REDUCING GREENHOUSE GASES THROUGH BIO-OXIDATION

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ABSTRACT

Bio-technologies have evolved into viable treatment technologies not only for odorous compounds, but more complicated mixed airstreams that include volatile organic compounds (VOCs). Digestion of compounds such as benzene, toluene, ethylbenzene and xylene (BTEX) have been of particular interest in petroleum processes and clean-up projects as an alternative treatment to incineration technologies.

A bio-oxidation treatment process, bioremediation, has been successfully implemented in a variety of projects and conditions. Taken one step further, a 'bio-oxidizer' controls the environmental factors that affect bioremediation technology success. The bio-oxidizers are enclosed with automated controls that provide consistent air flow to maintain aerobic conditions, spraying mechanisms for humidification, watering systems to provide necessary moisture content. All of these conditions are necessary for optimum conditions for the microbes. The last control factor is the substrate used for microbial growth, which may be inorganic, organic, or a combination of both.

Bio-oxidizers, although modular in nature, are designed for specific project parameters. Each site or facility should provide the following evaluation criteria: process airflow, contaminants in the airstream, concentrations for each of the compounds, and temperature of airstream. Other factors include: site location, utility resources, and the ability to discharge a small amount of blowdown during a routine weekly maintenance program. Last, and most important, the goal for the project whether it's strictly odor control or if a removal efficiency percentage is required by facility permits, government requirements or worker-related safety. The more factors analyzed and determined prior to install will ensure proper vessel sizing, as well as increase performance capabilities and reliability of the system.

A bio-oxidizer was selected as the best technology for a soil vapor extraction (SVE) remediation project in rural Oregon. The installation is located in a highly sensitive neighborhood and the goal for the system was odor removal. Due to the close proximity of homes, the project required a quiet, low maintenance and reliable technology to treat the off-gas vapors from the SVE system. The initial projected contaminant loadings were grossly underestimated, and although the ultimate goal for the bio-oxidizer was odor removal, the system continued to improve on overall hazardous pollutant removal efficiencies vented through the system.

In comparison, a bio-oxidizer was installed on a glycol dehydrator at a natural gas processing field in Louisiana. The project goal was reduction of benzene, a hazardous air

pollutant under state requirements. The contaminant loadings for this system were measured in excess of 100,000ppm of total VOCs, while the BTEX portion ranged from 50-80% of the total VOCs.

Biological systems are extremely viable for mid-to-lower range concentrations, and can even be sized to accommodate higher loadings by designing for longer retention times, lower airflows, and surge loading capabilities. Bio-oxidation provides a sustainable solution to incineration-type technologies, reducing greenhouse gas production by capturing and treating the contaminants, not creating any secondary pollutants during the process, and using less energy with little to no fossil fuels required to run the system.

Data from the above-mentioned installations will be discussed during the presentation, along with system design parameters, how to optimize biological systems, the environmental benefits and the economics of bio-oxidizers.

Introduction

Biofiltration technology has been successfully applied for decades in Europe, primarily for odor control. The technology made its way to the United States and was first popularized in the mid-80's to early 90's. Often, large in-ground systems, they were difficult to control the temperature and humidity levels, compaction and channeling of the media, and most importantly, monitor their success. These large systems were applied in industries that were never considered before, such as Wood Products, treating methanol and formaldehyde, and mixed hydrocarbon airstreams with limited success. The outcome for these initial systems often left industry and regulators with a limited view of the capabilities of biofilters for a wide range of applications.

Many lessons were learned and studied during these years, and as a result, many advancements have happened in bio-technologies for pollution control. The systems that are marketed today are usually pre-engineered designs, with only sizing changes (either width or height) for maximizing the efficiencies of each application.

Below is discussion regarding two particular installations for hydrocarbon removal, describing particular advancements in these systems and destruction efficiencies biofiltration is capable of achieving whether it is odor control or regulatory compliance.

Glycol Dehydrator Vent Gas Emissions

A biofilter, designed and manufactured by Bio•Reaction Industries of Tualatin, Oregon, operated on a glycol dehydrator vent for a three-year period at a natural gas production facility in Louisiana. Initial test results for this installation were first published [Stewart, 1997 #483]. This briefing provides additional information on the installation describing system modifications and final data.

Glycol dehydrators are commonly used in gas production fields for removing water and other contaminants from natural gas. The glycol is then recirculated through a boiler to drive off the water, and then recycled. The contaminated water is condensed, but not all of the contaminants are easily condensable, and a low flow of mixed VOCs at variable and often high concentrations are vented to the atmosphere.

The customer was under regulatory pressure to reduce benzene emissions at this particular facility. The operational criteria for this project were extreme: very high and variable VOC loadings, variable flow and temperature, and the gas stream consisted of almost 80% carbon dioxide. Design value for influent non-methane VOCs was 48,000ppmv; of these approximately 11,260ppmv were estimated as BTEX compounds. Methane gas was also present in concentrations as high as 44,000ppmv, with a mean of 22,983ppmv. Although the methane gas was not a target for treatment, its potential effect on biofilter performance was considered. Vent gas flow, initially estimated at a mean of 0.9 cfm, actually ranged from 2 to 3 cfm with higher surge flows.

The initial system design consisted of 3 bioreactors, each containing 2 layers of compost media connected in series. The system used modified venturi injectors with compressed air prior to each biological unit to provide necessary oxygen to the system. Daily monitoring was carried out using a Photovac 20/20 PID (with diluter), and intermittent GC analysis to provide data verification. Initial results were encouraging. The earliest results, based on GC analysis, showed a 99% removal of total BTEX (Influent = 17,685ppmv) with a 99.6% removal of benzene (Influent benzene = 11,671ppmv), proving the biofilter system was capable of applications with these extreme loadings.

The original reactors were replaced with a new three foot diameter design as shown below (Figure 1.). Soon after the upgrade, the test results proved the configuration of three vessels in series was an inefficient use of bed area. As a result the configuration was modified to two reactors (3 layers each) operated in parallel, with the final reactor (also 3 layers) used as a polishing vessel, if needed.

Figure 1. Glycol Dehydrator Bio-oxidation Unit

The table below depicts mean results of 23 independent sampling and GC analyses over an eight-month period (Table 1.). These data show the enormous range of influent concentrations, as well as the surge handling capability required of any control process designed for this application.

Table 1. Results from GC Analyses

	Non-BTEX VOCs (PPMV)	BTEX (PPMV)	Total VOCs (PPMV)
Mean	51,466	18,382	69,467
Standard Deviation	± 103,182	± 21,805	± 123,012
Minimum Value	8,540	70	17,240
Maximum Value	520,310	104,100	624,410
N	23	23	23

Immediately following startup, the condensate pump failed and the first bioreactor filled with condensate. The maintenance crew drained the biofilter, raked through the bed to restore permeability, and restarted within 24 hours. Removal efficiencies were immediately restored, demonstrating the inherent resiliency of the biofilter design. Bed drying and watering obstacles were also addressed in the newer design by incorporating a heater into the base of each bioreactor and updating the watering system with a more versatile water timer.

On one particular occasion, an unusually high surge loading was sampled and analyzed. It must be emphasized that influent loadings of this magnitude are very rare, having been identified on only one occasion in three years. The GC analysis is given below only to show that a biofilter is capable of treating such incursions (Table 2.).

Table 2. Glycol Dehydrator Vent Gas - GC Analysis

Compound (PPMV)	Influent	Effluent	% Removal
Methane	166,260	0	100.0 %
Ethane	18,190	60	99.7 %
Propane	267,130	28,270	89.4 %
i-Butane	6,360	0	100.0 %
n-Butane	13,170	350	97.3 %
i-Pentanes	14,730	280	98.1 %
n-Pentane	1,900	110	94.2 %
i-Hexane	7,760	60	99.2 %
n-Hexane	3,260	30	99.1 %
Heptanes +	17,520	360	97.9 %
Iso-Octane	4,030	50	98.8 %
Total - Non BTEX VOCs	**520,310**	**29,570**	**94.3 %**
Benzene	78,880	570	99.3 %
Toluene	25,220	450	98.2 %
Ethylbenzene	0	0	
Xylenes	0	0	
Total BTEX	**104,100**	**1,020**	**99.0 %**
Total VOCs	**624,410**	**30,590**	**95.1 %**

The installation allowed the advancement in the optimal bio-oxidizer design, keeping a small footprint while also minimizing the amount of biological media necessary to achieve compliance requirements. Using biofiltration to treat a highly concentrated VOC air stream from glycol dehydrator vents is feasible, and can be a cost-effective alternative to conventional treatment methods.

Soil Vapor Extraction (SVE) Emissions

A dual stage, single stack biofilter was installed on a SVE system in rural Oregon for a gasoline remediation project. This state owned site was under extreme scrutiny by nearby neighbors to install remediation techniques that would not exceed low noise level standards, retain a small footprint and minimize odors. The biofilter was installed in

January 2003 complete with an acoustical sound enclosure for the blower, leaving only the pump operation to provide any intermittent noise.

The consultant working with the state provided Bio•Reaction with preliminary data from engineering estimates based on site location and monitoring wells in place, prior to installation of any equipment. As a result, the biofilter system design was based on inlet airflows of 120-150cfm. A 6' diameter, 15' tall biofilter, as shown below, was installed to accommodate the request for odor reduction only. There were no compound destruction efficiency levels determined (or required) at this time, however based on past installations of similar systems, the biofilter could likely accommodate up to 1.5lbs/day of VOC, including BTEX, with its' current configuration.

Upon start-up of the system and initial sampling/analysis, the rural location and temperature fluctuations seemed to pose an issue for increasing treatment efficiency. The vessel was insulated and an air pre-heater added to maintain optimum conditions for the microbes. In addition, telemetric equipment was added to provide a means for the technical staff at Bio•Reaction to monitor the system by computer.

Several sets of data were then gathered over several weeks and it was soon learned that the initial data provided grossly underestimated the actual inlet concentrations. Gas chromatography analysis of bagged air emission samples showed total VOC inlet concentrations were averaging 12.8lbs/day of BTEX, TPH & MTBE compounds. Even so, the odor reduction was significant and kept the neighbors happy; the system was acclimating to the compounds; while still providing >60% removal of the compounds tested. Of the BTEX compounds, Toluene levels were averaging 50% of the total, with the xylenes (o, m & p) comprising another 25%, leaving Benzene and Ethylbenzene to make up the remaining portion as monitored.

During a 3 month reportable period, March through May of this year, a total of 923.64 total pounds of VOCs were removed from the subsurface by the biofilter system. The table below depicts monthly averages of inlet loadings and pounds of VOCs removed.

	Contaminant	ppm in (avg.)	ppm out (avg.)	Total lbs removed
March	BTEX	100	16	
	MTBE	11	5	
	TPH (Gasoline)	1700	720	
	TOTALS			396.44
April	BTEX	78.5	13	
	MTBE	9.7	5	
	TPH (Gasoline)	1700	770	
	TOTALS			370.25
May	BTEX	89.8	7.4	
	MTBE	5	3	
	TPH (Gasoline)	750	490	
	TOTALS			156.95

Due to the success of the six month project, an additional year's lease was signed to keep the biofilter in operation throughout the life of the SVE project. Acclimation of the system continues and reports from the consulting firm's lab are showing steady improvements in destruction/removal efficiencies for the biofilter. Latest sampling

Summary

Biological technology solutions are advancing as a technology of choice for odor control AND VOC/HAP control of air emissions. The advancements made in this system design coupled with the research on the optimization of microbial populations is allowing biofiltration to be utilized in new applications and industries. The ability of the bio-oxidation process to reduce hazardous air pollutants without creating any deleterious by-products or additional greenhouse gas emissions, and, at the same time, satisfying regulatory compliance, can prove to be a long-term, sustainable solution for many applications. The variety of those present in the petroleum, petrochemical and refining industries may be quite large and is certainly unexplored.