ODOR AND CORROSION CONTROL:
Winning the Battle on Both Fronts

WEBINAR TALK 1: Odor and Corrosion Control:
Getting the Best of Both Worlds

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MAY 2015
Presentation Outline

• Introduction
• Liquid phase reactions
• Gas phase reactions
• Think globally
• Approaches for controlling corrosion
• Approaches for controlling odor and corrosion
• Turbulence
• Pipeline design for corrosion control
Presentation Outline (cont)

- Pipeline rehabilitation
- Prevention of sulfide production in the liquid stream
- Destroy or tie up sulfide in solution
- Contain or remove and treat gas phase sulfide
- Atmospheric dispersion
- Application matrix
- Conclusions
- Questions
Odor and Corrosion are Interconnected

- In Chinese philosophy, *yin and yang* describes how apparently opposite or contrary forces are actually complementary, interconnected, and interdependent in the natural world, and how they give rise to each other as they interrelate to one another.

The symbol for yin and yang is:
Odor and Corrosion Connections

• Odor and corrosion are an excellent example of yin and yang
  • Hydrogen sulfide, which is produced under anaerobic conditions, is one of the primary sources of odor complaints
  • Hydrogen sulfide can be biologically converted to sulfuric acid, which corrodes concrete and metal pipes
Early Approaches

• Containment to prevent odor complaints
  - Seal manholes with caulk and stoppers
• Worked well for odor complaints
• Corrosion was not considered to be an issue in the northwest due to low sulfate and low water temperatures
• Besides, odor complaints were immediate, corrosion was out of sight and out of mind.
Theory Meets Reality
Theory Meets Reality
• The lessons learned is that it is not sufficient to address odor issues
• The interrelationship between odor and corrosion needs to be considered
• The following slides will address various approaches for controlling odor and corrosion and their interrelationship.
Liquid Phase Reactions

- Sulfate is converted to sulfide in the absence of dissolved oxygen
  \[ \text{SO}_4^{-2} + 2 \text{C} + 2 \text{H}_2\text{O} \xrightarrow{\text{bacteria}} 2 \text{HCO}_3^- + \text{H}_2\text{S} \]

- Sulfide is converted to sulfate in the presence of oxygen
  \[ 2\text{O}_2 + 2\text{HS}^- \xrightarrow{\text{bacteria}} \text{S}_2\text{O}_3^{-2} \]
Gas Phase Reactions

- Hydrogen sulfide is oxidized to sulfuric acid by bacteria on the pipe wall
  - \( \text{H}_2\text{S} + \text{O}_2 \xrightarrow{\text{bacteria}} \text{H}_2\text{SO}_4 \)
- Sulfuric acid attacks concrete leading to corrosion and ultimately to failure
  - \( \text{Ca(OH)}_2 + \text{H}_2\text{SO}_4 \rightarrow \text{CaSO}_4 \cdot 2\text{H}_2\text{O} \) (gypsum)
Think Globally

- Decisions for controlling odors can either increase or decrease the potential for corrosion
  - Containment of odorous air will help prevent odor release, but will increase the potential for corrosion
  - Evacuation of the headspace and treatment of the removed air can both control odors and limit corrosion
Think Globally (cont.)

• Similarly, decisions for controlling corrosion can have either positive or negative effects on odor
  • Evacuation of headspace air without treatment can limit corrosion, but increase odor issues
  • Steps taken to limit hydrogen sulfide production will help limit corrosion and concurrently help limit odors

• Rather than dealing with odors or corrosion as independent issues, select solutions which address both issues while minimizing cost
Approaches for controlling corrosion

• Pipeline design and rehabilitation
  • Limit release
  • Limit production
  • Protect pipeline from corrosion
Approaches for controlling odor and corrosion

- Prevent sulfide production in the liquid stream
  - Maintain aerobic conditions
  - Inhibit bacteria which produce sulfide
- Destroy or tie up sulfide that has been produced
  - Inject chemicals which destroy or precipitate sulfide
- Contain, remove and treat odorous air from the headspace
  - Requires containment, evacuation of air and treatment
  - Utilize dispersion where possible
The Yin and Yang of Turbulence

- Turbulence can maintain aerobic conditions by raising the dissolved oxygen level which inhibits sulfide generation.
- However, turbulence is the primary mechanism by which sulfide is transferred from the liquid stream to the gas phase.
- Minimizing turbulence can thus either help or hinder the control of odor and corrosion.
Pipeline Design for corrosion control

- Pipeline design
  - Gravity systems
    - Avoid areas of turbulence where sulfide is present
    - Avoid solids deposition
    - Maintain aerobic conditions
    - Use corrosion resistant materials
      - Applied coating such as Linabond
      - Use T-Lock Pipe
Pipeline Design for corrosion control (cont.)

- Siphons and force mains
  - Minimize detention times
  - Minimize turbulence at discharge points
  - Evaluate stripping manholes ahead of forcemain discharges
  - Install air jumpers around low head structures
- For parallel force mains
  - Size one for average dry weather flow
  - Size second for peak flow
  - Provide capability to drain and self prime
Pipeline Rehabilitation

- Power wash surfaces
- Install corrosion resistant materials
  - Applied coating such as Linabond
  - Slip lining such as Insituform or Hobas
- Redesign to eliminate turbulence
- Install air jumpers around low head structures.
Prevent sulfide production in the liquid stream

- Maintain aerobic conditions
  - Inject Air/oxygen to force main
    - Avoid systems with high points
    - Use specially designed “U-tube” systems
    - Consider new side stream injection systems
  - Design for oxygen transfer in upper sections of the system where sulfide is not present
- Feed nitrate compounds
  - Bioxide - calcium nitrate ~ 2-4 gal/lb H₂S
  - Nitrazyme - sodium nitrate: use where high concentrations of fats, oils and greases are present to avoid formation of “soap scum”
Prevent sulfide production in the liquid stream (cont.)

- Inhibit bacteria which produce sulfide
  - Caustic dosing
    - Raise pH above 11.5 for at least 30 minutes
    - Dosage dependent on wastewater alkalinity
    - Dosing frequency varies from weekly to every other day
  - Anthraquinone
    - Inhibits sulfide producing bacteria
    - Available as pure material and in conjunction with Bioxide
Prevent sulfide production in the liquid stream (cont.)

- Inhibit bacteria which produce sulfide (cont.)
  - Hypochlorite
    - Generally requires a high dosage
    - Acts as disinfectant
  - Bacteria/enzymes
    - Limited success
    - Requires pilot testing
Destroy or tie up sulfide that has been produced

- **Hydrogen Peroxide**
  - Inject 15 to 20 minutes prior to discharge from force mains
  - Dosage based on measured sulfide concentration. Typically 1-3 parts per part sulfide
- **Sodium Hypochlorite**
  - Dosage based on measured/anticipated sulfide concentration. Typically 5-15 parts chlorine per part sulfide
Destroy or tie up sulfide that has been produced (cont.)

- Precipitation
  - Iron salts
  - Other metal salts
- pH adjustment
  - Caustic injection to maintain pH above 9
    - Sodium Hydroxide
    - Magnesium Hydroxide
Contain or remove and treat odorous air from the headspace

- **Containment**
  - Sealing manholes
    - Requires corrosion resistant pipelines
  - Use of air jumpers
    - Prevents pressure buildup at low head structures, etc..
  - Maintaining negative pressure
    - Requires evacuation and treatment of exhaust air
Contain or remove and treat odorous air from the headspace (cont.)

- Headspace Air Treatment
  - Carbon scrubbers
    - Impregnated carbon
    - Unimpregnated carbon
    - Mixed bed carbon
    - Centaur carbon
  - Liquid scrubbers
    - Packed bed
    - Mist
Contain or remove and treat odorous air from the headspace (cont.)

- Headspace Air Treatment (cont.)
  - Biofilters
    - Bulk media filters
    - Packed bed wet biofilters
  - Ozone
Contain or remove and treat odorous air from the headspace (cont.)

- Carbon Scrubbers
  - Impregnated carbon
    - Most effective for hydrogen sulfide
    - Capacity of 0.12 g H₂S/cc of carbon
  - Unimpregnated carbon
    - Most effective for organics
Contain or remove and treat odorous air from the headspace (cont.)

- Carbon Scrubbers (cont.)
  - Mixed bed carbon
    - Used where both sulfide and organics are present, but two stage system is not justified
  - Centaur carbon
    - Water regeneration - hydrogen sulfide removal
    - Types:
      - Deep bed
      - Phoenix automatic regeneration
Contain or remove and treat odorous air from the headspace (cont.)

- **Liquid Packed Bed Scrubbers**
  - Caustic adsorption
    - Removes sulfide, but does not destroy it
  - Chemical oxidation
    - Combines caustic with oxidants
    - Select pH and oxidant based on constituents to be removed
    - Preferable to carbon for high H$_2$S concentrations and/or with high air flow rates
    - Use of multiple stages to maximize efficiency
    - Normal oxidants include hypochlorite and hydrogen peroxide
    - Limited effectiveness on low solubility organics
Contain, remove and treat odorous air from the headspace (cont.)

- Mist Scrubbers
  - Uses same chemical reactions as packed bed units
  - Single pass eliminates potential for release of previously captured contaminants
  - Low pressure drop
  - High gas flow rates
Contain or remove and treat odorous air from the headspace (cont.)

• Biofilters
  • Bulk media filters
    • Low operating cost
    • Not effective at high sulfide concentrations
    • Requires large surface area ~ $\frac{1}{3}$ ft$^2$/cfm treated
    • Good organic removal
  • Packed bed wet biofilters
    • Low operating cost
    • Higher throughput than for bulk media units
Contain or remove and treat odorous air from the headspace (cont.)

- Ozone and ionized air
  - Direct reaction of ozone or ionized particles with odorous materials
  - Limited performance data
  - Recommend testing before implementation
Atmospheric Dispersion

- Dispersion can be used in conjunction with other gas phase treatment systems to minimize odor potential
- May be adequate without treatment for low odor discharges
- Design of discharge stacks and vents critical to achieving maximum dispersion
- Use vegetation to maximize effectiveness
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Conclusions

- Control of odor and corrosion can both have a high cost
- Each situation is unique and requires a customized approach
- Use of a system approach can result in significant cost savings
- Make sure that your solution for one issue does not create issues in another area
Questions?

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