H2S Removal for Biogas Project

H2S Removal from Biogas for RNG and Electricity Projects

February 2019
Presented by Daniel Waineo, P.E.

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H2S Safety Issues

- Hydrogen Sulfide Levels in Biogas 0 – 10,000 ppmv

- 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)

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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.

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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)

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RNG and H2S

- H2S is removed from RNG gas to comply with pipeline Tarriffs (0.25 grains/100CF = 4 ppmv).
- H2S is also removed to protect equipment from corrosion.
- Typically other Sulfur compounds are limited to 1 grain/100CF

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Oxygen Effects

- Electricity and Boilers:
  - Some Oxygen in the gas is OK
- RNG Projects:
  - All Oxygen Must be kept out of the pipeline

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A Range of Options

1. Liquid Scavenger
2. Dry Media (Sulfatreat, Sulfatrap, Iron Sponge)
3. Impregnated Carbon
4. H2S Specific Carbon
3. Iron Added directly to Digester
4. Oxygen added to Digester
5. Caustic Scrubber
6. Biological Scrubber
7. Regenerable Biological Removal
8. Iron Chelate

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Selection Criteria

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

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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

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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

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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

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Sulfatrap System

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Sulfatreat/Sulfatrap Maintenance

- Vessels are difficult to changeout, because of bridging of sulfur between the media pieces.
- Heavy equipment is often required to changeout vessels and break up media
- Bridged media can suddenly fall to the bottom of the vessels (dangerous)
- 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

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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 CO2 in the gas in addition to the H2S (high Caustic usage)

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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

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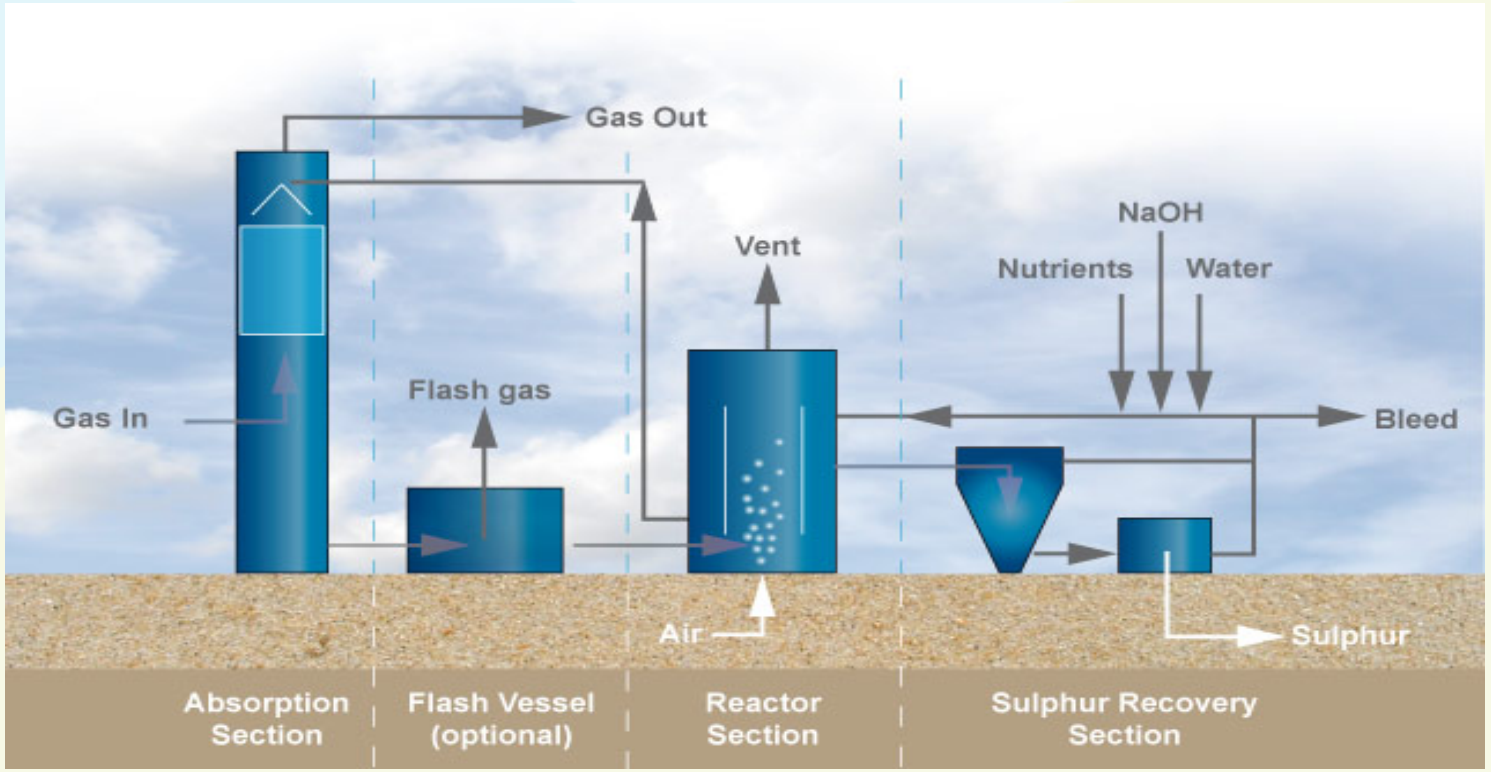
Caustic Scrubber
w/ Biological Regeneration



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Caustic Scrubber w/ Biological Regeneration

- Advantages:
  - Low Opex

- Disadvantages:

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

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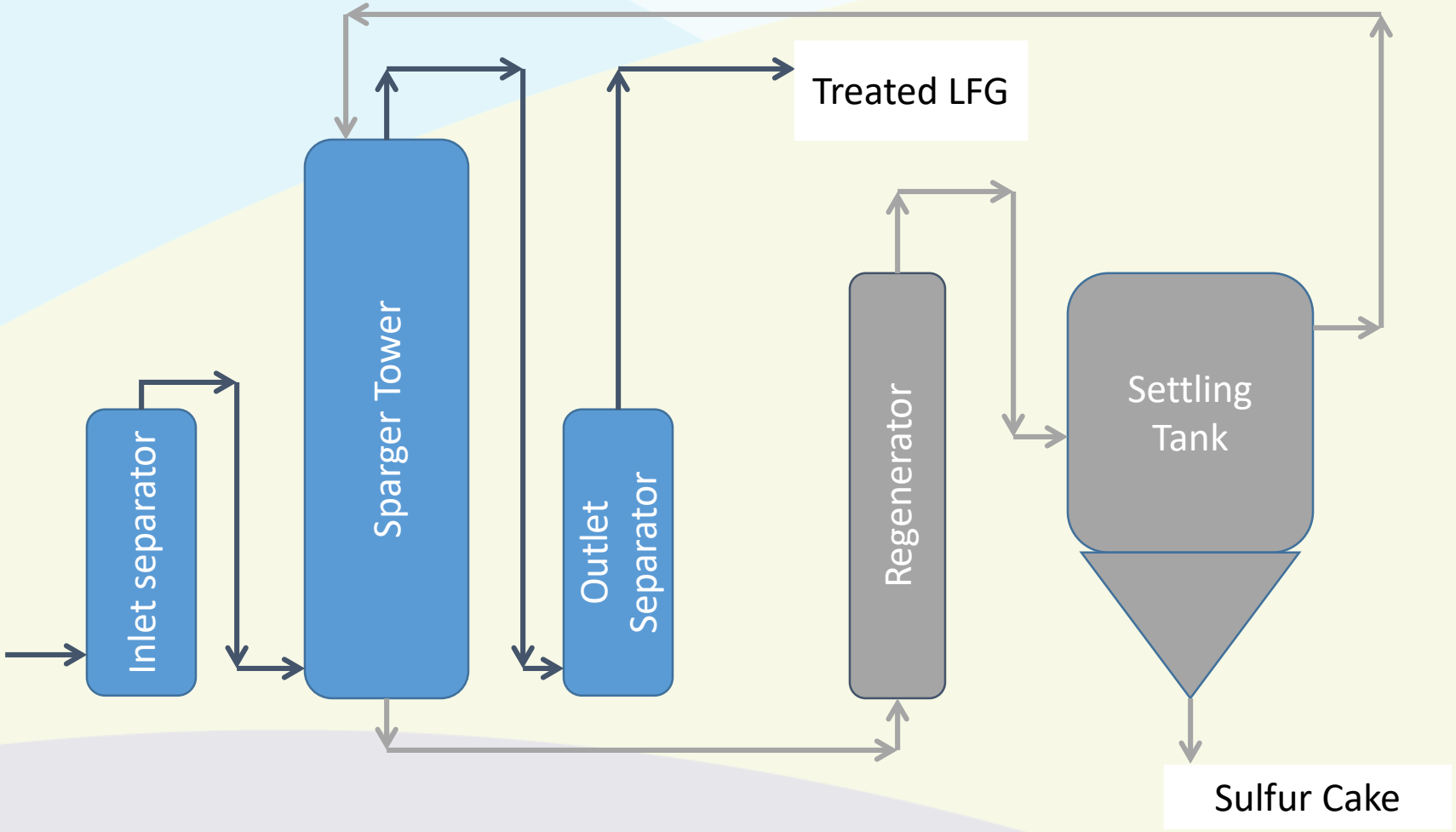
Caustic Scrubber with Biological Regeneration Maintenance

- 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

- Chemistry
- Treatment:
  - $H_2S + Fe^{+3}L \rightarrow 2H^+ + S^O + Fe^{+2}L$
- Regeneration:
  - $1/2O_2 + 2H^+ + 2Fe^{+2}L \rightarrow H_2O + 2Fe^{+3}L$
- Chelates:
  - Keep the Iron in solution
- Others: Caustic, Surfactants, degradation inhibitors

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Iron Chelate Spargers

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Regenerator and Settling tank

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Iron Chelate Pipe Bridge

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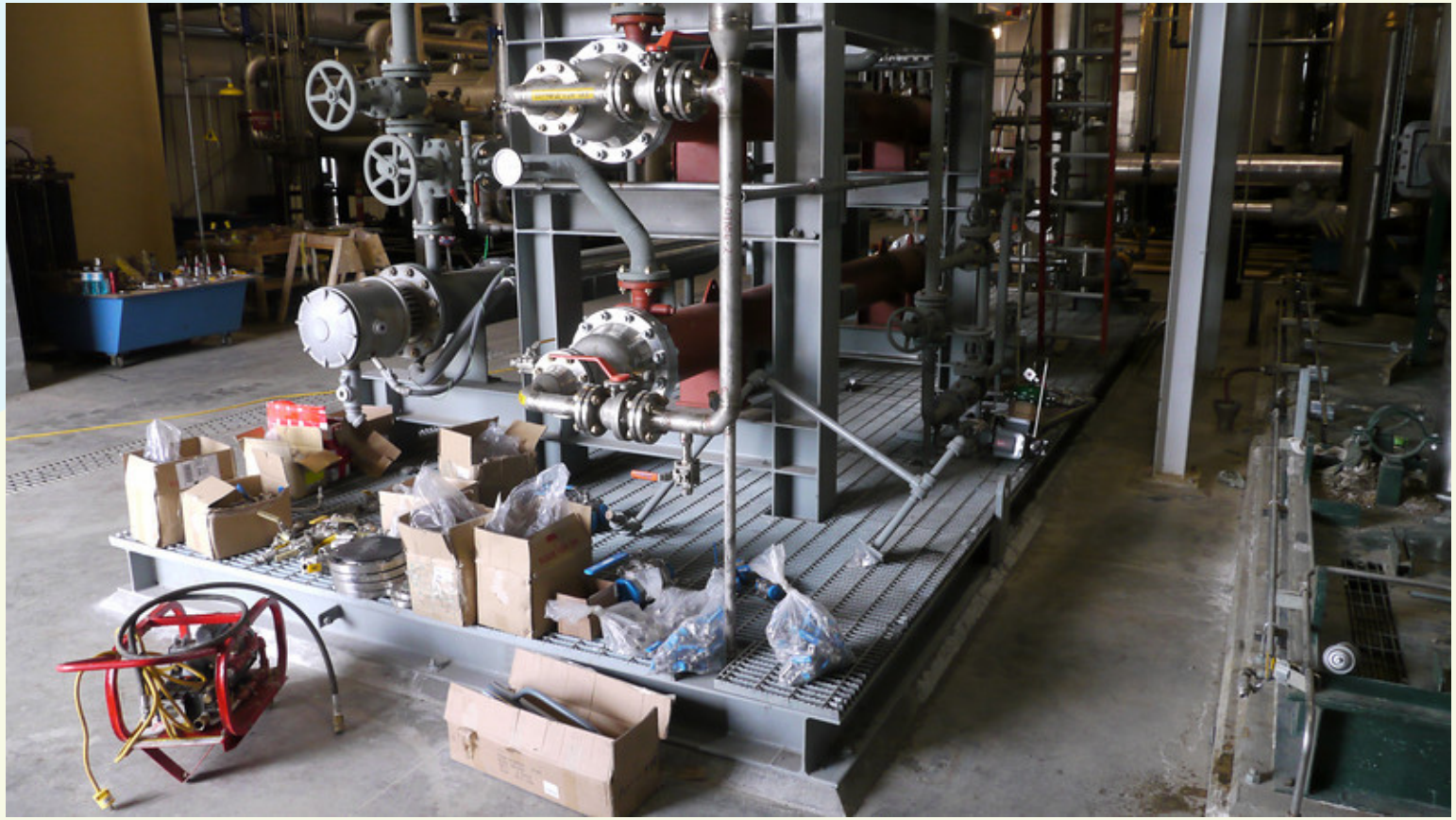
Iron Chelate Heater Skid



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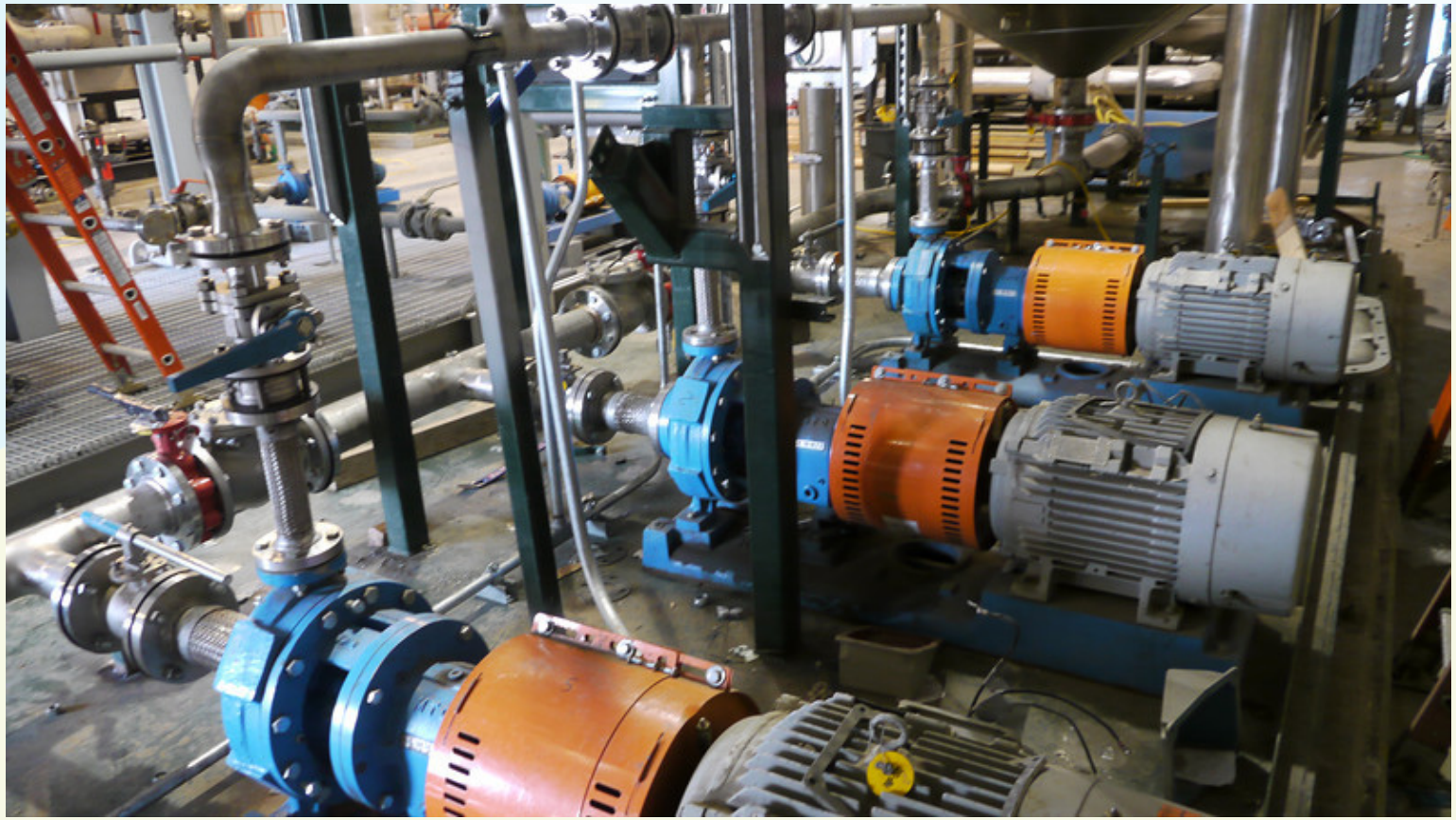
Iron Chelate Pumps



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Iron Chelate Chemical Injection

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Chelated Iron Treatment

- Sulfur Filter and Sulfur Cake

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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

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Iron Chelate maintenance

- Annually need to clean piping and vessels from sulfur settling

H2S Summary

- H2S treatment selection will depend on:
  - Inlet Flow rates
  - Use of the Gas (RNG/Engines/Etc).
  - Concentration of H2S in the gas