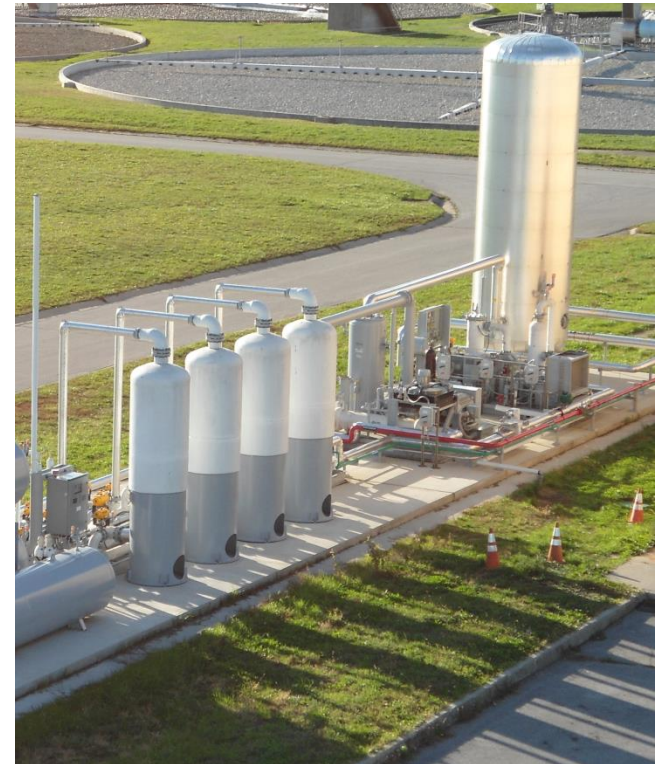


Gas-Cleaning and Siloxane Removal

Workshop on Fuel Cell Applications – March 6-7, 2014

- Guild Molecular Gate PSA based technology for impurity removal
 - H₂O, H₂S, Siloxanes, VOCs, CO₂, N₂ and O₂
 - Production of gas for Pipeline, CNG and LNG
 - Siloxasorb Siloxane removal systems
- Experience
 - 60 projects total
 - 19 for Digester and landfill sources
 - 100 SCFM to 12,000 SCFM

Molecular gateTM
Guild Associates, Inc.



Siloxane Concerns

- In Fuel Cells, or on catalyst or upon combustion forms particles of Silica (SiO_2)
- Found in WWTP Digester Gas and Landfill Gas
 - Concentrations increasing and varies widely. Different siloxane types
- Issues
 - In boilers reduces heat transfer and efficiency
 - IC engines require frequent oil changes & rebuilds
 - Manufacturers have variety of limits
 - Low pressure operation – impacts clean-up system design
 - Turbines
 - Typically lower limits than IC engines
 - Higher pressure operation
 - Fuel Cell and Post Combustion Catalyst
 - Causes catalyst deactivation



Targeted Siloxane Removal Technology

- **Pipeline Quality Gas Production**

- PSA, membranes, water wash or solvent scrubbing all remove siloxanes either directly or with additional treatment

- **Non-Regenerative Adsorption Systems (Replace bed when saturated)**

- Most appropriate for smaller flows and lower concentrations

- Water vapor interferes with siloxane adsorption

- Thus compression and pre-chilling is common

- H₂S also interferes with siloxane adsorption

- Thus H₂S pretreatment may be used either in a separate media bed or combined with siloxane media is a single bed

- Medias used can include (typically) carbon and graphite but also silica gel, alumina, resins and molecular sieves

- Lead-lag arrangement optional

Targeted Siloxane Removal Technology

- **Regenerative Adsorption Systems**

- Appropriate for larger flows and higher concentrations
- Typically feed compression and chilling (water and partial removal)
- Typically two beds of adsorbent with one removing siloxane and a second thermally regenerated
 - Regeneration with hot air or product gas
 - Reject to flare
- IC genset engines require low pressure gas as fuel.
- For turbines fuel is required at high pressure, either:
 - Operate at high inlet pressure (compressor/chiller/siloxane removal)
 - Operate at low pressure (blower/chiller/siloxane removal) and compress the treated product to required turbine pressure





Future Development Efforts

- **Non-Regenerable Systems**

- High media capacity for longer life

- **Regenerative Systems**

- Balanced media between adsorption capacity and regeneration requirements

- **Overall**

- Mixed bed of optimized media
- Lower cost on-line siloxane measurement
- Optimize media for H₂S co-removal or reduce H₂S interference
- Better address impact of landfill VOCs
- Biological, scrubbing, other technology approaches