SULFIDE GENERATION IN SEWERS

• Anaerobic conditions cause sulfate $\rightarrow$ hydrogen sulfide ($H_2S$)
• Occurs in force mains, siphons, flat sewers, surcharged sewers
• Slow-moving sewage = deposition
ODOR AND CORROSION IN COLLECTION SYSTEMS

- Force main discharges
- Pump station wet wells
- Junction boxes, turbulent manholes
- Siphons
WHY USE CHEMICALS?

1. Easy to implement
2. Can be used for temporary control
3. Can provide reduction in both odors and corrosion
4. Relatively low maintenance (but high operating cost)
TYPES OF CHEMICALS

- OXIDANTS
  \[ \text{S}^- + \text{O}_2 \rightarrow \text{SO}_4^- \]
- PRECIPITANTS
  \[ \text{S}^- + \text{Fe} \rightarrow \text{FeS} \downarrow \]
- pH ADJUSTER
  \[ (\text{H}_2\text{S})_g \rightarrow \text{HS}^- \]
- BIOCHEMICAL AGENTS
OXIDANTS

1. Sodium hypochlorite
   • $\text{HS}^- + 4\text{Cl}_2 + 4\text{H}_2\text{O} \rightarrow \text{SO}_4^{2-} + 9\text{H}^+ + 8\text{Cl}^-$
   • 10-15 lb Cl\textsubscript{2} per lb S
   • Effective for H\textsubscript{2}S and other odorants
   • Can be costly compared to other chemicals
   • Safety concerns
   • Fast acting
OXIDANTS

2. **Hydrogen Peroxide**
   - \( \text{H}_2\text{O}_2 = \text{H}_2\text{S} \rightarrow \text{S} + 2 \text{H}_2\text{O} \)
   - 1.5 to 3 lb \( \text{H}_2\text{O}_2 \) per lb S
   - Effective for \( \text{H}_2\text{S} \) control
   - Can be economical compared to other chemicals
   - Safety concerns
   - Add 20 minutes upstream of control point
OXIDANTS

3. **Pure Oxygen**
   - \( \text{H}_2\text{S} + 2\text{O}_2 \rightarrow \text{H}_2\text{SO}_4 \)
   - Highly effective and economical for force mains
   - Maintains aerobic conditions, preventing \( \text{H}_2\text{S} \)
   - \( \text{O}_2 \) uptake 10 mg/L/hr
   - On-site generation vs purchased liquid
4. Permanganate and Sodium Chlorite

- Powerful oxidants
- Potassium permanganate – crystals
- Sodium permanganate and sodium chlorite – liquid
- Effective for sludge streams, e.g. belt presses
- Usually not economical for sewer applications due to high chemical cost
1. Iron Salts

- $\text{FeCl}_2 + \text{H}_2\text{S} \rightarrow \text{FeS} + 2\text{HCl}$
- 1.6 to 3 lb Fe per lb S
-Predictable, effective
- Can be economical compared to other chemicals
- Corrosive
pH ADJUSTERS

1. Magnesium Hydroxide

- Increase pH to 8.5
- Dosage ≈ 50 to 100 gal Mg(OH)$_2$ per million
- Provides alkalinity
- Slurry requires mixing and freeze protection
- Economical for high sulfide levels
SULFIDE SPECIES vs. pH

The diagram shows the distribution of different sulfide species (H₂S, HS⁻, S=) as a function of pH. The graph indicates that H₂S is dominant at lower pH values, while HS⁻ becomes prevalent around pH 8, and S= is dominant at higher pH values.
pH ADJUSTERS

2. **Lime or caustic soda**
   - Goal is to achieve $pH \geq 8.5$
   - Lime slurry with polymer helps keep lime in suspension
   - Caustic soda dosage may be difficult to control
   - Less experience than with magnesium hydroxide
pH ADJUSTERS

3. **Crown spraying with magnesium hydroxide**
   - Applied to crown to neutralize acid and control pH
   - LACSD research: 50% Mg(OH)$_2$ slurry highly effective and economical
   - Typically applied annually
   - Crown pH < 4: need to re-apply
   - Cost: $2 to $3/ft
1. **Nitrate**

   • **Mechanisms:**
     a. **Prevention** – \( \text{NO}_3^- \) serves as an oxygen source for bacteria; prevents sulfide generation
     b. **Oxidation** – Nitrate promotes biological oxidation of \( \text{H}_2\text{S} \)

• **Prevention** – 3 gal \( \text{NO}_3^-/\text{lb S} \)
• **Oxidation** – 1 gal \( \text{NO}_3^-/\text{lb S} \)
• **Effective, safe to handle**
BIOCHEMICAL AGENTS

2. Bacteria, Enzymes, and “Stimulants”

- Many products available
- Some effective for grease control
- Manufacturer claims:
  - Grease removal
  - Odor reduction
  - Nutrient control
  - Sludge reduction
- Little or no documentation that these products are effective for control of hydrogen sulfide
REMOVAL OF SULFIDE-PRODUCING BIOLOGICAL SLIME LAYER IN SEWERS

• Developed in Australia
• Uses chemicals to remove biological slime that generates sulfide
• Must be repeated in 1 to 3 weeks
• Proprietary process (Cloevis BRS) marketed in the U.S. by USP Technologies
1. **Oxygen injection – Milford, CT**

- Before – sewer collapse, lift station $\text{H}_2\text{S} > 50$ ppm, odor complaints
- Twin force mains – 3 mgd
- Installed $\text{ECO}_2$ system w/Specce cone
- $\text{O}_2$ use ~ 1,000 lb/d
- $\text{H}_2\text{S}$ eliminated
FIGURE 1
H₂S vs. Time
Discharge of Gulf Pond FM
June 18 - 25, 2012

OXYGEN OFF
Avg. H₂S = 3.8 ppm

OXYGEN ON
Avg. H₂S = 0.0 ppm

Avg. Temp = 68.4°F
CASE HISTORIES

2. Iron salts – Macomb Co. MI

- Large interceptor conveying 10 mgd
- Moderate corrosion – odor complaints
- Approx. 10 miles of interceptor, pump station, and force main
- Piloted ferrous chloride, with single upstream addition point
**FIGURE 2. Summary of H₂S Reduction at Three FeCl₂ Dosages**
CASE HISTORIES

3. pH Adjustment; Nittany Valley, PA

- New collection system consisting of multiple small pump stations and force mains
- Severe corrosion within two years of start-up
- Tried biochemical agents – not successful
- Demonstrated successful application of Mg(OH)₂ for two pump stations in series – single dosage point
H$_2$S at Interchange FM discharge

H$_2$S at Lizardville FM discharge
SELECTING A CHEMICAL TO CONTROL ODORS AND CORROSION

1. Establish objectives
   - odor control, corrosion control, or both?
2. Temporary or permanent system?
3. Where is control desired?
4. Review chemicals and estimate dosages from literature, jar tests
5. Compare costs of alternative chemicals
6. Conduct trials – dosage vs. performance
7. Select chemical based on performance, cost, safety
QUESTIONS?
ANSWERS?