Hydrogen Sulfide Removal from Landfill Gas
Why do we care about H$_2$S?
H₂S 101

• Odors
  ▪ Characteristically a “rotten egg” smell
  ▪ Can be detected in concentrations as low as 0.1-1.5 ppm

• Irritant and asphyxiating
  ▪ NIOSH PEL of 10 ppm
  ▪ NIOSH IDLH of 100 ppm

• LEL – 4% v/v and UEL – 44% v/v

• Heavier than air – tends to collect in low-lying areas

• Colorless
H₂S 101

• Primary contributors in MSW landfills
  ▪ POTW sludges
  ▪ Pulp & paper mill wastes
  ▪ Gypsum/drywall
    – Alone and as part of C&D waste streams
    – C&D fines
    – Storm event debris
  ▪ Wet sites generate LFG (and H₂S) more quickly

• AP-42 (1998) indicated a default concentration of about 35.5 ppmv H₂S in LFG

• Changing waste compositions are trending that concentration upwards in many locations
$H_2S$ 101 – Generation Comparison

Potential Gas Generation

$k=0.04$, $L_0=100$ m$^3$/Mg (AP-42 Defaults)

$k=0.34$-$0.70$, $S_0=113$ m$^3$/Mg (EREF 2010 – 6 NE Sites)
H₂S 101

- H₂S combustion leads to SO₂ formation
  - 100 TPY of SO₂  Major Source Status
  - > 40 TPY of SO₂ incr.  AQ modeling for NAAQS compliance
  - 250 TPY of SO₂  PSD Status

- 250 tons per year is equivalent to:
  - 1,000 scfm of LFG @ 5,600 ppm H₂S
  - 5,000 scfm of LFG @ 1,100 ppm H₂S
How do we get rid of it?
Scavenger Systems

- Essentially a vessel full of media
- “Iron Sponge”
- “Sour” gas passes through the vessel
- Products are “sweet” gas and media with elemental sulfur
- Spent media can typically be disposed in landfills
- Sulfur is “fixed” and doesn’t leach back into waste
Scavenger Systems - Examples

- MV Technologies
- Schlumberger
- H2S Zero
- SulfaCHAR
- Granite Fuels
- Aptim – LFG Specialties
Regenerative Systems

- Wet scrubber application
- Liquid redox system
- "Caustic" solution – chelated iron, hydroxide, bicarbonate ...
- Solution can be recovered/recycled
- Chemical additions
- Biological regeneration
Regenerative Systems - Process

A. Absorber/contactor
B. Reactor
C. Settling

1. Raw (sour) LFG
2. Wash solution
3. Treated (sweet) LFG
4. High-sulfur liquid
5. Concentrated-sulfur liquid
6. Recovered wash solution
7. Elemental sulfur paste
Regenerative Systems - Examples

- Lo-Cat (Merichem)
- Thiopaque (Paques)
- Bioferm
- Haldor Topsoe
- Biorem
- Ecotec
- Hydro Thane
Regenerative Systems - Examples

Much more complex than scavenger systems
How clean do we need the gas to be?
Each application has a unique limitation for H₂S input:

- Flare: No technical limitation
- CAT Engines: 700 ppmv
- Jenbacher Engines: 225 ppmv
- Pipeline: 115 ppbv
- Vehicle Fuel: 23 ppbv

Typically measure using ASTM D 5504
What do I need to ask a vendor or my engineer?
Design Criteria

• Total LFG flow
  ▪ Current, peak, and minimum
  ▪ Try to project 20 years
• H$_2$S concentration at the noted levels
• Target treatment level
• Do I have to treat the entire LFG stream?
• Scalability
• Available blower discharge pressure vs system pressure drop
  ▪ What pressure can my current blower push?
  ▪ How much drop should I expect to see across the treatment system?
• Available footprint
Other things to think about...
Ancillary Systems

- Water
- Power
- Sewage
- Truck access
- Site grading
- Personnel

Most systems require a clean water supply (not leachate)

Liquid systems will have an effluent stream to dispose of, and solid media systems will have condensate

Media, chemical, and parts in spent media, sulfur cake out

Who is going to run this thing?

May need a service upgrade for larger LFG blowers or the treatment equipment

General access, stormwater controls

May need a service upgrade for larger LFG blowers or the treatment equipment
Remember that this is a piece of a larger puzzle

- Initial planning
- Equipment layout and sizing
- Site civil work
- Facility integration
- Electrical
- Mechanical
- Structural
- Permitting (Air, Building, Solid Waste)
- Bid documents
- Public meetings / presentations
Financial Evaluation

• Set up a cash flow analysis
  ▪ Initial CAPEX
    – Equipment, site work, media/chemicals
  ▪ Annual OPEX
    – Electric, water, sewage, media/chemicals, labor

• Typically
  ▪ Scavenger systems lower CAPEX, higher OPEX
  ▪ Regenerative systems higher CAPEX, lower OPEX

• Select a solution that makes sense financially and technically for your application
Financial Evaluation

- Scavenger
  - $1.8 M initial CAPEX
  - $58 M – 20 years
- Regenerative
  - $16.5 M initial CAPEX
  - $27 M – 20 years

- Highly dependent upon
  - LFG flow rate
  - H2S concentration
  - Duration of treatment
Summary

- Know your current and projected generation rates
- Understand what your treatment requirements are
- Consider a number of viable technologies
- Review the financial implications – not just the technical ones
- Make a selection that works for your application
- Air permitting may be critical path
Thank you

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