Sprinkler Pipe Corrosion

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Outline

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2) Concerns & Issues
3) Types of Pipe Corrosion
4) Leading Causes for Corrosion
5) Urban Legends
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Introduction to Corrosion
What is Corrosion

• Occurs between metal and air or water (moisture)
• Irreversible process
Concerns & Issues
**Corrosion in** Sprinkler Pipe

- Increase in Friction Loss & Reduction in Flow
- Premature Pipe Wall Failure
- Obstructions in Flowing Sprinklers
- Complete Failure of Systems
- Reduced Service Life & Increased Outages
Types of Corrosion
Types of Corrosion

Uniform corrosion
• “Normal Wear and Tear”

Localized corrosion
• Pitting
• Crevice Corrosion (Threads, Grooves, etc.)
• Galvanic Corrosion (Dissimilar metals)
• Environmental Corrosion (CPVC)
• Microbiologically Influenced Corrosion (MIC)
**Uniform (General) Corrosion**

- Corrosion uniformly distributed over a metal surface
- Reddish-brown color
Localized corrosion

- Often Associated with Dry and Preaction Systems or Wet System with Trapped Air
- Presence of Water and Oxygen is a Prerequisite for Corrosion to Take Place
- Sometimes, But Not Always Associated with Microbes
- Will Take Place in the Absence of Bacteria if Conditions for Electrochemical Activity Exist (i.e. Unprotected Metal, Potential and Electrolyte)
- Usually Takes the Form of Localized Pitting Resulting in Pinhole Leaks

Courtesy of Rockville City FMO
Galvanic Corrosion

- Corrosion between dissimilar metals in contact
- Electrons transfer from one metal (anode) to the other (cathode)
**Pitting Corrosion**

- Localized form of corrosion resulting in through pipe wall penetrations or surface cavities
- Considered to be one of the most destructive forms of corrosion
- Difficult to detect
- Can be covered or open and normally grow in the direction of gravity
Crevice Corrosion

- Localized form of corrosion found with crevices and other shielded areas
- Generally found beneath gaskets, between threads, within cut or rolled grooves, etc.
- Crevice corrosion is also referred to as gasket corrosion, deposit corrosion or under-deposit corrosion
Crevice Corrosion
Environmentally Induced Cracking

- Localized corrosion caused by stress, fatigue, embrittlement, etc.
- Exterior contamination and degradation by exposure to UV exposure, incompatible products or excessive cement
- Interior pipe wall contamination and degradation by exposure to incompatible water and/or pipe treatments (ABF II)
**Microbiologically Influenced Corrosion (MIC)**

- Corrosion Initiated or Accelerated By the Presence and Activities of Microorganisms.
- As Bacteria Grows, Produces Byproducts Corrosive to Metals Such as Alkalis, Acids (NH₃, H₂S, H₂SO₄, Other Organic Acids) and Reducing Agents
- Tubercles and Biofilms Restrict and Obstruct Pipe and Sprinklers Orifices
- Can Lead to Pipe Wall Failure Within 5 Years
- Less Than 20% of Pipe Failures We Investigated Can Be Attributed to MIC
Leading Causes for Corrosion
Leading Causes of Corrosion

- Poor Installation (Means & Methods)
- Inadequate Maintenance
- Microbiological Influenced Corrosion (MIC)
- Contamination (CPVC)
- Inferior Material or Manufacturing Process
Urban Legends
Urban Legends

- Galvanized Pipe is Better than Black Steel
- Dry and Preaction Systems Are Dry
- Not a Concern in Wet Systems
- Foreign Pipe is the Number One Cause of Pipe Leaks
- Today’s Water Quality is the Cause of Corrosion (Less Cl More NaClO)
- MIC is the Cause of Corrosion
Urban Legends

Galvanized piping is not the answer

- Case Histories Show Corrosion and Leaks in Systems < 3 Years Old
- Galvanizing Often Compromised at Roll Grooved Pipe Ends
- Can Accelerate Localized Corrosion
- White Rust Corrosion - Rapid Attack on Zinc that Reduces Service Life
- Galvanized Pipe Not Required By NFPA 13 For Dry Systems with Minor Exceptions
NFPA Requirements
**NFPA Requirements** NFPA 13 (2016 edition)

**Section 7.10** requires all MIC and corrosion additive treatments to be listed for use.

**Section 8.16.2.5.3.5** requires condensate drains on dry and preaction piping containing more than 5 Gallons of trapped water.

**Section 8.16.4.2.2** requires pipe to have a CRR ≥ 1 where unusual corrosive properties are known to exist.

**Section 8.16.6** requires manual or automatic air venting to reduce corrosion.
14.2.1.1 An assessment of the internal condition of piping shall be conducted at a minimum of every 5 years or in accordance with 14.2.1.2 for the purpose of inspecting for the presence of foreign organic and inorganic material.

14.2.1.2* Where an assessment frequency has been established by an approved risk analysis, the assessment shall be performed at a frequency determined by the approved risk analysis.

14.2.1.3 Tubercules or slime, if found, shall be tested for indications of microbiologically influenced corrosion (MIC).

14.2.1.4* If the presence of sufficient foreign organic or inorganic material is found to obstruct pipe or sprinklers, an obstruction investigation shall be conducted as described in Section 14.3.
NFPA Requirements  NFPA 25 (2017 edition)

14.2.1.5 Nonmetallic pipe shall not be required to comply with Section 14.2.

14.2.2* In buildings having multiple wet pipe systems, every other system shall have an assessment of the internal condition of piping as described in 14.2.1.

14.2.2.1 During the next inspection frequency required by 14.2.1.1 or 14.2.1.2, the alternate systems not assessed during the previous assessment shall be assessed as described in 14.2.1.

14.2.2.2 If foreign organic and/or inorganic material is found in any system in a building, all systems shall be assessed.
**NFPA Requirements** NFPA 25 (2017 edition)

14.3 Obstruction Investigation Required
- Foreign materials present
- Rattling in piping during draining, refilling
- Record of broken mains in the vicinity
- Frequent false trips
- Pinhole leaks
- 50% increase in water delivery time from a full flow trip test from original system acceptance test
14.3.2* Systems shall be examined for internal obstructions where conditions exist that could cause obstructed piping.

14.3.2.1 If the condition has not been corrected or the condition is one that could result in obstruction of the piping despite any previous flushing procedures that have been performed, the system shall be examined for internal obstructions every 5 years.

14.3.2.2* Internal examination shall be performed at the following minimum four points:
(1) System valve
(2) Riser
(3) Cross main
(4) Branch line
14.3.2.3* Alternative nondestructive examination methods shall be permitted.

14.3.3* If an obstruction investigation indicates the presence of sufficient material to obstruct pipe or sprinklers, a complete flushing program shall be conducted by qualified personnel.

14.3.4 Tubercules or slime, if found during an obstruction investigation, shall be tested for indications of microbiologically influenced corrosion (MIC).
NFPA Requirements

After confirming the presence of foreign material, it is recommended that pipe and water samples be processed by the following:

• Full Laboratory Water Analysis that Identifies and Quantifies Biological and Chemical Composition, Known Microbes Associated with MIC or Other Causes of Corrosion.

  ✓ Field Test Kits May Produce “False Positives” or “False Negatives” and Fail to Quantify Biological and Chemical Composition. Field Analysis Produces Less Accurate Results and Analytical Quality Assurance is Difficult to Maintain and Control. May lead to Costly, Useless Remedial Work.

• In-Depth Metallurgical Analysis Quantifies Pipe Wall Thickness/Material Loss, Confirms Material Composition, Identifies Type of Corrosion and Estimates Remaining Service Life.
Identification and Remediation
Clues to Identify Accelerated Corrosion

- Pin Hole Leaks?
- Staining and Sediment at Couplings, Test Outlets?
- Foreign Material (e.g. sludge, scale) During Routine Testing?
- Test and Drain Outlets Discharge Freely Without Plugging Outlets?
- Increase in Water Delivery Time During Full Dry Pipe Trip Tests?
- Reduction in Water Supplies including Fire Pump Flow Tests?
**Identification**

- Assesses Installation (pipe material, drainage, pipe pitch, etc.)
- History and Frequency of Leaks
- Review Available Inspection, Testing & Maintenance Records
- Representative Internal Piping Investigation – Risers, Feed & Cross Mains, Branch Piping, Sprinklers
- Water Chemistry & Metallurgical Analysis
Identification

Lower Quality Video
Provides an Image That Fails to Clearly Represent Conditions, Nature of Foreign Material and Extent of Pipe Damage.

High Definition Recording
VIDEO REMOVED DUE TO SIZE, RE-INSERT PRIOR TO PRESENTATION
Identification

Top picture clearly shows unobstructed branch line welded outlet. Whereas, picture to the right shows obstructed outlet.
Corrective Action

Comprehensive Approach that Assesses
- Inspection, Testing & Maintenance
- Failure Potential
- Installation Modifications
- Service Life Remaining
- Water/Air Treatment
- Pipe Replacement Priorities
Remediation Plan

- Addresses the Cause and Not the Symptom
- Phased In vs. Complete Replacement
- Scheduled vs. Crisis
- Budgeted Solution
Identification & Remediation

Ultrasound technologies
- May Only Determine General Pipe Wall Thickness
- Cannot Characterize the Cause of the Corrosion
- Cannot Identify Individual Scale “Nodules”
- Cannot Identify Trapped Water That Would Lead to Corrosion

Field water sample testing only without conducting a metallurgical exam

Flushing could compound obstruction problems
- Move Scale To Dead-end Piping (Branchlines)
- Does Not Assess Piping Integrity
Manufacturers Response To Corrosion

- Antibacterial Film (ABF) or Antimicrobial Coating (AMC) Protected Pipe
- Post Installation of MIC Treatment Additives
- Pre-Engineered Nitrogen Generation Systems
- Closed Loop Water Flow Testing Devices
- Manual and Automatic Air Venting Equipment
- Inline Corrosion Detection Equipment
Case Studies
Case Study | 1

Media Data and Transmitter Facility

Problem
• Pin Hole Leaks
• Initially Blamed on MIC by Installing Contractor

Assessment
• Assessed Pipe Pitch and Drainage Features
• Borescope Discovered Severe Corrosion within Galvanized Pipe – Feed and Cross Mains
• Laboratory Analysis Confirmed No MIC

Solution - Value
• Interior Preaction Mains Removed and Replaced
• Avoided Branchline Replacements over Critical Equipment

* Mission Critical Facility with 3 Year Old Preaction Systems
**Case Study | 2**

**Office Building – Bethesda, MD**

**Problem**
- Pinhole Leaks in Fire Pump Room Piping

**Assessment**
- Water Chemistry & Metallurgical Analysis – Confirmed MIC
- Detailed Investigation Revealed Minimal Systems Exposure
  - Reviewed Pump Running Frequency
  - Assessed Systems Pressures
  - Oxygenated Water Causing MIC Not Circulated Downstream from Pump Room

**Solution - Value**
- Limited Remedial Work Required Confined to Fire Pump Room
- Avoided Costs of Extensive Investigations – Three Buildings Served by the Fire Pump
Case Study | 3

Office Buildings – Reston, VA

Problem
• Reoccurring Pin-Hole Leaks in Copper Sprinkler Piping
• Buildings Owners Negotiating Sale

Assessment
• Borescope No Large Scale Signs of Severe Corrosion
• Pipe Samples Indicated Ferrous Material Present
• Laboratory Analysis Confirmed Presence of Ferrous Material

Solution - Value
• Adjust Testing Schedule and Methodology
• Perform Temporary Repairs and Replace During Annual Shut Down
• Avoid One Time Complete Systems Replacement – Priorities Recommended - Phased Over 10 Years
**Case Study | 4**

**Office Buildings – Arlington, VA**

**Problem**
- Unacceptable Fire Pump Performance
- Water Supply Identified as a Concern

**Assessment**
- Fire Pump and Water Supply Retested
- Excessive Loss in Pressure Between Incoming water Supply and Fire Pump Identified
- Initially Thought to be Foreign Object Obstruction
- Borescope Found Severe Pipe Restriction From Corrosion
- Laboratory Analysis Confirmed MIC

**Solution - Value**
- Fire Pump Supply Piping Replaced
- Avoided Costly Fire Pump Repair/Replacement and Future Emergency Piping Replacements


**Case Study | 5**

**Office Buildings – Arlington, VA**

**Problem**
- Reoccurring Leaks in Existing Preaction Systems Protecting Mission Critical Operations
- Total Annual Pipe Failure Repairs Exceed 1M Dollar

**Assessment**
- Borescope Found Significant Signs of Corrosion and Foreign Material Present to Question Pipe Integrity and Operational Reliability in Selective Pipe Segments.
- Laboratory Analysis Confirmed Degradation to Pipe not Caused by MIC.
- Primarily Trapped Water – Inadequate Drainage

**Solution - Value**
- Pipe Replaced: Mains and Branch Lines Within Only Selective Areas. Avoided Total Systems Replacements to Include Piping in Critical Equipment Rooms
Summary

1. Understand the Problem
2. Comprehensive Assessment
3. Focused Corrective Action
4. Cost Effective Resolution
Questions & comments
Sources


Questions for PDH credit
Questions for PDH Credit

1. Which type of corrosion is often the most difficult to detect?
   **PITTING**

2. The internal examination of sprinkler piping shall occur at what four points?
   **SYSTEM VALVE, RISER, CROSS MAIN, BRANCH LINE**

3. True or false? Galvanized piping is always the best solution for lessening the effect of corrosion in sprinkler piping systems.
   **FALSE!**