Hydrogen Sulfide Treatment - A Case Study Involving the Selection, Construction and Treatment of Two Technologies at a Regional MSW Landfill

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Hydrogen Sulfide Generation

- Increasing concern due to management of disaster-related debris as well as trending increase in $\text{H}_2\text{S}$ concentration in many landfills across North America.
- Heightened sensitivity to odors.
- Reduction in Ambient $\text{SO}_2$ standard
Hydrogen Sulfide Effects

- High H$_2$S concentrations are problematic for utilizing biogas for energy production
- During the combustion process in gas engines and flares, H$_2$S is oxidized to sulfur dioxide (SO$_2$) which is an important air contaminant causing acidification (“acid rain” associated with damage to vegetation and buildings)
- H$_2$S potentially causes rapid corrosion of gas handling equipment and damage to engine components
Hydrogen Sulfide Effects

- The corrosion to equipment increases operational costs
- The corrosion to equipment increases construction cost:
  - to upgrade materials of construction to more corrosion-resistant material and
  - if necessary H$_2$S removal cost
- Potential hazard for intrusive on-site work – drilling or trenching etc.
Increasing trend in H$_2$S concentration in LFG in England, Scotland and Wales (Parker and Pointer in 2008)

Changes in waste composition due to source separation and recycling were suggested factors (Parker and Pointer in 2008; Stalleicken and Slack, 2010)

Another potential factor identified is removal of metal wastes prior to landfilling. The metal deposited with the waste in the landfill has previously acted as a ‘sink’ for hydrogen sulfide, with the concomitant generation of metal sulfides.

The younger a landfill cell is, the higher the H$_2$S concentrations appear to be in the LFG and then decrease as the cell ages (Parker and Pointer in 2008).
The Project

- Regional MSW Landfill in Michigan
- Need to upgrade blower system to single vacuum source providing gas under pressure to 3rd party Landfill Gas-to-Energy (LFGTE) Plant
- Proposed 12.8 MW LFGTE Plant
- Air permit issues related to SO$_2$ resulting from H$_2$S combustion – needed control
- Necessity to Fast Track Project
Project Team

- Waste Management Renewable Energy
  - Jay Maruska – Project Manager
- NTH Consultants, Ltd.
  - Lori Myott – Senior Project Engineer
- Cornerstone Environmental Group, LLC
  - Tom Bilgri, PE – Manager – Biogas Engineering Services
- Conestoga-Rovers & Associates, Inc.
  - Steve Wilsey – Vice President/Principal
This was a multi-disciplined design and construction project involving:

- Permitting
- Landfill gas blower & control system
- Open and enclosed flares
- Existing LFGTE Plant
- Two Sulfur treatment systems
- New LFGTE Plant
- 36 Months from permitting to start-up
Key Elements

- Air permit for SO\textsubscript{2} emissions necessitated treatment.
- 30+ week lead time for preferred biological treatment system.
- Elected for scavenger system in the short term, followed by biological system.
- Expedited time frame due to air permit requirements and electric generating contracts.
Landfill Aerial
Site Aerial
Typical Operating Costs

- Scavenger - +/- $3/lb

- Biological - +/- $0.1/lb

*always site-specific considerations, capital expense significantly higher for biological
New LFGTE Plant
Scavenger Technology

- $4 \text{H}_2\text{S} + \text{Fe}_2\text{O}_3$ yields $2 \text{FeS}_2 + 3 \text{H}_2\text{O} + \text{H}_2$
- $\text{H}_2\text{S}$ converted to Iron Pyrite
Scavenger System

**Pros**
- Multiple vessels allow for adjustment of flow or treatment of full or partial gas streams.
- Allows change-out of media without shutting down entire system
- Simple and flexible operation

**Cons**
- Media cost
Interim Sulfur Treatment
Discharge Piping to End-Users
THIOPAQ™ technology Process

Two step working-principle for removing H$_2$S from high-pressure gaseous streams:

1. Absorption into a mild alkaline solution
2. Microorganism oxidation of the absorbed sulfide to elemental sulfur
Biological System

- **Pros**
  - Cheaper operating cost

- **Cons**
  - High capital cost
  - Relatively complex operation
  - Difficult adjustment to changing conditions
Sulfur Building
Sulfur Building
Walls and Foundations
Off-Loading Pump Skid
Indoor Components

- Filtrate Tank
- Sulfur Settler
Steel Erection
Steel Erection
Equipment Delivery

Bioreactor
Equipment Placement
Equipment Placement

Bioreactor
Steel Erection Completed
Exterior Wall
Exterior Wall
Exterior Wall Completed
Conduit
Caustic Loading Area
Odor Treatment

Caustic Tank

Odor Control Unit
Equipment Delivery

Contactor
Equipment Placement

Contactor
Equipment Placement

Outlet Gas Scrubber

Inlet Gas Scrubber

Caustic Tank
Piping & Support
Completed Piping
Landfill Gas Fired Heaters
Installed Pump Skid
Completed Building
Lessons Learned

- Both systems were functional and satisfied permit requirements.
- It’s nice to have a back-up plan!
- Well coordinated project team eliminated many potential problems.
- No significant issues with scavenger system.
- Biological systems take significant time to acclimate and fine tune – does not adapt well to changes.
- Steady-state costs have been difficult to evaluate due to operational fluctuations (flow, concentration, delivery requirements).
Questions?

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