Company Name:	Environmental Restoration	Analysis Number:	9-133
Submitted By:	Alan Campbell	Date Sampled:	August 27, 2009
Sample ID:	SNiPER™ (16 oz. Sample)	Date Received:	August 27, 2009
Sample Location:	Lot No. 58014-5206-000153	Date Completed:	October 2, 2009

Product Efficacy Analysis

Testing Protocol Description

Environmental Restoration asked us to determine if their product, SNiPER™, a proprietary, stabilized chlorine dioxide, would scavenge, oxidize, and remove hydrogen sulfide gas. And, during tests, determine a stoichiometric quantity of product required to effectively remove a given amount of sour gas. The SNiPER™ product is a liquid that is typically applied in a fine mist aerosolized through a trigger sprayer or a fogging unit. The ULV (ultra low volume) fogging unit develops mist particles under 10 microns and some sub-micron mist develops. Residency time, application volumes, particle size of mist, and surfaces in which the material are to be applied are all variables that the lab would have to consider in a larger, time-consuming, and expensive technical project. But, the company wanted confirmation that their product removed hydrogen sulfide in a misted form. We also tested the liquid without misting by utilizing it as a sparging column to determine effectiveness. It should be noted that particle size coming from the standard trigger sprayer head developed mist particles sized between 10 to 100 microns. Tests indicated that was sufficient to contact sour gases.

Intergen Resources developed the hydrogen sulfide gas insitu for the tests. Hydrogen chloride (HCl) and sulfur develop stoichiometric quantities of hydrogen sulfide gas. Specific volumes of hydrogen sulfide gas were created in sparging vessels and predetermined volumes of SNiPER™ were sprayed into the vessels. Three minutes of contact time were allowed and hydrogen sulfide levels were determined by ASTM standards via Gastec length of stain test tubes (the same test utilized by gas pipeline companies to determine contract levels in gas transmission lines or gathering systems). Furthermore, in order to determine effective treatment ranges based on direct contact with the liquid compound, SNiPER™, a clean sparging tower was filled with the SNiPER™ product and a given volume of hydrogen sulfide was vacuum pumped through the column and circulated for three minutes, at which time the hydrogen sulfide levels would be tested.

Results Based on Protocol

1. Triplicate Tests – 29.6 ml. (1 oz.) Spray Mist, 3 Min. Contact Time
2. 10 ppm (parts per million; each ppm is 1,000 ppb) Hydrogen Sulfide (H_2S) in a 1 Liter Vessel

Test 1	Test 2	Test 3
<10 ppb (parts per billion), >99.9% Effectiveness	-0- ppm, 100% Effectiveness	<10 ppb, >99.9% Effectiveness

3. Triplicate Tests – Direct Contact, 3 Min. Contact Time
4. 50 ppm H_2S Vacuum Sparged /Circulated in a 500 milliliter Vessel with 400 ml.'s of SNiPER™

Test 4	Test 5	Test 6
-0- ppm, 100% Effectiveness	-0- ppm, 100% Effectiveness	-0- ppm, 100% Effectiveness

5. In order to determine the stoichiometric quantities of H_2S removed by SNiPER™. The sparge/circulation tests were run repeatedly with 100 ppm aliquots of H_2S until the material is spent.
    a. It was determined that each milliliter of SNiPER™ contains 2.1 mg of ClO_2
    b. Further it was determined that it requires 5.8 mg of ClO_2 to oxidize/remove each mg of H_2S

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c. Each 2.76 ml.'s of SNiPER™ oxidizes/removes one mg of H_2S

d. In a separate test, 100 ppm of H_2S was sparged and circulated for one minute. Results were checked and SNiPER™ was found to be 100% effective. And, in a follow-up subsequent test, 100 ppm of H_2S was sparged and circulated for 30 seconds. Results were again found to yield 100% effectiveness.

e. Theoretically, each gallon of SNiPER™ will oxidize/remove over 1,300 mg. of H_2S

f. 1 ppm of H_2S equals 1.4 mg/m3 @ 25°C or 77°F. One cubic meter of vapor space is equivalent to 35.3 cubic feet. It is given that length X width X height in feet yields cubic feet. A room that is 10' long by 10' wide by 10' high equals 1,000 cubic feet. 1 ppm of H_2S in 1,000 cubic foot room will contain 40 mg of H_2S. Theoretically each gallon of SNiPER™ will remove and oxidize 1 ppm of H_2S from 32,500 cubic feet of vapor space…or over 32 rooms as mentioned above

g. The odor threshold of H_2S is 8.1 ppb. 1 ppm of H_2S is over 120 times the odor threshold (the point at which you begin to smell H_2S)

h. The majority of gas pipeline sales contracts are based on less than 4 ppm of H_2S (5.6 mg per cubic meter or 35.3 cubic feet) allowed. In each 1,000 standard cubic feet of natural gas, 4 ppm equates to 160 mg of H_2S. Theoretically, based on the tests performed, one gallon of SNiPER™ will remove and oxidize all 4 ppm of H_2S from over 8,000 standard cubic feet of natural gas.

Notations/Comments

1. It is the author's opinion that SNiPER™ will effectively remove H_2S from the vapor space of any area contacted by the product. As long as the SNiPER™ is fogged or finely misted/aerosolized into a vapor space and allowed to contact the sour gas or organic sulfurs it will deliver results as advertised and promoted.

2. The author is impressed with the results and believes the product has usage in deodorizing, sour gas and organo-sulfur removal//oxidation.

3. It was found that the smaller the particle size delivered in fogging the SNiPER™ compound the better the results that will be achieved. Although composed of a hybrid, stabilized, proprietary ClO_2, it was found that the product did not bleach our equipment or clothing. The product specifically expends its reaction chemistry on the organics encountered. One might consider that the proprietary chemical method by which it works actually involves the requirement of interaction with organic substances to release its stored oxidative energy. Regardless of how it releases its oxidative reaction, the product was found effective against H_2S.

4. Other associated organo-sulfurs commonly mistaken for hydrogen sulfide, but are easily removed and oxidized by SNiPER™ are as follows: Carbonyl Sulfide, Methyl Mercaptan, Ethyl Mercaptan, Dimethyl Sulfide, Carbon Disulfide, I-Propyl Mercaptan, T-Butyl Mercaptan, N-Propyl Mercaptan, Methyl Ethyl Sulfide, S-Butyl Mercaptan, Thiophene, I-Butyl Mercaptan, Diethyl Sulfide, N-Butyl Mercaptan, Dimethyl Disulfide, 3-Methyl Thiophene, 2-Methyl Thiophene, Dimethyl Thiophene, Diethyl Disulfide, and Trimethyl Thiophene.

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