Ventilation and Odor Control for Sewers and Tunnels

Lawrence H. Hentz Jr, P.E., BCEE
Shahriar Eftekharzadeh, P.E., Ph.D., PMP
Rich Atoulikian, P.E., BCEE, PMP
Do You Know My Friend?
She Changed My Life

IRC, FL
Sarasota, FL
Ypsilanti, MI
NGWRP, AZ
91st Avenue, AZ
Ocotillo, AZ
Avondale, AZ
Palm City/Tuscany Hills, FL
Seattle, WA
Iron Bridge, FL
Dade County, FL
Sacramento, CA
Hartford, CT
East Bay MUD, CA
Rock Hill, SC
Yellowstone, WY
PG County, MD
Harford County, MD
Seneca, MD
Patuxent, MD
Mill Creek, MD
Broadwater, MD
Mont. Co. RCF
Howard Co, MD
Arlington, VA
Alexandria, VA
DC WASA
Philly (x2), PA
HRSD, VA (x4)
Chez Liz, VA
Dick Creek, GA
Long Trail, VT
NBC, RI
New England Fert
MPW, SC (x4)

Athens, Greece
WERF
H$_2$S and Olfactory Science
Analytical Chemistry And Chemical Engineering
Typical Gas Chromatograph
Publications and Patents

...More Than 30 Articles on Odor Control

...Contributing Author to the WEF / ASCE Manuals of Practice
ODOR CONTROL IN WASTEWATER TREATMENT PLANTS

...U.S. Patent Holder For Scrubber Technology
By Judy Odierna
jodierna@herald.com

North Miami residents living along Northwest 125th Street and 11th Avenue can open their windows again.

Their neighbor, a city sewage lift station, has finally cleaned up its act.

**NORTH MIAMI**

After years of trying to neutralize the lift station’s foul odor with chemical deodorants and renovations, the city hired a company that created a $90,000 biofiltration system.

The treatment center sucks all the air in-the-space above the wet well in the pump and puts it through cubes that take away the odor.

“It’s been up for three weeks, and the smell has gone away,” said City Manager Lee Feldman.

The sewage pumping station is a busy one. It collects sewage from the city’s residential area and 20 other private pump stations, including the one from North Shore Medical Center in unincorporated Miami-Dade.

“Residents have expressed their gratitude,” said Councilman Ossmann Desir, who represents the Sunkist Grove district. “We have to wait a bit and observe and see if it will stay that way in the long term.”

Feldman agrees and says the real test for the system will be the summer months.

“In the summer, there’s high humidity, the air becomes saturated and the odor doesn’t disappear so quickly,” he said.
I Am Forever Grateful
Lessons Learned

Use Fundamental Scientific Principals

Use Best Available Information and Best Available Technology

Develop An Odor Control Plan That Can Adapt To Actual Conditions
An Ounce of Prevention

Planning

Odor Control Costs
Ventilation and Odor Control in Sewers and Tunnels

- Forces Causing Airflow and Ventilation
- Tools for Estimating Airflow and Pressurization
- Technologies for Controlling Emissions of Odorous Compounds
Sewer Ventilation

Positive Pressure: 0.25 inches water column
Airflow Phenomenon in Gravity Sewers

Surface Drag Induces Airflow in Gravity Sewers
Velocity Affects Stripping of Odorous Compounds
Pressure Buildup and Odor Release

Reduced Surface Drag and/or Head Space Causes Pressure Build Up and Potential Odor Release
1. Estimates $V_{air}$ Using Empirical $V_{air}/V_{water}$ ratios

<table>
<thead>
<tr>
<th>d/D</th>
<th>$V_{air}/V_{water}$</th>
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<tbody>
<tr>
<td>&lt; 0.1</td>
<td>0.15</td>
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<tr>
<td>0.1 - 0.2</td>
<td>0.25</td>
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<tr>
<td>0.2 - 0.48</td>
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<td>0.48 - 0.75</td>
<td>0.60</td>
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<tr>
<td>0.75 - 0.85</td>
<td>0.35</td>
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<tr>
<td>&gt; 0.85</td>
<td>0.15</td>
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Empirical Modeling Approach

2. Estimate \( Q_{air} = V_{air} \times A_{head \ space} \)

3. Compute \( Q_{diff_{air(i)}} = Q_{air(i)} - Q_{air \ (i+1)} \)

Positive \( Q_{diff_{air(i)}} \) Means Pressure Buildup
City of Los Angeles
Wastewater Collection System

- Complex system
- Serves > 4 million people
- Service area > 600 sq. mi.
- 6,500 miles
- 140,000 maintenance holes
- 47 wastewater pumping plants
- 29 Satellite Agencies
- Conveys 450 MGD average daily flow
Overall Study Goal
Minimize Odor Issues in the City of Los Angeles Sewer System

Study Objectives

- Identify sources and causes of odor
- Establish effective means of reducing odor
- Determine best location(s) and most effective technologies for Air Treatment Facilities (ATF)
Airflow Modeling Components and Purpose

- **Empirical Airflow Model**
  - Approximated airflow behavior
  - Predicted locations of high pressures
  - Measured pressures in field

- **Theoretical Airflow Model**
  - Computed airflow rates and air pressures
  - Evaluated management techniques
    - Extraction
    - Sewer modifications
  - Identified best locations for air extraction and treatment
Sewer Pressure Data Collection

Pressure Data Collection
Results of Empirical Model

- Used LA Sewer Model to Locate Pressure Buildup Areas (“Hot Spots”)
- Analyzed At Various Flow Regimes
- Provided Reasonable Prediction of Positive Pressure Locations and Airflow Rates
- Could Not Predict Pressures For Future Conditions
- Could Not Simulate Some Structures
  - Drop Structures
  - Air Extraction (Ventilation/Treatment)
  - Siphons

Reasonably Analyzed the Existing System
Theoretical Model Principles

- Air Mass Continuity (node)
  \[ \sum kQ = 0 \]
- Energy Principle (loop)
  \[ \sum \Delta P = 0 \]
- Airflow in Headspace
- Air Leaking In and Out
- Drop Structure Impact
- Air Jumpers Junctions
  \[ h_j = \frac{Q^2}{2gA^2} \left( \frac{fL}{D} + k_e \right) \]
- Air Extraction (\( Q_{out}, P_j \))
  \[ \Delta P_{DS} = f(Q) = \gamma Q^2 + \alpha Q + \beta \]
  \[ Q_{E_j} = C_d j A_{0j} \sqrt{2g(P_{E_j} - P_{ATj})} \]
Drop Structure Physical Models
Air Model Input Data

- Depth and Velocity (Hydraulic Model)
- Drop Structure Characteristic Curve (Physical Model)
- Field Pressure Data $P_{av}$ and $P_{max}$
Model Calibration at Average Flow

Predicted vs Measured Nodal Pressure (l.w.c.)

Nodal Manholes:
1. 0.69
2. 0.54
3. 0.47
4. 0.23
5. 0.21
6. 0.12

Pressure Monitored Manhole
Air Jumper
Flow Blockage
Scrubber
Dropstructure
Reach ID
Flow direction
Theoretical Model Summary

- Computed Airflow and Air Pressures
- Analyzed Various Flow Scenarios
- Simulated Drop Structures, ATF(s), Siphons (air jumpers), and Air Curtains, etc.

Model Can Be Used as a Good Planning and Decision-Making Too
Originally 8 Proposed Air Treatment Facility Locations
Final 4 Planned Air Treatment Facility Locations
NCOS ATF – 12,000 cfm 3 BTFs

Eliminated 4 Originally Planned ATFs at an Estimated Savings of $50 Million
Ventilation Model Can Help Control Odorous Emissions from Sewers and Tunnels

- **A Sensitized Community Is Much More Difficult to Please**
  - Creation of crusaders (lawyers) and loss of trust
  - Criteria for success go way up

- **Ventilation Model Can Help Plan For Impacts**
  - Predict location of hot spots
  - Assess impacts of drop structures
  - Analyze effects of extractions
Ventilation Model Approach

- **Plan**
  - Use HDR Ventilation Model and Utility Sewer Model
  - Validate the model in the summer
  - Collect \( \text{H}_2\text{S} \) data
  - Assess impacts of tunnel or sewer connections
  - Assess emissions mitigation techniques (extraction, drop structures, etc)

- **Output**
  - Air flow rates at hot spots under various flow regimes
  - Locations of most influence for air extraction
  - Options for control
  - Estimates of \( \text{H}_2\text{S} \) concentrations
Most Important Odor Control Principles

- **Location, Location, Location**
  - Distance to nearest detector
  - The number of detectors
  - Direction of prevailing winds

- **Control Technology Parameters**
  - Airflow rates
  - H$_2$S concentration
  - Emitted H$_2$S mass emission rate

- **Most Often Need BACT**
  - PPM to PPB = 99.9% efficiency
Odor Control Scrubbers
Packed Tower Scrubbers

- Gas Velocity Enhances Gas Phase Diffusion to Liquid Film
- Plastic Packing Creates Liquid Film (Transfer Area)
- Liquid Recirculation Allows Efficient Chemical Use
- Sump Allows Reaction Time
- Liquid Blowdown Important to Prevent Chemical Backpressure
Odor Control Scrubbers
Misting Scrubber

• Spray Contacts Odorous Chemicals in Gas Phase
• Spray Nozzles Creates Liquid Droplet (Transfer Area)
• Once Through Chemicals Maximizes Chemical Gradient
• Reaction Time Limited to Reactor Detention Time
Cost Comparison of Caustic vs. Acid/Bleach Scrubber

- NaOH, CO2 = 6,000 ppm
- NaOH, CO2 = 4,000 ppm
- NaOH, CO2 = 2,000 ppm
- NaOH, CO2 = 1,000 ppm

Cost ($/hr) vs. H2S Concentration (ppmv)
Custom and Modular Biofilters
Bio Trickling Filters
Practical Capacities of Odor Control Technologies

- Scrubbers
- Custom Biofilters
- Modular Biofilters
- Bio Tr Filt
- Activated Carbon

Avg 1,000 cfm
Scrubbers - Any Flow and Any \( \text{H}_2\text{S} \) Concentration
Custom Biofilters - Any Flow & H$_2$S < 25 ppmv
Organic Biofilters - < 25 kcfm & H₂S < 25 ppmv
Synthetic Biofilters – Flow < 50 kcfm & H$_2$S < 50 ppmv
Biotowers – Any Flow & H2S >10 ppmv
Carbon – Flow < 15 kcfm & H2S < 25 ppmv

Note – Sometimes Carbon Becomes Biofilter
Recommendations

- Establish Air Flow Rates and $H_2S$ Concentrations
  - Need Ventilation Model to Estimate Hot Spots and Air Flow Rates
  - Look At $H_2S$ Data and Predicted Hydraulic Regimes To Estimate Range of $H_2S$ Concentrations

- Consider Location of Receptors and Determine Control Efficiency Requirements
Recommendations

- Use Estimated Flow and Estimated H$_2$S Concentrations to Establish Type(s) of Control Technologies Most Appropriate
- Evaluate Options and Costs – Pick a Solution
- Develop a Plan for Higher Flow Rates and/or Higher H$_2$S Concentrations
  - Parallel Ducts and Controls
  - Multiple Stages or Technologies
- An Ounce is Worth a Pound of Cure
Thank You

Lawrence.Hentz@hdrinc.com