Odor & Corrosion Control in Collection Systems

by Jay Boyd

FORS®e
Eliminating Collection System Odor & Corrosion

ANUE™ WATER TECHNOLOGIES
About Anue Water Technologies

- Established in 2006
- Based in Vista (San Diego), CA
- Design / manufacture / market systems for...
  - Odor and Corrosion control for wastewater collection
  - Fat, Oil and Grease (FOG) remediation in wet wells
• Odor and Corrosion: Annual Estimated Costs in US
  - Odor control: $500 MM
  - Infrastructure repair: $15 BB

• Corrosion is Expensive Odor is Political…COMPLAINTS
  - Businesses- *loss of customers*
  - Residences- *lower home values*
**Type & Odor Source**

- **Principal Odor Types**
  - Sulfides → Collection system
  - Ammonia → Influent sources
  - VOCs → Influent sources

- Odor is expressed from...
  - Manholes
  - Lift stations
  - Valves
  - Vents

- Odor usually occurs with biological activity deep in the collection system...
About Hydrogen Sulfide (H₂S)

**Most Common Sulfide in Wastewater: H₂S**
- Gaseous phase molecule
- Soluble in water - carried by wastewater flow
- Odorous - rotten eggs
- Highly corrosive - precursor to H₂SO₄ (sulfuric acid) formation
- Dangerous in confined space

**Human Effects**
- Detectable < 20 parts per billion
- 25 ppm strong odor
- 100 ppm with 5 minutes of exposure
  - *sense of smell loss*
  - Lung irritation with coughing
- 500 ppm loss of consciousness and life threatening for exposures > 30 minutes
- 1000 ppm *imminent threat to life*
• Two slime layers compete for nutrients

• Dissolved oxygen (DO) determines which layer is favored…
  – >1 mg/l O$_2$ favors aerobic layer
  – < 1 mg/l favors anaerobic layer with Sulfate Reducing Bacteria (SRB)

• Anaerobic layers thrive with
  – low DO
  – low pH
  – warmer temperatures

Anaerobic (SRB):
Desulfovibrio desulfericans bacteria
• **Sulfate** ($SO_4$) commonly found in water where:

$$SO_4 + \text{organic matter} \xrightarrow{\text{anaerobic bacteria}} S^= + H_2O + CO_2 \xrightarrow{} S^= + 2H^+ \xrightarrow{} H_2S$$

• **Sulfides** are produced through anaerobic respiration:
  - Sulfates and organic matter are the resources
Conventional Odor Treatment Methods

Vapor Phase Treatment:
• Focus on head space with extraction or infusion

Liquid Phase Treatment:
• Focus on flow with biological or chemicals
**Vapor Phase: Extraction Methods**

**Head Space Extraction:**
- Extracts
- Treats
- Exhausts

- Chemical or biological treatment
- Systems specified for air volume and H₂S concentration
Vapor Phase: Extraction Considerations

• **Costs**
  – Equipment Capital Costs
    • Moderate to high procurement costs
  – Site Costs
    • Engineering, permits & construction
  – Recurring costs
    • Electrical, water, media, filters, maintenance

• **Limitations**
  – $\text{H}_2\text{S}$ peak concentrations can overwhelm treatment
  – Capital & operating costs
  – Sites must accommodate large footprint
  – **No** $\text{H}_2\text{S}$ source treatment
  – **No** corrosion treatment
**Vapor Phase: Head Space Infusion Methods**

**Head Space Infusing**

Chemical applied to head space

- **Non-Reactive**
  - Masking: fragrance used to *mask* odor with more pleasant scent

- **Reactive**
  - Reactive Treatment: chemicals reactively *oxidize* \( \text{H}_2\text{S} \) in head space
Vapor Phase: Infusion Methods

• **Ozone mist reaction**
  – Treatment is an ozone, air and water “mist”
  – Highly effective oxidizer

• **Limitations**
  – *No* H$_2$S source treatment
    • Treats head space not flow
  – *No* corrosion control
    • H$_2$S dissolved in flow creates downstream corrosion potential
  – Dosing control limited
    • Too much can damage infrastructure
**Liquid Phase: Biological Methods**

- **Two types of biological treatments**
  - New bacteria added
  - Bio-chemical additives to enhance resident “good” biology

- **Advantages**
  - Perceived as “green” versus chemicals
  - Fewer side effects than chemicals

- **Limitations**
  - Treatment takes weeks/months to take effect
  - Tests are prolonged & expensive
  - Sensitive to chemical changes in collections system
  - High cost compared to chemicals
Liquid Phase: Chemical Treatments

- **Sulfide scavengers- Ferric (Iron) Salts**
  - Ferric Chloride FeCl₃ / Ferrous Chloride FeCl₂

- **Advantages**
  - *Low cost per gallon* $0.70 to $1.00/ gallon
  - Proven effective for H₂S odor

- **Limitations**
  - Highly corrosive to pipes and equipment
    \[
    2\text{FeCl}_3 + 3\text{H}_2\text{S} \leftrightarrow \text{Fe}_2\text{S}_3(\text{s}) + 6\text{HCl}
    \]
  - \(\text{Fe}_2\text{S}_3(\text{s})\) forms precipitants & sediments
  - Aggressively removes dissolved oxygen from the water
    \[
    4\text{Fe}^{2+} + 3\text{O}_2 \leftrightarrow \text{Fe}_2\text{O}_3(\text{s}) \text{ (rust)}
    \]
  - Low DO and pH increases H₂S production & release
  - Does not treat non-sulfide odors i.e., VOC, ammonia
**Liquid Phase: Chemical Treatments**

- **Sulfide oxidizer- hydrogen peroxide (H₂O₂)**
  - Powerful & effective oxidizer
    \[ \text{H}_2\text{O}_2 + \text{H}_2\text{S} \rightarrow 2\text{H}_2\text{O} + \text{S}_0 \text{ (Neutral to Acidic)} \]

- **Advantages**
  - Oxidizes sulfides and...
  - Increases dissolved oxygen (DO)

- **Limitations**
  - Cost at $3.50 (35%) to $5.00 (50%) per gallon (national average)
  - Worker **must be protected**
  - Needs *special site containment*
  - Requires site storage and regular deliveries
**Liquid Phase: Chemical Treatments**

- **pH control: Magnesium Hydroxide**
  - Mg(OH)$_2$
  - Magnesium hydroxide:
    - “Milk of Magnesia”, “Thioguard”
  - Mechanism:
    - pH of 9 “holds” H$_2$S in solution
    - ~$2.50 / gallon (national average)

- **Advantages**
  - Relatively safe to handle

- **Limitations**
  - Does not react with H$_2$S
  - Tanks *must be mixed or even heated to avoid hardening*
  - Users report increased issues with pump clogging
  - No effect on ammonias or VOCs

*Thioguard is a registered trademark of Martin Marietta*
Liquid Phase: Chemical Treatments

- **SO₄ (sulfate) substitutes**

  \[ \text{SO}_4 + \text{organic matter} \xrightarrow{\text{anaerobic bacteria}} S^= + H_2O + CO_2 \xrightarrow{} S^= + 2H^+ \xrightarrow{} H_2S \]

  - Calcium nitrate \( \text{Ca(NO}_3\text{)}_2 \), saltpeter, “Bioxide” (Siemens)
  - ~$2.00 / gallon (national average)

- **Advantages**
  - Safe for handling & low toxicity
  - Slower reaction helps with downstream treatment
  - “Bioxide” widely used & considered low risk decision

- **Limitations**
  - *Feeds* the anaerobic layer & may require higher usage over time
  - *Increases nitrate* levels that *may impact* WWTP
  - Increases grease mat formation rates in wet wells
    - Requires frequent cleaning

*Bioxide* is a registered trademark of Siemens.
Emerging Technologies
Applying Oxygen & Ozone
Oxygen & Ozone: Multiple Actions

H₂S + O₃ → SO₂ + H₂O

SO₂ + O₃ → SO₃ + O₂

2SO₂ + O₂ → 2SO₃

SO₂ + O₃ → SO₄ + O₂

2SO₃ + O₂ → 2SO₄

Primary Beneficial Actions of O₂ and O₃

- Oxidation
  - Excellent: Ozone
  - Good: Oxygen
- Dissolved Oxygen Increase
  - Excellent: Oxygen
  - Good: Ozone
About Ozone

- **Ozone** (O$_3$): tri-atomic, gaseous phase oxygen molecule
- **Ozone scent**: sharp, sweet, fresh, chlorine-like, thunderstorm
- **Very High oxidizing potential @ 2.07V (fourth highest)**
  - Hydrogen peroxide (1.77V)
  - Chlorine (1.36V)
  - Oxygen (1.23V)
- **Half-life**
  - Up to 3 days in air
  - Up to 30 minutes in water (forms H-O@2.80V)
- **Half life in wastewater- minutes to seconds**
- **Ozone wide-spectrum oxidizer effective with:**
  - VOCs, other sulfides, fats, oils
- **Ozone solubility at 77°F (25°C) & 1 atmosphere (14.7psi)**
  - Ozone: 109 mg/liter
  - Oxygen: 8 mg/liter (aerated)
  - Ozone: 13x more soluble than oxygen
Three Applications of FORSe 5 systems…

- FORCE MAINS
  - Systemic Treatment

- LIFT STATIONS
  - Localized Treatment

- COMBINATION
  - Localized & Systemic Treatment
Liquid Phase Treatment

1. Create **side stream** with untreated flow

2. **Dissolve** (infuse) $O_2$ & $O_3$ into side stream
   
   Create 2 to 5 micron (0.00008” to 0.0002”) “micro-bubbles”

3. **Return treated flow** into untreated flow
Localized Treatment: Lift Station

System Control

- Browser
- Cellular
- SCADA

Communication

- \( \text{O}_2 \) & \( \text{O}_3 \) Generators
- \( \text{O}_2 \) & \( \text{O}_3 \) On Timer

Wet Well Infusion Point

- Wet Well Treatment Recirculation
Primary Action: 
*Liquid Phase*
Dissolved O$_2$ & O$_3$ delivered back to wet well (liquid phase)

Secondary Action: 
*Vapor Phase*
Fractional treatment is released into headspace (vapor phase)
Force Main: Systemic Treatment

Oxygen & Ozone Generator

FloSpec™ System Control
Communication:
Browser Cellular SCADA

Control

Flow Sensor

O₂ Output 100% Duty Cycle
O₃ Output Only with Wastewater Flow

Force Main: Upstream Treatment with Total System Effect

Treatment Site

Flow

Remediation Site
## Force Main Infuser Factors

<table>
<thead>
<tr>
<th>TYPE</th>
<th>FM Length (feet)</th>
<th>FM Diameter</th>
<th>Average Daily Flow</th>
<th>H₂S Uptake</th>
<th>O₂ Uptake</th>
<th>FM Pressure (psi)</th>
<th>Force Main Access Needed for Tap</th>
</tr>
</thead>
<tbody>
<tr>
<td>IFM-100)</td>
<td>to 22,000 (4 miles)</td>
<td>≤ 12”</td>
<td>to 1 MGD</td>
<td>Low to moderate</td>
<td>Low to moderate</td>
<td>to 70</td>
<td>Limited Access ≤ 3’</td>
</tr>
<tr>
<td>V1</td>
<td>to 22,000 (4 miles)</td>
<td>≤ 16”</td>
<td>to 1 MGD</td>
<td>Low to high</td>
<td>Low to moderate</td>
<td>to 70</td>
<td>Limited Access ≤ 1’</td>
</tr>
<tr>
<td>V2S</td>
<td>to 27,000 (5 miles)</td>
<td>≥ 12”</td>
<td>to 20 MGD</td>
<td>Low to very high</td>
<td>Low to very high</td>
<td>to 120</td>
<td>≥ FM 7’ inlet to outlet</td>
</tr>
<tr>
<td>V2H</td>
<td>to 27,000 (5 miles)</td>
<td>≥ 12”</td>
<td>To 20 MGD</td>
<td>Low to very high</td>
<td>Low to very high</td>
<td>100 to 200</td>
<td>≥ FM 7’ inlet to outlet</td>
</tr>
</tbody>
</table>
Single Point Tap (IFM-100)

Selection Variables

- Pressure to 70 psi
- FM Length to 22,000 ft (4.2 miles)
- FM diameter ≤ 12”
- Avg. Flow ≤ 1 MGD
- H2S low to moderate
- Access to FM 3 ft
Dual Tap Infuser Systems V2x

Selection Variables
- Pressure to 120 psi (V2S)
- Pressure to 200 psi (V2H)
- FM length to 27,000 ft
- FM diameter ≥ 12"
  - Avg. Flow ≤ 20 MGD
  - H₂S low to very high
  - Access ≥ FM 7’
  - Tap 2” to 6

Air → Compressors → Oxygen → Ozone

Control

O₂ / O₃

Ripper Pump

Booster Pump

Flow

Force Main

7 feet
Single Point Infuser System V1

Selection Variables

- Pressure to 70 psi
- FM length to 22,000 ft
- FM diameter ≤ 16”
- Avg. Flow ≤ 1 MGD
- H₂S low to moderate
- Access to FM 4”
Fast Action Infusion

Untreated wastewater

Treatment: 2 minutes

Treatment: 5 minutes
HydroZone™ Oxygen & Ozone Generator

Ozone Generator

IFM-100 Infuser

N2 Separation Pressure Swing Adsorption

Ambient Air

Filter

Compressor

Oxygen Concentrator 94% to 96%

H2O Vapor Separator

HDEP Infuser

5% weight O3
System Configurations: Small & Medium

Wall mount, rail mount, free standing or skid packing

NEMA 4 standard or NEMA 4X option

San Jacinto River Authority- Skid

Dixon, KY- Wall Mount
System Packaging - High Flow

- Flows of up to 20 MGD
- Systems to
  - 1400 gph $O_3$
  - 600 lpm $O_2$
CASE STUDY

Force Main Study:
San Jacinto River Authority
Houston, TX
Force Main Treatment: San Jacinto River Authority

Lift Station #12

Force Main: 14”, 2,280’ (0.5 miles)
Flow: 0.5 to 1.0 mgd

Timberloch and High Timbers Manhole

Gravity 1.0 miles
Flow: 0.5 to 1.0 mgd

N. Millbend Manhole

Lift Station #2

Odor complaints
Pre-treatment Lift Station 12:
Average: 3 ppm
Peak: 15

SJRA LS. No. 12 Wet Well 12-9-10 thru 12-16-10
20101227_09001923_01: Session 2

Temperature

H2S

Lift Station #12
Timberlock Manhole
Log Stop

Period Displayed: 12/8/2010 - 12/17/2010 (Oda File: 20101227_09001923_01.oda -- Serial Number: Odalog Type L2 09001923 Instrument Range 0-1000PPM)
Pre-treatment at Timberloch Manhole ½ Mile:
Average: 22 ppm
Peak: 90

SJRA MH @ Timberloch & High Timbers 12-9-10 thru 12-16
20101217_09001924_01: Session 1

Average: 22 ppm
Peak: 90
Treatment Week 1 at Timberloch:
Average: 22 ppm to 1 ppm
Peak: 90 ppm to 18 ppm
Treatment Week 2 Timberloch:
Average: 22 ppm to 1 ppm
Peak: 90 ppm to 10 ppm
Post Treatment Week 3:
downstream sulfide levels
Average: 1 ppm to 13 ppm
Peak: 10 ppm to 70 ppm

Treatment Stopped:

San Jacinto River Authority
Pre-treatment: 2nd Downstream Manhole
Average: 37 ppm
Peak: 96 ppm
Treatment Week 1:
2nd Manhole
Average: 37 to 6 ppm
Peak: 96 to 30 ppm

These are surprising given that the retention of the treatment in gravity is limited

System was shut-down
CASE STUDY

Force Main Study:
Santa Margarita
Las Flores, CA
Force Main Treatment: Santa Margarita, CA

No Treatment
Average H2S: 10.5
Peak H2S: 29 ppm

5500’
10”
0.3 to 0.6 MGD

System Off 2X
demonstrating effect
without treatment

1st Treatment
Average H2S: 0.2
Peak H2S: 1 ppm

O3: 120 grams/hr
O2: 33 liters/min

2nd Treatment
Average H2S: 1.0
Peak H2S: 6 ppm

O3: 60 grams/hr
O2: 22 liters/min
Mobile Diagnostic Unit (MDU-300)

MDU Application Capacity:

Ozone: 300 grams/hour
Oxygen: 90 liters/minute

MDU Includes:

Oxygen generator
Ozone Generator
Control with Cellular MODEM
Transformer
System Capacity:
MDU-120:
120 grams/hr $O_3$
45 liters/min $O_2$

MDU-300:
300 grams/hr $O_3$
100 liters/min $O_2$
Test Protocols

Pre-Demonstration Baseline Data Collection (User)
Duration: 7 days minimum
Test Type: H₂S vapor
Measurement: OdaLog, H₂S ppm & temperature
Frequency: Continuous

Demonstration Data Collection (Anue)
Duration: 7 to 14 days typical
Test Type 1: H₂S vapor
Measurement: OdaLog, H₂S ppm & temperature
Frequency: Continuous

Test Type 2: Total, dissolved sulfides (liquid phase)
Measurement: LaMotte, mg/l
Frequency: Once daily

Test Type 3: Dissolved oxygen, temperature
Measurement: Hach HQ40

Post Demonstration Data Collection Repeat “Pre” or “Demonstration” (User)
Duration: 7 days minimum
Test Type: H₂S vapor
Measurement: OdaLog, H₂S ppm & temperature
Frequency: Continuous
Demonstration Process

**Qualify Application**
- Force main length & Diameter
- Dynamic (peak) pressure
- Average daily flow
- Loads: Sulfide, COD?

**Assess Costs**
- Cost of current method

**Site Survey**
- Access to force main
- Power at site

**Site Testing**
- Pre, during, post data collection

**Determine Required System Capacity**

**Determine Break Even & ROI**

**Demonstration Proposal**

**Test Report and Budgetary Proposal**

**Electrician for connection**

**Two-inch saddle tap and stainless ball valve**
Thank you!
EnviroPrep™

Fat, Oil & Grease (FOG) Remediation Products
Anue FOG Remediation

FOG Remediation means automating clean-out to reduce operating expense

- Removes and prevents fat, oil and grease build-up
- Re-conditions the wet well fluent for consistent operation
Market Opportunity: Collection System FOG Remediation

• Lower “hard” and soft” costs…
• “Hard” Costs for Clean-Out
  – Vacuum trucks- purchase
  – Vacuum truck operating expense
    • Fuel
    • Repairs
    • Insurance
  – Third party services
• Clean-out “Soft” Costs: Real Costs often not Accounted
  – Coordination and application of labor
  – Consistency of lift station operation
  – Water usage
Mechanically Induced Pre-treatment

Mechanical system offers four distinct beneficial actions…

- Surface *Agitation*
  - *Accumulation prevented*
- Aeration
  - *Increases dissolved Oxygen*
- Recirculation
  - *Breaks down and Homogenizes fluent*
- Wash down automates *cleaning*
Recirculation: How They Work

- Wastewater recirculation...
  - Tapping discharge main
  - Using a dedicated pump
- Hydraulic force spins head
  - Flow at >10 psi
  - Different head sizes have different flow requirements (see data sheet)
Dedicated Pump vs. Tap

**Dedicated Pump**
- EP system, grinder pump, control panel and timer

**Single Tap**
- EP system tapping one discharge main

**Dual Tap**
- EP system tapping two discharge mains with manifold
## Head Assembly Comparison

<table>
<thead>
<tr>
<th>Series</th>
<th>Application</th>
<th>Head Output</th>
<th>Output Sizes</th>
<th>Head Image</th>
<th>Mounting Options</th>
<th>Head Material</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>EP-1100A</td>
<td>All Wet Wells ≥ 6’ diameter</td>
<td>Dual, rotating</td>
<td>2.0” 1.5” 1.0” 0.75”</td>
<td><img src="image1.png" alt="Image" /></td>
<td>1. Hatch 2. Wall</td>
<td>Composite</td>
<td>$3,997</td>
</tr>
<tr>
<td>HS-500</td>
<td>Wet wells 4’ to 6’ diameter</td>
<td>Single, stationary</td>
<td>2.0” 1.5”</td>
<td><img src="image2.png" alt="Image" /></td>
<td>1. Hatch 2. Wall</td>
<td>Stainless Steel</td>
<td>$2,795</td>
</tr>
<tr>
<td></td>
<td>Wet wells with 26” space for head rotation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HS-100D</td>
<td>Grinder stations</td>
<td>Single, stationary</td>
<td>2.0” 1.5” 1.0” 0.075”</td>
<td><img src="image3.png" alt="Image" /></td>
<td>Direct mount to discharge</td>
<td>Composite-stainless steel</td>
<td>$2,305</td>
</tr>
</tbody>
</table>
EP “Kit” Configuration

Three piece “kit:
1. Head Assembly
2. Mounting Bracket
3. Feed Mast

To complete installation parts such as stainless steel pipe and flex hose are added with lengths fitted to each well.
EP-1100A Series: Low Cost High Action System

3-Piece “Hatch” Mount Kit

Composite head
Inserts determine

2-Piece “Wall” Mount Kit
HS-500 HydroSpear™ Series

HS-520 wall mount

HS-520H Hatch mount

HS-500 Series Non-Rotating Head Low flow requirements
HyrdoStar™ HS-100D Series

- **Fixed Washer** head assembly
- Mount directly to discharge main in grinder stations
- Composite
- Grinder Pump Applications ONLY
- Low to Medium Flow Applications
EP Product Design Evolution

Changes improving performance and durability...

ED PRO 1000
“T” design
2005

ED PRO 1000
“Y” design
2006

ED PRO 1000 with
Mixing Chamber
2008

EP-1300
• High Turbulence
  Mixing Chamber
  • Sealed Stainless
    Bearing
  July 2009

CURRENT MODEL: EP-1100A
Composite, self-adjusting deflectors
Low-mass, lower flow head
Composite SureSeal™ Rotary
Assembly
July 2011

ED PRO 1000
“T” design
2005

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CURRENT MODEL: EP-1100A
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Assembly
July 2011
Thank you!

End
Sulfide Release

- Velocity increases turbulence
  - Turbulence increases surface area
  - Faster gas release with more surface area
  - Turbulence can increase DO to some extent

- Depth of Flow
  - Depth of flow determines cross-sectional area and water surface area
  - Larger area increases release potential for $\text{H}_2\text{S}$
Concrete Corrosion in Collection Systems

- **Acid Attack of Sulfuric Acid**
  - Concentration of up to 5% $\text{H}_2\text{SO}_4$ can be found
  - Attack is usually uneven
  - Attack most common at the crown and the water line

$$\text{H}_2\text{S}(g) + 2\text{O}_2 \rightarrow \text{H}_2\text{SO}_4$$