Pre-Action Sprinklers and Growing Corrosion Problems

...What you do now could save you a bundle!

Code Requirements? MIC? Microbiologically Induced Corrosion?

Why can it be so damaging? Alternative Systems? How to prevent it?
A Corrosion Story

- Allied Signal, Inc. - Worldwide Computing Center
  - Located in Tempe, AZ
  - Arizona’s largest private employer

- Sprinkler System Pinhole Leak – May 1994
  - Shutdown all Eastern US Manufacturing operations for 6 hours!
  - $16M loss from downtime
  - $25M replacement costs
  - Federal Court Lawsuits
Not a New Problem…

- The Cost of Corrosion
  - U.S. Electric Power Industry
    - $5-10B annually
    - 50% of all outages in steam-generating plants
    - Makes up 10% of total U.S. power generation costs
  - $1.5B spent annually on corrosion prevention

- A Growing Problem in Fire Sprinkler Systems:
  - 5th leading cause of system failures [1]
  - 40% - 60% of failures due to MIC [2]

What is Corrosion?

- An Electrochemical Process
  - Corrosion = Metal + Oxygen + Water
  - A natural process - all metallic systems corrode at varying rates

- The Best way to Stop Corrosion...
  - Best: use something other than *Metal*
  - 2nd Best: eliminate the *Water*

- Bacteria can be an Accelerator
  - *Aerobic Bacteria* requires O₂ ... *so eliminating the Oxygen will do the trick.*
  - *Anaerobic Bacteria* doesn’t require O₂ ... *so must remove the Water or use some other inhibitor.*
What is MIC?

- **Microbiologically Induced Corrosion**

  “An electrochemical corrosion process that is *concentrated* and *accelerated* by the activity of *specific bacteria* within a fire sprinkler system, resulting in the premature failure of metallic system components.”

- Corrosion that is *influenced by* the presence and activity of micro-organisms.
- The normally slow rate of growth in corrosion is *accelerated abnormally.*
Corrosion Leads To...

- **Catastrophic Pinhole Leaks**
  - Property & Equipment Damage
  - Costly Ongoing Repairs
  - Possible System Replacement

- **Renders Fire Sprinkler System Inoperable**
  - System Impairments Due to Repairs
    - Fire safety risks
  - Increased Friction Factors
    - 1/8” of corrosion in 2” pipe means double the friction
  - Sprinkler Head Blockage
  - Deterioration of System Components
    (i.e. Gaskets and Seals)
Corrosion Impact

Schedule 80 pipe:
0.400 inches exists to corrode before reaching minimum acceptable standards.

Schedule 10 pipe:
Only 0.088 inches exists to corrode before reaching minimum acceptable standards.

Schedule 80: 0.500 inches
Schedule 40: 0.322 inches
Schedule 10: 0.188 inches
Corrosion: What’s at Risk?

- **Life Safety Risk**
  - Will the sprinkler system provide the appropriate level of response to prevent injury or loss of life?

- **Catastrophic Structure Risk**
  - Will the sprinkler system prevent loss of the structure?

- **Piping Failure Risk**
  - Will the sprinkler piping fail and leak during a dormant period resulting in water damage to the structure and contents?

- **Business Continuity Risk**
  - Will the failed (leaking) fire sprinkler system cause business interruption?
Top Contributing Factors  
...in Dry-Pipe Sprinkler Systems

Factor # 1: Trapped Water

- Improper pitching
- Missing low point drains
- Flow testing
- Certain types of fittings (ex. roll-grooved)

NFPA 13 (2010)

8.16.2.3.2 In preaction systems, branch lines shall be pitched at least 1/2 in. per 10 ft, and mains shall be pitched at least 1/4 in. per 10 ft.

8.16.2.4.1* Provisions shall be made to properly drain all parts of the system.
Factor # 2: Periodic Flow Testing

- Fresh Water is *Oxygen Rich* Water
- **Procedure:** Water flows through *entire system* to the inspector’s end line test connection.
- **Required Frequency:** Every 3 years and after *any system modification*

**NFPA 25 (2011)**

13.4.4.2.2.* Every 3 years and whenever the system is altered, the dry pipe valve shall be trip tested with the control valve fully open and the quick-opening device, if provided, in service.
Top Contributing Factors

...in Dry-Pipe Sprinkler Systems

Factor # 3: Moist Compressed Air

- Used to pressurize the sprinkler pipe
  - Supervises for leaks
  - Pressure loss from sprinkler operation opens dry pipe valve

Even a small amount of moisture combined with Oxygen that is introduced with the pressure maintenance air creates a very corrosive environment.
Top Contributing Factors

...in Dry-Pipe Sprinkler Systems

Factor # 3: Moist Compressed Air

- Another Complicating Factor
  - Acidic water caused by “distilling” effect of injecting compressed moist air.
  - A more **acidic water means a faster rate of corrosion**.

Injecting Compressed Air has Distilling Effect on the Water

Distilling Removes all the Water’s Minerals

No Minerals to Neutralize the Carbonic Acid formed by CO2 from Air Dissolving into Water

Water Becomes Acidic (pH of 5.5)
NFPA Requirements

Pitch Pipe Properly

- **Non-Refrigerated Dry and Pre-Action Systems**
  - Branch Lines: ½ inch per foot
  - Mains: ¼ inch per foot

- **Refrigerated Dry and Pre-Action Systems**
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8.16.2.3.3 Dry Pipe and Preaction Systems in Refrigerated Areas. Branch lines shall be pitched at least 1/2 in. per 10 ft, and mains shall be pitched at least 1/2 in. per 10 ft in refrigerated areas.

**NOTICE**

Prior to 2007, NFPA didn’t require pitching of pipe in Pre-Action Systems. Systems installed before 2007 most likely have a significant amount of trapped water.
Install Low Point Drains

- Must be able to completely drain every part of the system.

NFPA 13 (2010)

8.16.2.4.1* Provisions shall be made to properly drain all parts of the system.
NFPA Requirements

Test & Treat Water Supply

- Evaluate water supplies and environmental conditions
- If you find MIC, choose one of the following:
  - Install a pipe that won't be affected
  - Treat all water entering system
  - Periodic scanning of pipe interior
  - Install corrosion monitoring station

23.1.5.1 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 using one of the following methods:

1. Install a water pipe that will not be affected by the MIC microbes
2. Treat all water that enters the system using an approved biocide
3. Implement an approved plan for monitoring the interior conditions of the pipe at established time intervals and locations
4. Install corrosion monitoring station and monitor at established intervals
**Internal Inspection**

- Every 5 years
- Visually inspect for presence of foreign material
  - At end of main *open flushing connection*
  - At end of branch line *remove sprinkler head (most remote branch line for Preaction)*
- Consider nondestructive methods for Mission Critical
- When in doubt, test for MIC

**NFPA 25(2011)**

14.2.1 Except as discussed in 14.2.1.1 and 14.2.1.4 an inspection of piping and branch line conditions shall be conducted *every 5 years* by opening a *flushing connection* at the end of one main and by *removing a sprinkler* toward the end of one branch line for the purpose of inspecting for the *presence of foreign organic and inorganic material*.

14.2.1.1 Alternative *nondestructive* examination methods shall be permitted.

14.2.1.2 Tubercules or slime, *if found, shall be tested* for indications of microbiologically influenced corrosion (MIC).
NFPA Requirements

Obstruction Investigation

- Only if any one of 14 conditions exist [NFPA 25 – 14.3.1]

1. Defective intake for fire pumps taking suction from open bodies of water.
2. The discharge of obstructive material during routine water tests.
3. Foreign materials in fire pumps in dry pipe valves, or in check valves.
4. Foreign material in water during drain tests or plugging of inspector’s test connections.
5. Plugged sprinklers.
7. Failure to flush yard piping or surrounding public mains following new installations or repairs.
8. A record of broken public mains in the vicinity.
9. Abnormally frequent false tripping of a dry pipe valve.
10. A system that is returned to service after an extended shutdown (greater than 1 year).
11. There is reason to believe that the sprinkler system contains sodium silicate or highly corrosive fluxes in copper systems.
12. A system has been supplied with raw water via the fire department connection.
13. Pinhole leaks
14. A 50% increase in the time it takes water to travel to the inspector’s test connection from the time the valve trips during a full flow trip test of a dry pipe sprinkler system when compared to the original system acceptance test.
Obstruction Investigation

Procedure found in Annex D (NFPA 25)

"Large quantities of water are needed for investigation and for flushing. It is important to plan the safest means of disposal in advance. Cover stock and machinery susceptible to water damage, and keep equipment on hand for mopping up any accidental discharge of water."

- Excerpt from Annex D.3 Investigation Procedures
How is Corrosion Detected?

-Leaks... after it’s already too late!
-Discoloration/Corrosion on Pipe Exterior
-Abnormal Performance
  - Longer trip times
  - Solid particles in drain water
-Water Testing Kits
-Borescope (Video)
-Ultrasonic Pipe Inspection
-Corrosion Monitoring Coupons
Ultrasonic Scanning Technology

- **Predictive Maintenance Program**
  - Locates Corrosion Buildup
  - Locates Pitting & Wall Thinning
  - Satisfies 5-year internal inspection requirement [NFPA 25 -14.2.1]

- **Nondestructive**
  - No interruption to business operations
  - No need to shut down equipment
  - Safe even for Clean Rooms, Hospitals and Food Processing

- **Inspection Report Maps Problem Areas**
  - Make informed decisions
**Corrosion Solutions: N₂ Generator**

...a dehydrated sprinkler system

**Why Nitrogen makes sense**
- Inert Gas: non-toxic, colorless, odorless
  - No harmful Environmental effects
- A very dry gas (dewpoint of -71° F)
  - Absorbs any moisture trapped in system
- Will not in any way support the corrosion process

**Completely Dry Pipe**
- Oxygen free – breaks the corrosion triangle
- Stops MIC - will not support microbial growth and propagation
- Won’t degrade elastomeric seats in sprinkler valves
  (Oxygen rich air causes Oxidative Degradation)
Corrosion Solutions: N$_2$ Generator

How it works...

- **Nitrogen Generator placed in-line**
  - Between air compressor and air maint. device
- **Supplies a continuous stream of Nitrogen**
  - Concentrations of 95% to 99%
- **Venting through Membrane Filter**
  - 50% efficient
  - Lets Oxygen out but not Nitrogen
- **Eliminates Oxygen and Dehydrates Pipe**
  - All that remains is Nitrogen (O$_2$ content drops to zero)
  - Completely removes all trapped moisture
Corrosion Solutions: N₂ Generator

N₂ Generation:
✓ Simple Installation
✓ Leave sprinkler system as-is
✓ Optional Manifold Unit for Multi-Zone

Typical Nitrogen Generation System Configuration

1" Mechanical Tee
Dry or Pre-Action Valve
Riser

N₂ Supply Line w/ APMD

Manifold Unit

Pressure Gauge

N₂ Generator

Air Compressor (Source Air)

Condensate Drain Line

Air In

N₂ Out
Advantages over N\textsubscript{2} Cylinders

- No need for remote supervision of N\textsubscript{2} levels
- No need for routine change out of cylinders
- No risk of cylinders running out of gas and depressurizing the system.
- No safety concerns
  - Unlike high pressure compressed gas N\textsubscript{2} cylinders (DOT transport rules)
  - N\textsubscript{2} cylinders are heavy and must be handled with extreme care
Advantages over Corrosion Inhibitors

Chemical Additives to Water

- No possibility of chemical hazards
  - N₂ is completely non-toxic
- No risk of toxic backflow into municipal water main
- No risk of discharge and runoff into municipal sewer system
- No need for added cost of retreatment
  - After every periodic flow test
  - After any system modification
New System Considerations

The Type of Pipe Matters...

- Schedule 40 black iron pipe is good choice
  - Commonly installed thin wall pipes often develop pinhole leak in only 12 months!
- Corrosion Resistance Rating (CRR) > 1.0
- Galvanized is not the answer
  - Data indicates significant corrosion problems in Dry and Pre-Action Sprinkler Systems

Install with Flow Testing in Mind

- Appropriate pitching
- Plenty of low point drains
- Avoid roll-groove type fittings
- Weld seam at top
What if I already have problems?

- Evaluate the Degree of Localized Damage
  - Loss of pipe wall affects future longevity
  - Surface roughness affects friction loss and system hydraulic flow characteristics
  - Cannot be restored by chemical cleaning.

- Replace as Necessary
  - **Goal:** Restore to NFPA 13 specifications for interior surface of pipe
  - Replace *only damaged sections* or *entire system*

- Add Sufficient Auxiliary Drains
  - Everywhere trapped water is found

- Install Preventative Measures
  - Such as Nitrogen Generation System
Wet System Issues

- Wet systems have problems too!
- Oxygen exits within
  - Air pockets
  - Dissolved in water
- Corrosion leaks form at high points in system
Nitrogen treatment systems for wet pipe sprinklers
- Relatively new

Steps to eliminate oxygen
1. Fill piping with dry nitrogen
2. Fill system with deoxygenated water < 1.0 ppm dissolved $O_2$. 