H2S Removal for Biogas Project

H2S Removal from Biogas for RNG and Electricity Projects

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H2S Safety Issues

320–530 ppm leads to pulmonary edema with the possibility of death. 530–1000 ppm causes strong stimulation of the central nervous system and rapid breathing, leading to loss of breathing. 800 ppm is the **lethal concentration** for 50% of humans for 5 minutes' exposure (LC50). (Wikipedia)

Hydrogen Sulfide Levels in Biogas 0 – 10,000 ppmv

H2S Environmental Issues

H2S → Sox when combusted. This combines with water to form Hydrogen Sulfide. This is a strong acid associated with Acid Rain.

SOX is air pollution and affects the health of plants, animals and the environment.

Electricity and Boilers

H2S is removed for engine projects and Boilers for the following reasons:

Sox Emission Limits (air permits)

Equipment protection from Acid Gas (corrosion)

RNG and H2S

H2S is removed from RNG gas to comply with pipeline Tarriffs (0.25 grains/100CF = 4 ppmv)

Typically other Sulfur compounds are limited to 1 grain/100CF

H2S is also removed to protect equipment from corrosion

Oxygen Effects

Electricity and Boilers:

- Some Oxygen in the gas is OK

RNG Projects:

- All Oxygen Must be kept out of the pipeline

A Range of Options

- Liquid Scavenger
- Dry Media (Sulfatreat, Sulfatrap, Iron Sponge)
- Impregnated Carbon
- H2S Specific Carbon
- Iron Added directly to Digester
- Oxygen added to Digester
- Caustic Scrubber
- Biological Scrubber
- Regenerable Biological Removal
- Iron Chelate

Selection Criteria

- Capex Costs
- Opex Costs
- Removal Efficiency
- Effect on Oxygen Levels
- Reliability
- Labor to change out material
- Wastewater Treatment options
- Uptime

Liquid Scavenger

- Once through liquid treatment system
- Can be direct injected or a contact tower may be used

Advantages

- Low Capex

Disadvanges

- High Opex
- Find a place to send spent chemical

Iron Sponge

- Dry Media
- Iron impregnated woodchips
- Works best with a little Oxygen
- Low Capex
- Higher Opex
- Media changeouts (downtime)
- Saturated Gas Required
- Changeouts can be hazardous

Iron Sponge Changeouts

- Used Iron Sponge react exothermically with Oxygen

One site's changeout strategy:

Take vessel off line

Flood vessel with water

Bubble Air through vessel for a day

Change out vessels with new media

Sulfatreat/Sulfatrap

- Iron impregnated clay
- Works best with a little Oxygen
- Lower Capex
- Higher Opex
- Media Changeouts (downtime)
- Saturated gas

Sulfatrap System

Sulfatreat/Sulfatrap Maintenance

Vessels are difficult to changeout, because of bridging of sulfur between the media pieces

Bridged media can suddenly fall to the bottom of the vessels (dangerous)

Heavy equipment is often required to changeout vessels and break up media

This is a difficult job taking one or two days and a number of operators

Carbon

- Carbon Impregnated with Caustic
  - Reacts with H2S in the gas

    Carbon designed for H2S removal
  - Requires semi- saturated gas and high velocities

    Both are lower Capex and Higher Opex

    Downtime from Changeouts

Carbon Maintenance

Vessel changeouts are much easier than for Sulfatreat. The media pours out easily from the vessels

Carbon media tends to remove other compounds, and disposal may be a problem as the media has reacted with other compounds in the gas

Caustic Scrubber

- Lower Capex
- Higher Opex (from Caustic Usage)
- Must have a place to dump used Caustic
- Caustic reacts with CO_2 in the gas in addition to the H_2S (high Caustic usage)

Caustic Scrubber Maintenance

Chemistry will need to be checked and maintained

Waste water from the Caustic scrubber will need to be treated

Biological Scrubber

- Similar to the Caustic scrubber, but bacteria convert some of the H2S to elemental sulfur. This frees Caustic to react with more H2S.
- Relies on Colonies of bacteria (need a backup)
- Medium Capex
- Medium Opex
- Need a place to dump used Caustic
- Oxygen is added to the process (bad for RNG)

Biological Scrubber Maintenance

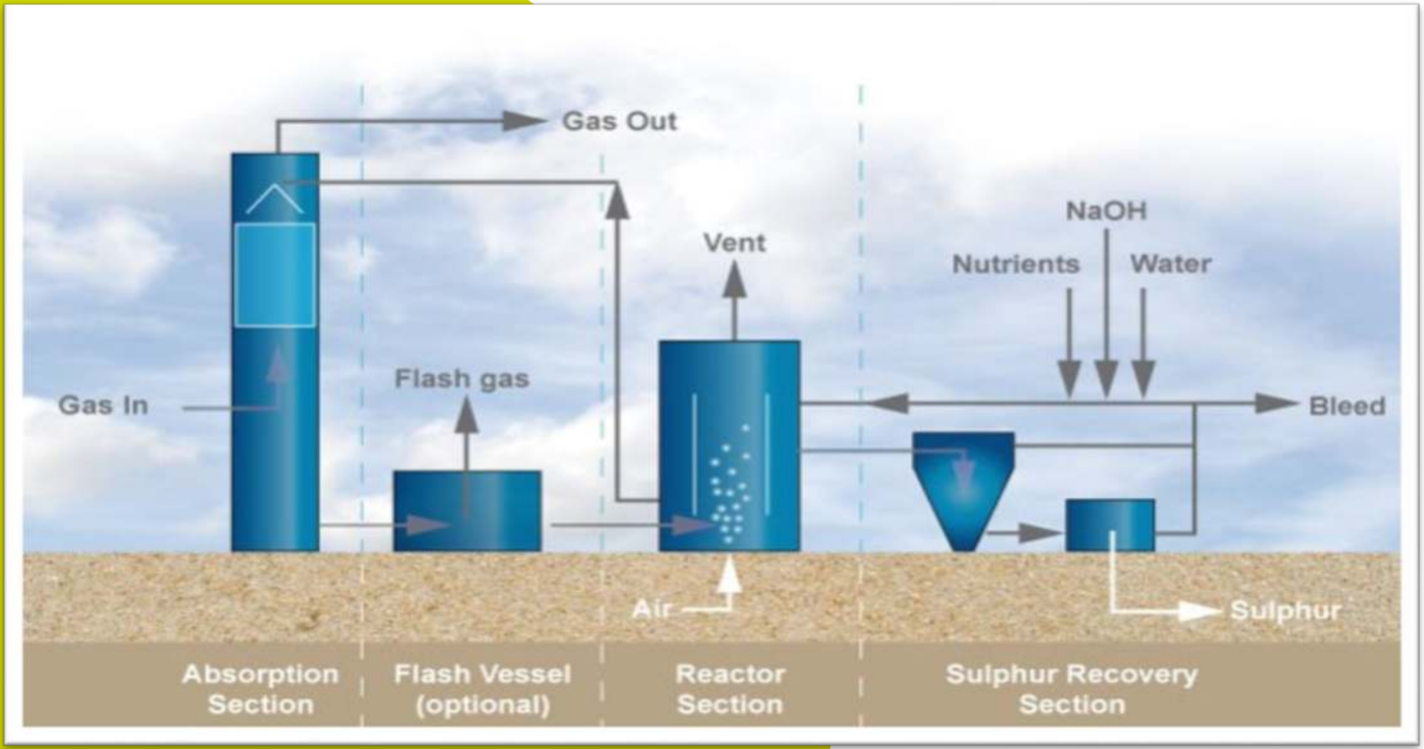
Operators are required to dose nutrients

Media may need to be periodically cleaned due to biofouling

Waste water from the scrubber will require treatment

Biological Scrubber

Caustic Scrubber w/ Biological Regeneration



Caustic Scrubber w/ Biological Regeneration

Advantages:

- Low Opex

Disadvantages:

- Needs a backup H2S removal system due periodically unstable bacteria colonies
- Requires Nutrients from system supplier
- Creates Hydrophilic Elemental Sulfur that is difficult to filter
- Higher Capex

Caustic Scrubber with Biological Regeneration Maintenance

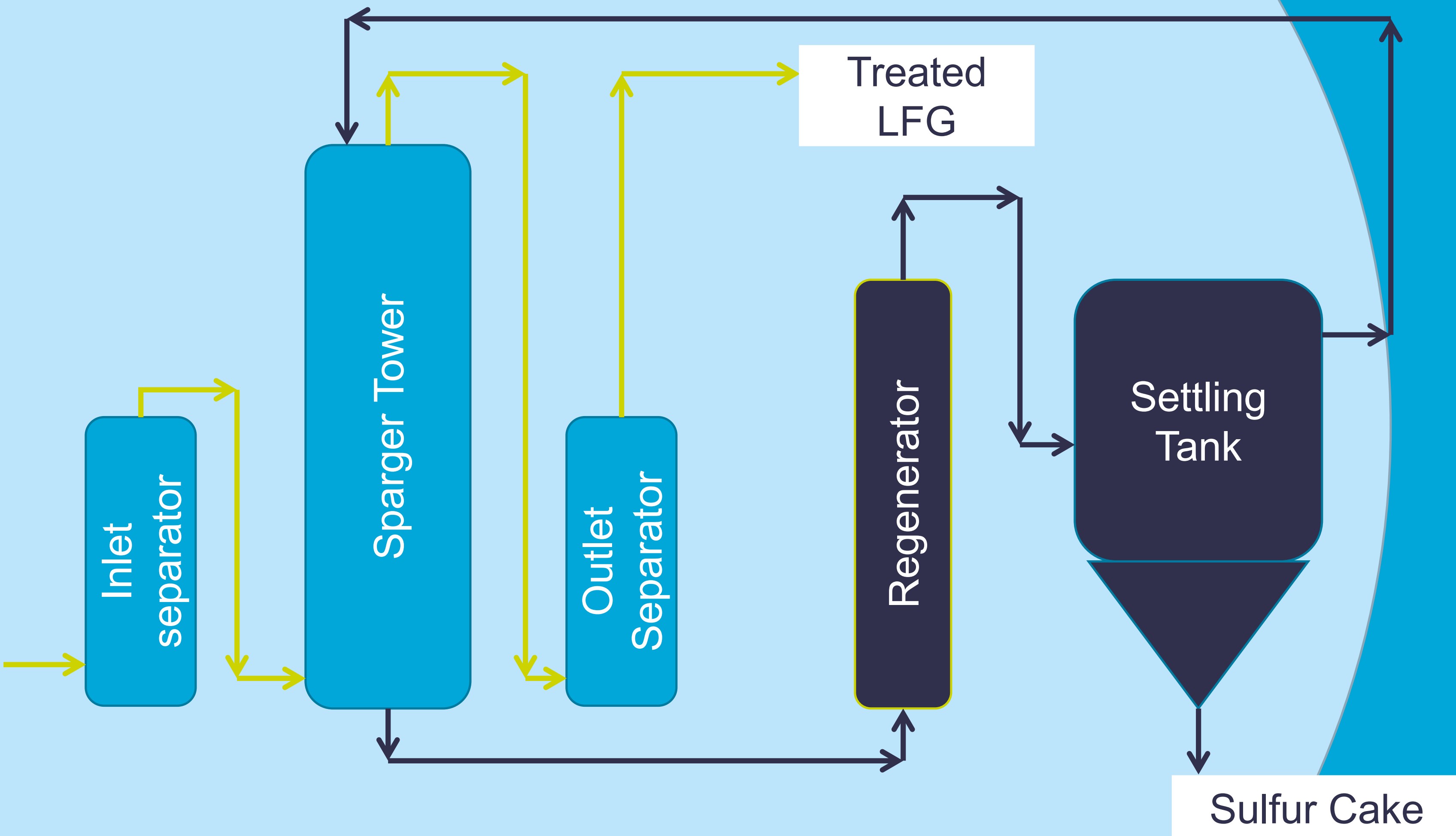
Still need to changeout replace backup media

Check chemistry and dosing requirements

Must dispose of sulfur slurry and waste water from process

Periodically clean system from biofouling

Iron Chelate H2S Removal



Iron Chelate

Treatment:

- $H_2S + Fe^{+3}L \rightarrow 2H^+ + S^O + Fe^{+2}L$

Regeneration:

- $1/2O_2 + 2H^+ + 2Fe^{+2}L \text{->} H_2O + 2Fe^{+3}L$

Chelates:

- Keep the Iron in solution

Others: Caustic, Surfactants, degradation inhibitors

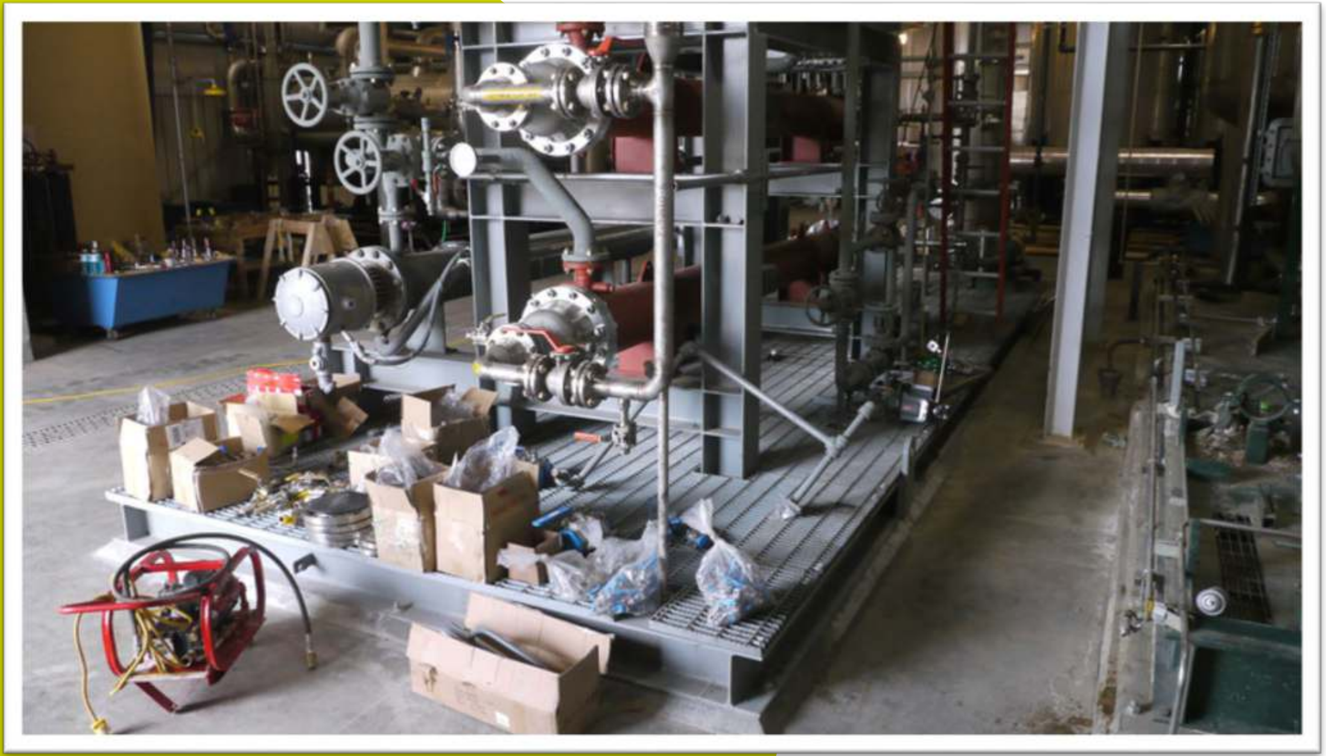
Iron Chelate Spargers

American Biogas Council
www.americanbiogascouncil.org

Regenerator and Settling tank

Iron Chelate Pipe Bridge

Iron Chelate Heater Skid



Iron Chelate Pumps

Iron Chelate Chemical Injection

Chelated Iron Treatment

- Sulfur Filter and Sulfur Cake

Iron Chelate Summary

Advantages

- Low Cost of Operation
- No disposal (except sulfur cake)
- Continuous process

Disadvantages

- High Capital Costs
- Process operates warm

Performance

- Inlet: 1000 ppmv H2S
- Outlet: <4 ppmv H2S

Iron Chelate maintenance

Annually need to clean piping and vessels from sulfur settling

H2S Summary

H2S treatment selection will depend on:

Use of the Gas (RNG/Engines/Etc)

Inlet Flow rates

Concentration of H2S in the gas