor  
  • Change lubricant, air filters and oil filter  
• Nitrogen Generator & Related Accessories  
  • Change all (3) filters  
  • Rinse the inside of each filter bowl  
  • Hour meter should be less than 1000 hrs/year  
• Wipe down all surfaces |
DATA CENTER
TYPE 2 SYSTEM
WET SYSTEMS: DEOX - TECHNOLOGY
Wet System Corrosion

Oxygen exists within **Water**

- Water is continuously being maintained within the steel piping.
- That water contains ~ 10 parts per million (ppm) of dissolved oxygen. Therefore each wet system will experience initial corrosion because of dissolved oxygen.
- However, this can become self-limiting in the sense that all of the dissolved oxygen will be consumed and will cease until the system is refilled with fresh, oxygenated water.
- Reduction of the dissolved oxygen in water to a level below 0.3ppm will result in inhibiting corrosion of the steel that is in contact with water.
Wet System Corrosion

Oxygen exists within **Air Pockets**

- Trapped air pockets frequently exist within Wet systems
- These trapped air pockets contain 20.9% Oxygen and therefore electrochemical corrosion is fully sustained
  - As a result, pin hole leaks eventually develop at the location of the air-water interface
- Reduction of the 20.9% oxygen to a level below 2% will inhibit corrosion in the steel surrounding the trapped air pocket.
  - However, the oxygen concentration of the water surrounding the trapped air pocket must also be reduced.
Wet System Corrosion

Why Corrosion in Wet FPS?

- Oxygen molecules found trapped around water molecules*
- High spot in piping system trapping air pockets during the initial water fill
- Air is made up of 29% Oxygen and 70% Nitrogen
- The Main Water typically has up to 9 PPM oxygen. In order to arrest the galvanic corrosion process, less than 0.3 PPM of oxygen should be present.

*Note: Water is made up of H2O molecules and that is a liquid. Trapped around H2O molecules are separate Oxygen (O2) molecules. Fish breathe the trapped O2 molecules, not the O2 in the H2O molecules.
Mitigating Wet Sprinkler Pipe Corrosion

How? Pre-purge with a N2 gas and charge the sprinkler system with DeOx™ - Deoxygenated Water

- By pre-pre-purging the system with Nitrogen, the pockets of trapped air will now be pockets of trapped nitrogen gas, no longer containing harmful Oxygen.
- Then by charging the sprinkler pipe with DeOx™ - Deoxygenated Water, less than 0.1ppm of dissolved oxygen (under the Oxygen limits known to cause corrosion) remains in constant contact with the steel sprinkler piping.
- There isn’t enough Oxygen in the water to dissipate into the trapped nitrogen gas pockets, hence protecting the piping area where in the past, corroded.
- In conclusion, by eliminating the trapped air pockets and removing all but .1ppm of dissolved oxygen from within the sprinkler piping, the overall threat of corrosion is eliminated.

In order to slow down or completely eliminate internal wet system corrosion, the following must be accomplished:

- Objective # 1
  - Reduce the dissolved oxygen in water to a level below 0.3ppm
- Objective # 2
  - Remove the Oxygen from within the trapped air pockets

• Objective # 1
• Reduce the dissolved oxygen in water to a level below 0.3ppm

• Objective # 2
• Remove the Oxygen from within the trapped air pockets
Key Contacts:

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    - sbodemann@gmail.com
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  - Molly Hollifield
    - 910.332.4173 ext. 112
    - mhollifield@southteksystems.com
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    - o: 910.332.4173 ext. 125