Hydrogen Sulfide Remediation at King George County Landfill

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Agenda

- Site Overview / History
- H2S Detection and Determination of Extent
- Gas Collection and Control System Upgrades
- Intermediate Cap
- Evaluation of H2S removal systems
- Installation of Temporary/Intermediate H2S Scavenger System for LGTE Plant and Flares
- Way Ahead
- Questions
Site Overview

- 295 acres
- 190 acres filled
- 14 acres capped
- 11.4 M tons filled
- 1.2M tons in 2010
- 5K tons/day
  (2,500 tons/day rail)

Gas:
- Current: 7K Scfm
- LGTE: 4 turbines
- 12.4 Mw
H2S Detection and Determination of Extent

Compliance Drivers

• Title V permit:
  • 240 Ton/Yr SO2 (770 ppm H2S @ 8000 Scfm)
  • No off site odors

• LFGTE Stationary Source Permit.:
  • 0.15lb/MMBtu SO2 (435 ppm H2S)
  • Stain tube test for H2S for 30 days upon startup
    Results 1200-1400 ppm (2007 test 235 ppm)
  • Stack Performance Test within 90 days
    Results average .319lb/MMBtu
H2S Field Detection Methodology

- Stain tube testing at flare, plant and key areas of landfill (Cell 5A/B 2C)
- Tedlar bags at flare, plant and key areas of landfill
- 100% stain tube test of all collectors
- Tedlar bags of high concentration collectors (+2000ppm)
- 3 X daily monitoring of flare and LGTE plant
H2S Field Test Results

[Map showing hydrogen sulfide concentration isopach map (ppm)]

Legend:
- 2000+ ppm
- 1800 ppm
- 1600 ppm
- 1400 ppm
- 1200 ppm
- 1000 ppm
- 800 ppm
- 600 ppm
- 400 ppm
- 200 ppm
- 0 ppm
Projected SO2 Emissions Tons/Yr
12 Month Rolling Average

King George Landfill Projected SO2 Emissions (NO 4th Turbine)

- No H2S Removal
- H2S Removal (flares and turbines) installed 11/30/2010
- H2S Removal (turbines only) installed 8/31/2010

Assumptions for Future Months:
1. 8,000 scf/m LFG at 50% methane
2. Turbine SO2 emission factor of 0.319 lbs/MMBtu (avg stack test)
3. 4,300 scf/m LFG to 3 turbines on average
4. Actual H2S readings used through 8/9/10.
5. Highest avg monthly H2S reading used for future months (1.146 ppm)
6. H2S Removal System removes 99% of H2S.
7. All H2S converted to SO2 in flares

Permit Limit of 240 tons

H2S Removal System (turbines and flares) begins operation on November 30, 2010.
H2S Removal (turbines only) begins operation on November 17, 2010 and Flares on January 1, 2011.
### Key Stats

- 102 collectors
- 4500 Scfm
- No collection in 5A/B 2C
- 24 in header ends in cell 4
GCCS System as of Sep 2010

Key Stats
• 182 collectors
• 7000 Scfm
• 35 collectors in 5A/B 2C
• 24 in header
Extended to cell 5
Exposed Intermediate Cap

Key Stats
- 20 acres 40mil HDPE
- 6000 foot gas trench
- 17 trench collectors
- PLATiPUS® anchors
Interim Cap
Evaluation of H2S Removal Systems

• Design Criteria
  • LFG flow rate: 8000 Scfm interim, 12000 Scfm life of site
  • Input H2S levels: 1200 ppm
  • Output H2S level: <1 ppm
  • Implementation: as soon as practical. Only solutions with short implementation times were considered for the interim treatment solution

• Technology Available
  • Activated carbon
  • Liquid scavenger chemicals (Q2, Benzeco Scientific)
  • Solid scavenger chemicals (SulfaTreat®)
  • Bio-process (THIOPAQ®)
Solid Scavenger System

- Ceramic base impregnated with Iron Oxide. \((\text{Fe}_2\text{O}_3)\)
- Saturated LFG with \(\text{H}_2\text{S}\) flows through solid media, converted to Iron Pyrite. \((\text{FeS}_2)\)

\[
4\text{H}_2\text{S} + \text{Fe}_2\text{O}_3 \rightarrow 2\text{FeS}_2 + 3\text{H}_2\text{O} + \text{H}_2
\]

- Lead lag system: 3 vessels (turbine) 4 vessels (flare)
- Change out done at 20ppm \(\text{H}_2\text{S}\) outlet of lag
- Lead changed out, lag becomes lead, standby becomes lag
Solid Scavenger

**Pros**
- Proven in LFG application
- Short implementation: used vessels available
- Relatively low capital cost
- Simple operation / controls
- Vessels can be reused when H₂S levels drop

**Cons**
- High pressure drop, upgrade compressor required
- Media replacement costs
- Disposal of spent media (landfill)
Solid Scavenger System (Flare)
Solid Scavenger System

Flare treatment

Plant treatment
H2S Monitoring/Change Out

King George Turbine Lead Bed Outlet H2S Levels (ppm) vs Time

- Changout 11/28
- Changout 12/23
- Flowrate 6,500 scfm
- Changout 1/10
- Changout 1/31
- Changout 2/15
- Changout 3/3
- Flowrate 4,500 scfm
- Turbine Compressor Down
- Changout 3/25

Date Range: 11/18/2010 to 3/18/2011
H2S Monitoring/Change Out

King George Turbine Lag Bed Outlet H2S Levels (ppm) vs Time

- Changout 12/23
- Changout 1/10
- Changout 1/31
- Changout 2/15
- Changout 3/3
- Changout 3/25

H2S Level (ppm)

- 11/8/2010
- 11/28/2010
- 12/18/2010
- 1/7/2011
- 1/27/2011
- 2/16/2011
- 3/8/2011
- 3/28/2011
- 4/17/2011
THIOPAQ®

- Biological process for removal of H2S from gas streams

- Gas is contacted with an aqueous soda solution

- H2S is absorbed by the soda

- H2S is removed from the soda by biological conversion to elemental sulfur using air

- Regenerated soda is returned to the absorber
THIOPAQ®

• **Pros**
  - Effective H₂S in large scale / life of site (12000 Scfm)
  - Regenerative
  - Waste product is organic elemental Sulfur which can be landfilled or used as organic fertilizer
  - Lower operational costs
  - Controls will improve gas system performance

• **Cons**
  - High capital costs
  - Relatively new process in landfill environment
  - One supplier for nutrient
  - Extensive design and construction
THIOPAQ® Process Chemistry

- **Absorption**
  \[ \text{H}_2\text{S} + \text{OH}^- \leftrightarrow \text{HS}^- + \text{H}_2\text{O} \]

- **Bio- Regeneration**
  \[ \text{HS}^- + \frac{1}{2}\text{O}_2 \rightarrow \text{S}^0 + \text{OH}^- \]

- **Oxidation into sulfate (bleed) <5%**
  \[ \text{HS}^- + 2\text{O}_2 \rightarrow \text{SO}_4^{2-} + \text{H}^+ \]

- **Bioreactor conditions**
  - pH 8-9
  - Temperature 60-100°F
  - \( \text{O}_2 \) controlled to limit sulfate production
THIOPAQ® Process
Way Ahead

- Installation of 4th turbine June 2011
- Construction/startup of Cameron THIOPAQ® biological sulfur removal system
- Continuing GCCS upgrades of header, well installations and collection in Cell 14A/B
- Continuing H₂S monitoring
- Interim cap cell 14 A/B
Questions/Discussion