INTERRA GLOBAL

APPLICATION INFORMATION - FERROSORP®

Pelletized gas purification compound for the removal of hydrogen sulfide from biogas and landfill gas

FerroSorp is a pelletized gas purification compound based on iron hydroxide; it excels at removing hydrogen sulfide (H_2S) from the gas found in anaerobic digesters, landfill gas, and other natural gas sources. FerroSorp, with its iron hydroxide base, achieves high loading rates due to its highly porous surface, and pellet shape, and can be used to adsorb H_2S in both moving and fixed-bed vessels.

APPLICATIONS

FerroSorp is exceptionally effective at removing H_2S from the following sources:

- Biogas that originates in sewage treatment plants due to anaerobic conditions in sludge
- Biogas originated from food waste anaerobically processed
- Gases from anaerobic industrial sewage treatment facilities
- Landfill gas
- Industrial combustion and synthetic gases
- Waste and co-fermentation plant biogas from dairies after anaerobic digestion
- Miscellaneous H_2S-containing industrial exhaust gas (i.e., paper industry, oil-mill applications)
- The treatment of H_2S-containing exhaust from industries and wastewater treatment facilities
- Natural gas
- Carbon dioxide gas

TECHNICAL DATA

- Chemical characteristics: Iron (III) hydroxide-based pelletized gas purification compound
- Chemical formula: FeO(OH)
- Appearance: Light brown, variably shaped granules
- Standard pellet sizes: For use in moving-bed columns: 5 – 25 mm
  For use preferred in fixed-bed columns: 2 – 4 mm, 2 – 8 mm, and 5 – 25 mm (at pressure sensitive sites
- Other sizes: Upon request

LOADING CAPACITY

The reachable H_2S loading capacity is dependent upon several parameters, such as gas moisture, H_2S concentration in the crude gas stream, gas pressure levels in the installation, contact time in the column, oxygen level in the gas, and flow-rate gas velocity. FerroSorp has performed at loading capacities ranging from 20 to 70 weight percent of the sulfur content. For customers of FerroSorp, Interra Global offers analyses to determine the load of sulfur bound. By comparing to known performance benchmarks, one can determine if the H_2S removal media has reached full loading capacity.

MODE OF OPERATION

Chemical Reactions

- The following chemical reactions describe the H_2S removal process from various gases:
  - Adsorption: $2\ Fe(OH)_3 + 3\ H_2S \rightarrow Fe_2S_3 + 6\ H_2O$ - 62 kJ/mol (1)
  - Regeneration: $Fe_2S_3 + 1½\ O_2 + 3\ H_2O \rightarrow 2\ Fe(OH)_3 + 3\ S$ - 603 kJ/mol (2)
- The entire process can be summarized by the following equation:
  - $3\ H_2S + 1.5\ O_2 \rightarrow 3/8\ S_8 + 3\ H_2O\ \Delta G° =$ - 665 kJ/mol (3)
- Reactions 1 and 2 are exothermic, where the regeneration reaction (2) creates a 10x greater amount of heat than the adsorption reaction. This process must be particularly observed when the adsorption and the regeneration process occur separately, or if the supply of oxygen or regeneration air is temporarily interrupted due to technical defects.

Influence of Gas Moisture

- Detailed research of the binding reaction mechanism of hydrogen sulfide to the surface of iron hydroxide found that the hydrogen sulfide first becomes solved in water, which is contained in the mass as moisture. Hydrogen sulfide ions then form, reacting with the iron hydroxide to form iron sulfide. The reaction requires a certain minimum moisture of the gas purification pellets to react and ensure the pellets do not dry out. The pellet environment must maintain a relative gas moisture level of at least 30%.
- The regeneration process requires that the gas moisture level must be higher than the 40% needed for adsorption of H_2S. This is because 1 mol iron sulfide uses 3 mol water to reform into iron hydroxide.
- When optimizing the moisture content, we recommend that the gas not condense in the absorber, or at least the condensate should not stay in contact with the compound for extended periods.

Sulphur Precipitation

- Following the regeneration reaction, elemental sulfur is bound onto the pellets' porous surface. The iron hydroxide on the surface of the pellet gets blocked as the elemental sulfur builds up. Thus, the loading capacity of each FerroSorp pellet declines. When the pellets are no longer effective at removing H_2S, the media should be replaced with fresh pellets.

Siloxane Binding (Through Adsorption)

- Several studies have inferred that the gas purification compound FerroSorp is also capable of removing siloxane. Although there are no studies proving the process, it is assumed that H_2S is taken up through the process of adsorption. Municipal sewage treatment plants are a popular application for FerroSorp. In addition to H_2S, decamethylcyclopentasiloxane and dodecamethylpentasiloxane have been found in the anaerobic digester gas. To achieve complete removal of siloxanes and H_2S, it is recommended to have an additional purification stage using activated carbon.

CONDITIONS FOR THE APPLICATION

The FerroSorp gas purification pellets can be applied in both fixed-bed absorbers and tower-shaped absorbers. While fixed-bed absorbers replace media once the effectiveness at removing H_2S diminishes, tower vessels continuously change out the purification compounds.

Used media can be removed through the discharge valve under the gas purifier. New media is loaded through the valve at the top of the vessel.

The gas streams from the bottom to the top, against the direction of the movement of the gas purification compound. With lower levels of H_2S, the gas purification compound might not fully load. This partially loaded media can be reused by removing it from the bottom and replacing it at the top of the vessel. Before reloading the pellets, the small fines and dust created from previous use should be removed. Almost fully loaded media will have a grey-black color that persists in the presence of oxygen. Material should be removed every 14 days to prevent blockages or mineralization of the pellets.

Due to the different types of desulphurization installations and the wide variation of desulphurization equipment available, we can provide the following general information:

- H_2S concentration in raw gas: ca. 20 ppm - ca. 15,000 ppm
- Fill height of gas purification compound: min. 0.5 m (1.64 feet); max. ca. 12 m (39.4 feet)
- Pressure loss in the filter-bed: < 1 to 12 mbar/m (0.004 to 0.054 psi/ft), depending on the filling height, the chosen size of pellets, as well as the velocity / flow rate of the gas
- Pressure range: 100 mbar (1.45 psi) under pressure – ca. 25 bar (362.6 psi) overpressure
- Gas contact time in the empty vessel (EBCT): ca. 20 sec – ca. 3 min

- Gas flow rate in the empty vessel: ca. 2 m/min (6.5 feet/min) – ca. 15 m/min (49 feet/min)
- Relative gas moisture (depending on the product):
  - FerroSorp SD: min. 30%, ideally 40% - 60%
  - FerroSorp SK: min. 50%, ideally 60% - 95%, non-condensing
- Moisture content in pellets: min. 5 %, optimally 10% - 15%
- Amount of oxygen needed for regeneration: about 2 - 4 x stoichiometric excess relative to the concentration of H_2S in raw gas.

For example, in a regeneration reaction at a gas stream where 1,000 ppm H_2S needs to be removed, 0.2 - 0.4% pure oxygen is necessary for sufficient regeneration. Alternatively, instead of oxygen, a rate of approximately 1 - 2% by volume of air can also be used. If the gas stream contains 2,500 ppm H_2S, this would mean 0.5 - 1.0 % pure oxygen, or around 2.5 - 5% of air, respectively.

For use in fixed-bed vessels, we recommend adsorbers with multiple stages and individual tiers. The individual tiers allow the pellets to be changed separately.

IMPORTANT: Any amount of condensation in the reactor should be removed on a regular basis. The pellets can potentially turn into a sludge if they come in direct contact with water.

Use caution when loading the H_2S removal media into the vessel. Broken pellets are less effective. We recommend using a hose attachment so the product can be gently placed at the bottom of the vessel.

TRANSPORT AND STORAGE

- When transporting FerroSorp, take precautions to minimize agitation and vibration, which can result in pulverization of the pellets due to friction.
- When storing FerroSorp, any opened bags should be kept closed to prevent exposure to moisture and debris.
- There are no restrictions regarding the transport and storage of FerroSorp; however, do not store the containers in direct sunlight. UV rays may cause the plastic packaging to disintegrate. FerroSorp should be stored in a manner that prevents direct contact with water (e.g., rain). If stored outdoors, cover the super sacks with a canvas tarp.
- When stored appropriately, the product itself will last almost indefinitely.

SAFETY INFORMATION

Dust may occur when handling FerroSorp. A dust mask, gloves, and safety glasses should be worn when filling the reactor with product. All known chemical-safety precautions are also applicable.

DISPOSAL OF THE LOADED PRODUCT

For the disposal of used FerroSorp, we recommend acting in accordance with your local US regulations. European users should follow the guidelines of the European Waste Catalogue EWC and use the waste code number 060603 - “wastes containing sulfides other than those mentioned in 060602.”

Numerous landfills containing household trash and building materials will accept the loaded gas purification product, which is totally harmless to the environment, after submitting a declaration of analysis.

FORM OF DELIVERY

- FerroSorp SD: available in 2-4 mm pellets in 2000 lb Super Sacks
- FerroSorp SK: available in 2-4 mm pellets in 2200 lb Super Sacks

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