SCAP

Treatment of Digester Gas

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Digester Gas Composition

- Approximately 60% CO_2
- Approximately 40% CH_4
- Water vapor – saturated at 95-100 degrees F
  - Remains saturated as it cools releasing large amounts of water into piping and downstream equipment
- Trace levels of contaminants including H_2S and Siloxanes, greases, dirt, hair, etc.
  - H_2S varies from 50 to >10,000 ppmv
  - Siloxanes vary by site and are increasing over time
- Typical pressure: 2-12 inches w.c.

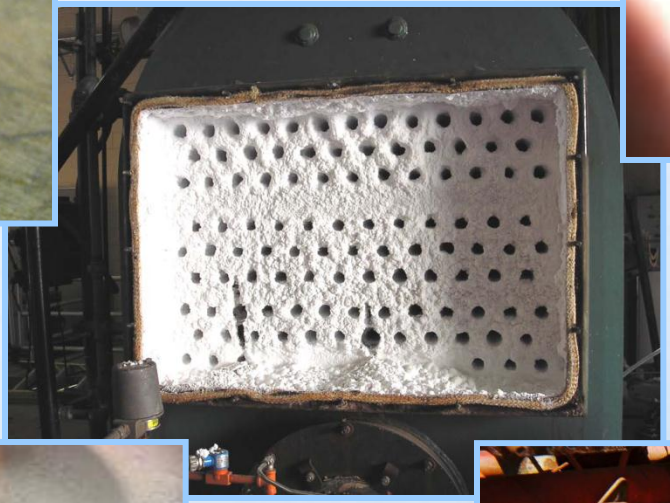
Contaminants of concern

- H_2S
  - Forms by biological breakdown of organics in anaerobic conditions
  - Typically present at levels of approaching 2000 ppmv if untreated
  - Most air districts regulate H_2S in some way, typically gas must have levels reduced to < 200 ppmv
- Siloxanes
  - Organic Silicon compounds
  - Derived from several common household products (shampoos, cleaning products, solvents, foods, etc.)
  - Generally water soluble

Consequences of Contaminants

- H_2S
  - Forms with water vapor both in the gas and in the combustion products to form H_2SO_4
  - Health hazard
  - Degrades lubricants
  - Forms acidic compounds, causes corrosion
- Siloxanes
  - Causes hard abrasive “glass” like buildup on combustion equipment such as engine valves and pistons
  - forms fine powdery “ceramic” like substance upon cooling which plugs boilers, heat exchangers, silencers, etc.
    - Insulates heat transfer surfaces greatly reducing effectiveness of equipment

Siloxane Damage



Contaminant Detection

- Laboratory analysis
  - Various sampling and analysis methods
    - H_2S can be sampled with drager tubes, but not reliable to low levels
  - Requires upwards of a week for results for Siloxanes
  - Expensive; Typically $500 to $3,000+ for testing
- H_2S can be monitored with electrochemical gas diffusion sensors
  - Real time monitoring
  - typically used for controlling mercaptan level in natural gas
- Siloxanes can be monitored with on-line gas chromatograph
  - Near real time Siloxane and H_2S measurement

Value of Digester Gas Treatment

- Gas quality has direct impact on cost of maintenance
  - Cummins quotes maintenance as follows:
    - $0.008/kWh for units operating on natural gas, or equiv.
    - $0.020/kWh for units operating on digester gas with approximately 100 ppmv H_2S
    - Siloxanes are required to be removed for either
- Less frequent maintenance
  - Oil changes, spark plug life, O_2 sensors, overhauls

H_2S Treatment Options

- Iron sponge (adsorption)
- Ferric Chloride into process
  - Odor control in sewers or liquid process
  - Advanced primary treatment
  - Struvite control
  - Digester gas H_2S control
- Water stripping
- Biological removal
- Caustic Scrubbing/Oxidation
  - Biological oxidation
  - Chemical oxidation

Iron Sponge

- Combustible
  - Exothermic reaction when oxidized
- Requires high degree of O&M (regeneration/replacement)
- High removal efficiency
  - Dependent on contact time and remaining "life" of media

Ferric/Ferrous Addition

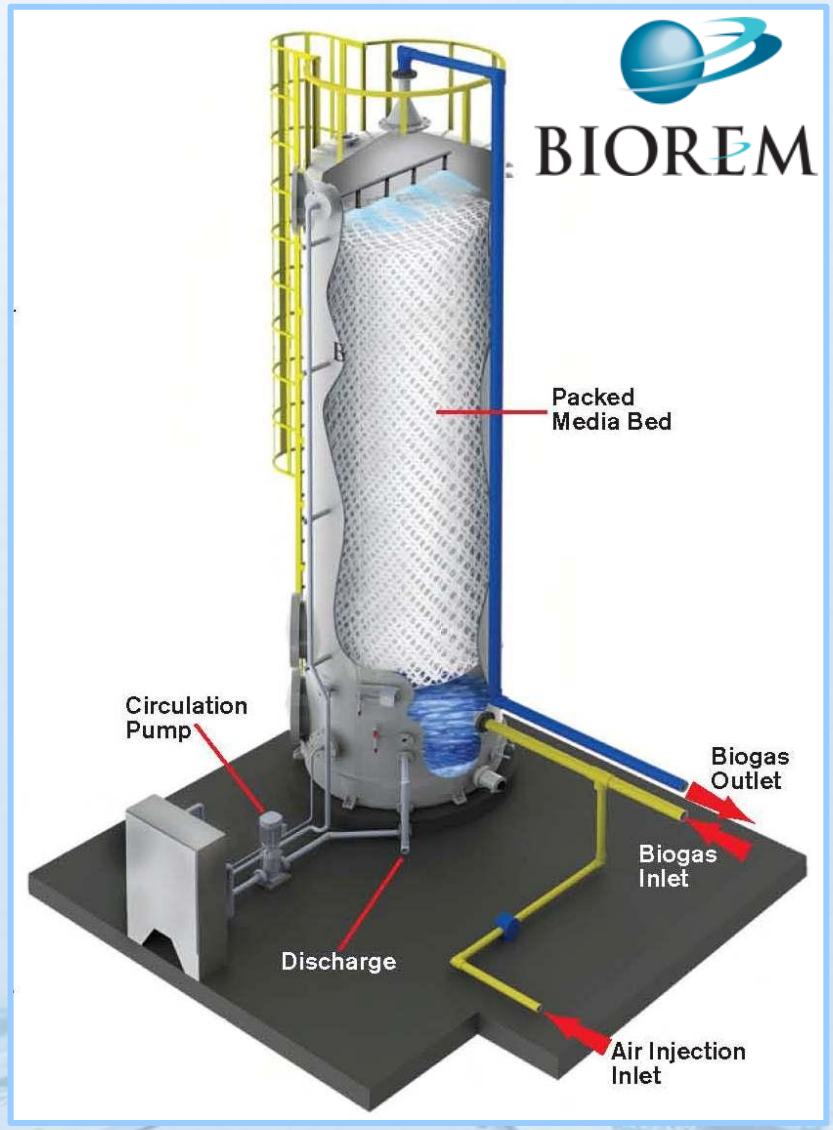
- Chemical storage/handling/delivery issues
  - Very corrosive
  - Expensive
  - Hazardous Chemical
- Process issues
- High removal efficiency
  - Dependent on quantity of chemical added
- Often used due to other process benefits

Water Stripping

- Large quantity of water required
- Shifts Sulfur compounds to water
  - Could present discharge permit issue
- Process and treatment plant capacity issues
- 80-85% removal efficiency

Biogas Biological Trickling Filter Treatment

- New technology to USA
- Requires active controls, biological process is pH sensitive
- Small amount of O_2 added to the digester gas
- 80-85% removal efficiency



Caustic Scrubbing/Chemical Oxidation Treatment

- Generally used for large systems; >1,000 scfm
- Requires complex active controls, process is pH sensitive
- 90-95% removal efficiency

Caustic Scrubbing/Biological Oxidation Treatment

- Generally used for very large natural gas processing systems; >5,000 scfm
- Requires complex active controls, process is pH sensitive
- 90-99% removal efficiency
- Produces elemental Sulfur which can be sold

Siloxane Treatment Options

- Adsorption
  - Carbon
  - Desiccant
- Remove water from gas (gas drying)
- Typically both are required due to quantity of Siloxane compounds in the gas

EMWD Moreno Valley RWRF

Siloxane Removal O&M Issues

- Costly media to replace
- Requires energy to regenerate
- Regeneration results in off-gas that must be eliminated
  - Flared; results in loss of 5-10% of digester gas
  - Thermal Oxidizer
  - Microwave disintegration
- Energy costs for moisture removal

Carbon Based Systems

- Very common – 100's of systems in use
- Highly porous adsorptive engineered media
- Most effective when moisture is controlled
  - 30-70% relative humidity recommended
- 95+% removal efficiency

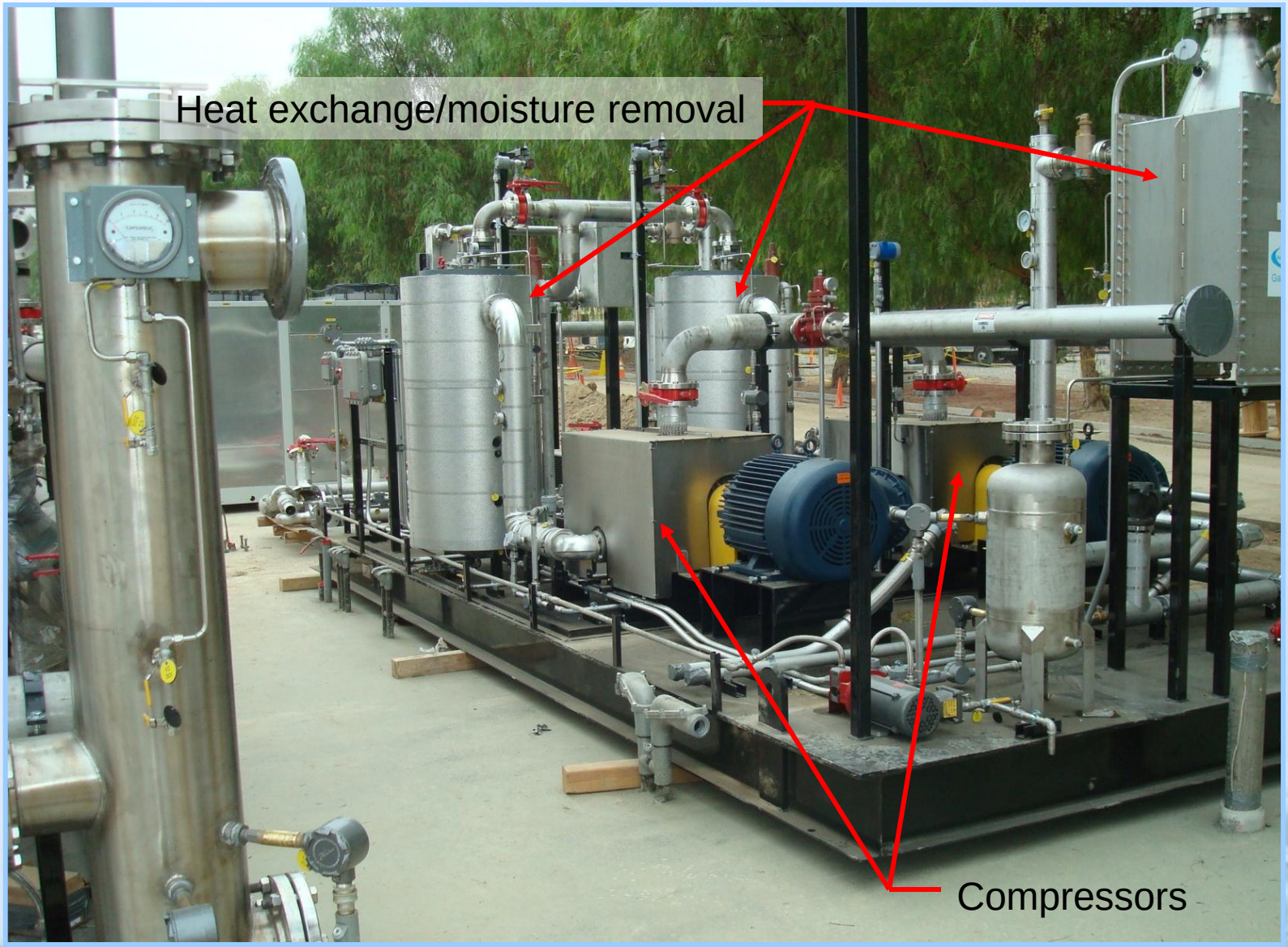
Desiccant Based Systems

- Generally meant for large systems
  - Typically >1,000 scfm
  - Applicable size quickly coming down
- Regenerable media reduces replacement costs
- 90-95% removal efficiency
  - Does not respond well to spikes
- Generally followed by Carbon to polish

City of Chico WWTP – Fuel Conditioning System for an Engine

EMWD Moreno Valley RWRF – Fuel Conditioning System for Fuel Cells

EMWD – Gas Conditioning/Compression



City of Tulare – Fuel Treatment System

Fuel Treatment Key Issues

- Redundancy in media
  - Dual vessel trains for both H_2S and Siloxane removal
  - Switchable lead/lag operation
- Redundant or spare long lead components
- Flow control to prevent channeling
- Maintainability
- Flexibility to adapt to digester gas changes
- Contaminant monitoring to minimize risk of breakthrough

Thank You