High BTU and the Billings Landfill

LMOP 15th Annual Conference

January 18, 2012

Molecular Guild Associates, Inc.
Billings Project Team

- Montana-Dakota Utilities
  - Owner
- LFG Technologies
  - Overall project manager, developer and equipment supply
- Wenck Associates
  - Design and installation of the gas collection system
  - Installation of facility for compression and gas clean-up equipment
- Guild Associates
  - Provider of Molecular Gate systems for gas clean-up
Guild Products to the Natural Gas Industry

- Molecular Gate for N2 Rejection
- Molecular Gate for CO2 Removal
- Compressors
- Sulfatreat units
- TSA dehydration units
- Membrane units
- Chiller packages
- Sorbead “Quick-Cycle” dew point control
- NGL Removal for CARB standards
- CO2 removal for LNG / Peakshaver plants
- Helium purifiers
<table>
<thead>
<tr>
<th>Unit</th>
<th>Location</th>
<th>Raw Landfill Flow, SCFM</th>
<th>Product</th>
<th>Start-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>UK</td>
<td>1800</td>
<td>LNG</td>
<td>May 2008</td>
</tr>
<tr>
<td>2</td>
<td>Tennessee</td>
<td>1600</td>
<td>Pipeline</td>
<td>December 2008</td>
</tr>
<tr>
<td>3</td>
<td>Washington</td>
<td>11000</td>
<td>Pipeline</td>
<td>March 2009</td>
</tr>
<tr>
<td>4</td>
<td>Pennsylvania</td>
<td>10000</td>
<td>Pipeline</td>
<td>June 2009</td>
</tr>
<tr>
<td>5</td>
<td>California</td>
<td>2300</td>
<td>LNG</td>
<td>July 2009</td>
</tr>
<tr>
<td>6</td>
<td>Montana (2X PSA)</td>
<td>2400</td>
<td>Pipeline</td>
<td>December 2010</td>
</tr>
<tr>
<td>7</td>
<td>Brazil</td>
<td>12000</td>
<td>Pipeline</td>
<td>2012</td>
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</tbody>
</table>

36 PSA Systems in total including 7 Landfill and 6 Digester Projects
Guild Molecular Gate PSA System
Greentree Landfill, PA
Raw Flow 10,000 SCFM
Product to Pipeline Quality (96% Methane)
Billings Design (2400 SCFM)

Stage #1
CO2 PSA & Vacuum

FEED
115 psig

Tail Gas #1 – Flared
H2O, CO2
H2S, Siloxanes
VOC’s, Organic Halides

Stage #2
N2 PSA & Vacuum

Recycle

PRODUCT
90 psig
CH4 = 95%

Tail gas #2 to GENSET
3 psig
N2, CO2
Lost Hydrocarbons
Process Steps – CO2 PSA (& Water Vapor / Halides / VOCs / Siloxanes)

Product
CO2 = 1%

Adsorption
Flow
Upward

CO2
H2S
VOC
Siloxanes
CL & FL
H2O

FEED

Small Methane Purge

Vacuum Pump

“Tail Gas”

Regen
Flow
Downward

CO2
H2S - VOC
Siloxanes
CL & FL
H2O
Process Steps – N2 / O2 PSA

Sales Gas
N2 ~4%

Adsorption Flow Upward

N2 / O2
CO2

FEED

Small Methane Purge

Regen Flow Downward

N2 / O2 CO2

Vacuum Pump

“Tail Gas” To GENSET
Molecular Gate Adsorbent - Pore Size to Exclude Methane

- CO2: 3.4 Å
- O2: 3.5 Å
- N2: 3.6 Å
- CH4: 3.8 Å

3.7 Angstroms
<table>
<thead>
<tr>
<th>Time</th>
<th>ADSORPTION 100 psig</th>
<th>DEPRESSURIZE 100 psig to ATM</th>
<th>VACUUM &amp; PURGE Vacuum</th>
<th>REPRESSURIZE Vacuum to 100 psig</th>
</tr>
</thead>
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<tr>
<td></td>
<td>REPRESSURIZE Vacuum to 100 psig</td>
<td>ADSORPTION 100 psig</td>
<td>DEPRESSURIZE 100 psig to ATM</td>
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<td>REPRESSURIZE Vacuum to 100 psig</td>
<td>ADSORPTION 100 psig</td>
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Guild Molecular Gate PSA System – First Stage
Billings, MT Landfill
2400 SCFM (3860 nm3/hr) Feed
Product 95% Methane
Guild Molecular Gate PSA System – Second Stage
Billings, MT Landfill
2400 SCFM (3860 nm3/hr) Feed
Product 95% CH4
Billings Design (2400 SCFM)

- **Feed**
  - CH4 = 50%
  - N2 = 6%
  - CO2 = 43%
  - O2 < 1%
  - VOCs / Siloxanes
  - H2S

- **Product**
  - CH4 = 95+%  
  - N2 < 4%
  - O2 < 1%
  - CO2 = Nil
  - VOC’s = Nil
  - H2S = Nil
  - Dry

Tail gas #1 to Flare
Tail Gas #2 to Genset
## Billings VOC Results

<table>
<thead>
<tr>
<th>Substance</th>
<th>Feed – PPB (PPM)</th>
<th>Product - PPB</th>
<th>Detection Limit - PPB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vinyl Chloride</td>
<td>2100 (2.1)</td>
<td>ND</td>
<td>0.067</td>
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<tr>
<td>Freon 12</td>
<td>2900 (2.9)</td>
<td>ND</td>
<td>0.034</td>
</tr>
<tr>
<td>1,2-Dichloroethylene</td>
<td>1900 (1.9 PPM)</td>
<td>ND</td>
<td>0.043</td>
</tr>
<tr>
<td>Methylene Chloride</td>
<td>500 (0.5)</td>
<td>ND</td>
<td>0.095</td>
</tr>
<tr>
<td>Tetrachloroethene</td>
<td>1700 (1.7)</td>
<td>ND</td>
<td>0.025</td>
</tr>
<tr>
<td>Trichloroethene</td>
<td>700 (0.7)</td>
<td>ND</td>
<td>0.030</td>
</tr>
<tr>
<td>Trichlorofloromethane</td>
<td>160 (0.16)</td>
<td>ND</td>
<td>0.032</td>
</tr>
<tr>
<td>1,4-Dichlorobenzene</td>
<td>220 (0.22)</td>
<td>ND</td>
<td>0.028</td>
</tr>
</tbody>
</table>
**Stage #1 CO2 PSA**

- **Flow**

**Stage #2 N2 PSA**

- **CO2 Flow**
- **N2 Flow**

**PRODUCT**

CH4 = 95%

**FEED**

110 psig

**Flare**

- **Flow**

**TAIL GAS to GENSETS**

- 3 psig
- N2, CO2
- Lost Hydrocarbons

**Automatic Controls**
Landfill Gas Clean-up Items for Consideration

- Landfill flow – Current and future
- Level of N2 in the feed
  - And allowable N2 in product
- Allowable O2 in the product
  - Impacts gas clean-up route - Membrane or PSA or Deoxo
- Overall pipeline specifications
- Pipeline required pressure
- Tail gas use
  - Stage #1 - Flare / TOX for major impurity destruction
  - Stage #2 - Genset, leachate evaporation, local fuel, flare