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Chemical-Free Alternative for Municipal Sewer Line Odor and Corrosion Control

Case History **March 2013**

INTRODUCTION

Santa Cruz, California, a progressive seaside community of about 60,000 residents on the Monterey Peninsula, was experiencing extreme odor and corrosion from Hydrogen Sulfide (H_2S) emissions along sections of the wastewater collection system that runs from south to north through the city. There are numerous locations along the collection system where manholes and lift stations are in close proximity to high traffic tourist attractions and the world renowned scenic coastline. Therefore, it is critical for the Santa Cruz County Sanitation District to operate a highly effective odor and corrosion control program within this collection system.

Toward this end, over the past decade the county has gradually expanded its use of a nitrate-based treatment product called Bioxide™ for odor and corrosion control. Though this chemical treatment was the most cost-effective option, it represented an average usage rate of about 1000-1500 gallons/day (GPD) fed into numerous lift stations, and with an overall cost of ~$1,000,000/year. At the time of this writing, there were six Bioxide™ bulk tank feed stations located in and around the city.

The largest volume Bioxide™ feed point is at a location called Rodeo. Depending on seasonal conditions, the Bioxide™ dose at Rodeo would typically range from 600 to 1000 GPD being fed into an average flow of about 8.5 MGD over a distance of about 4.5 miles through a 36" line to the receiving municipal wastewater treatment plant. Without treatment, the H_2S concentration at the WWTP head works averaged >4.5 mg/L. With Bioxide™ treatment, the H_2S at the head works was normally <1.2 mg/L.

The three most important factors limiting the effectiveness of Bioxide™ were 1) relative ineffectiveness immediately downstream of the feed point, 2) adverse effect of excessive nitrate at the WWTP, and 3) the never ending treatment cost.

Bioxide™ is a nitrate (NO_3^-) containing chemical designed as an alternative oxygen-source to sulfate (SO_4^{2-}) as a nutrient for anaerobic microorganisms living within the sewer line. By feeding nitrate to the wastewater, the microorganisms gradually transform from:

- sulfate-reducers - which produce the malodorous, toxic, and corrosive H_2S, to
- denitrifiers - which produce odor-free and noncorrosive nitrogen gas, N_2.

From an environmental perspective, the application of a chemical that minimizes odor while releasing nitrogen gas into the atmosphere (which already contains 80% N_2) is a very environmentally-friendly process. However, the conversion of the wastewater microbiology from sulfate-reduction to nitrate-reduction takes time, resulting in poor odor control performance for a certain distance downstream from the feed point.

The other technical problem with Bioxide™ is related to overfeed situations. During the hot summer months, the activity of wastewater microorganisms increases, resulting in more rapid production of H_2S. In order to counter this increased activity it is common to significantly increase the dose of Bioxide™ into each of the six collections system feed points. This may result in increased levels of nitrate being transported through the collection system to the WWTP. Unfortunately, elevated levels of nitrate entering into a municipal WWTP can cause excessive denitrification to occur within the primary clarifiers. The anoxic reduction of nitrate in a primary clarifier into nitrogen (N_2) gas, and the subsequent release of gas bubbles within the clarifier can cause the wastewater solids to float instead of settling, adversely affecting the efficiency of the primary solids separation process. Therefore, under the hot summer conditions when people most enjoy being outdoors, the use of Bioxide™ for odor control treatment has to be closely monitored, perhaps resulting in well performing clarifiers at the WWTP but insufficient odor control out in the collection system.

For these reasons, along with monthly receipt of the next chemical bill, and the continuous stream of chemical tanker trucks driving through the city streets to top off bulk chemical storage tanks, the county decided to research other odor and corrosion control options.

REVIEW OF ODOR TREATMENT PROCESSES

There are numerous chemical feed processes used for sewer line odor control. Some approaches attempt to kill the microorganisms in the line. This approach typically involves using “shock doses” of hazardous chemicals, like bleach or hydrogen peroxide. There is normally an immediate positive impact, but soon after the odor returns, showing that it’s practically impossible to kill them all. One of the biggest concerns with this approach is that it involves the transport and handling by field operators of extremely hazardous chemicals.

Another chemical approach is to raise the wastewater pH to a level where the majority of the H_2S present in the wastewater is held in solution as the hydrogen sulfide ion (HS^-). The limitation of this treatment approach is that it does not inhibit the bacteria from forming sulfides. H_2S is still being produced, but is gradually accumulating in the water-phase. When the treated wastewater having the elevated pH blends downstream into an untreated, lower pH wastewater line, the hydrogen sulfide ion will return to the H_2S form and escape to cause severe odor and corrosion at that point.

Another common treatment is the use of iron salts to precipitate out the sulfides being formed. This approach is highly effective, but involves the feeding of highly hazardous acidic chemicals, such as ferric chloride, which can depress the wastewater pH being transported to the WWTP. In addition, iron has coagulation properties that can greatly increase the loading of solids being transported within the sewer line.

Each of these approaches, including the Bioxide™ approach, attempt to address a symptom of the odor control problem. They each address in some way a method to either 1) attack or trick the anaerobic microorganisms, or 2) to perform a chemical reaction to reduce the presence of volatile hydrogen sulfide gas. In each case, these treatment approaches are responding to the activity of the anaerobic microorganisms present within the system.

While doing this odor control treatment review, the county became aware of a new intriguing option - a technology proposing to address the odor control problem from its root cause. Since the root cause of the problem is the very presence of anaerobic microbiological activity in the sewer line, the purpose of this new technology from Inland Environmental Resources (IER) was to completely convert the sewer line to an aerobic environment.

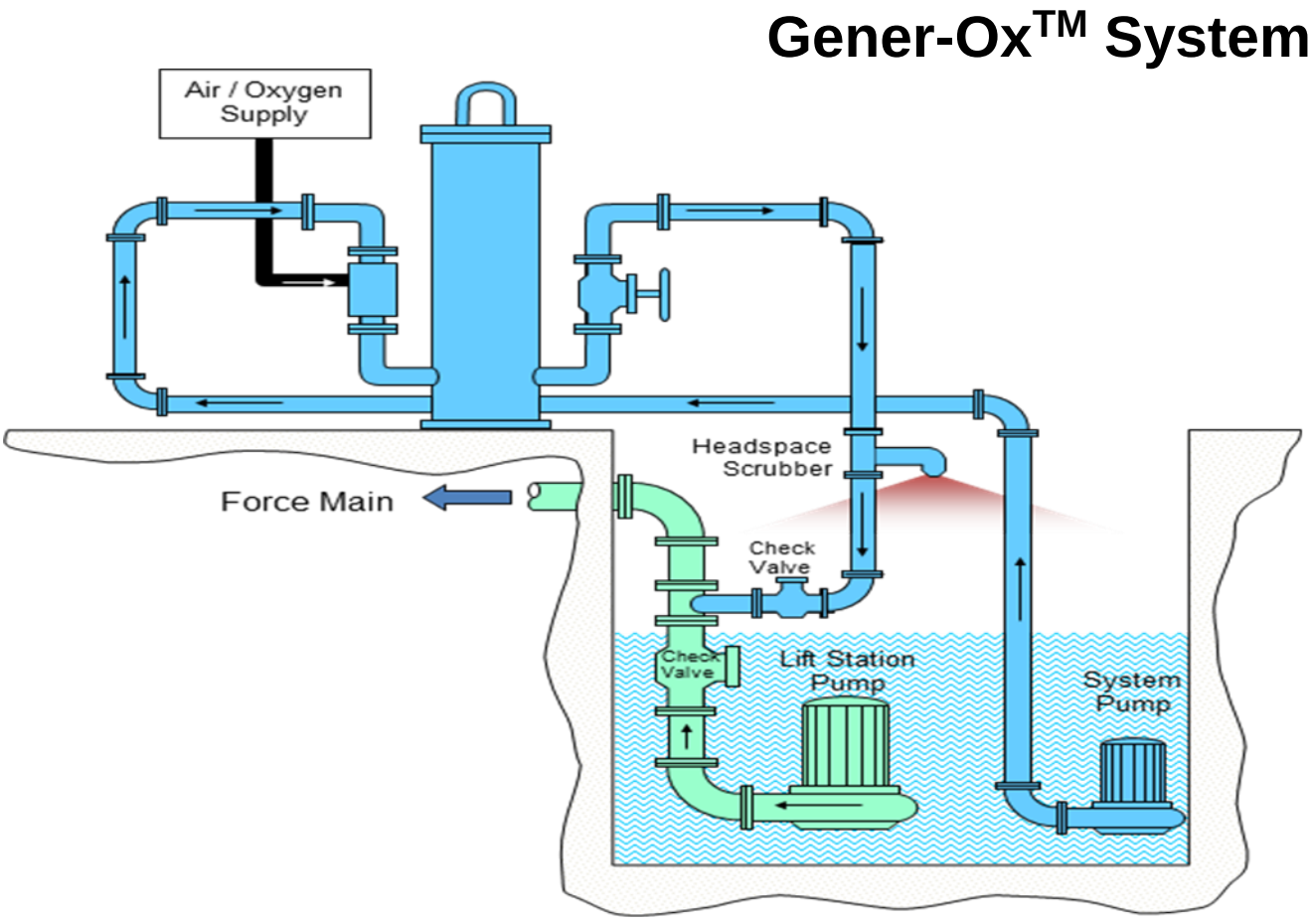
Simply put, IER’s Gener-Ox™ System was proposed as a chemical-free technology that separates and purifies gaseous oxygen from the air, drives it into a wastewater side-stream on-the-fly, and injects the concentrated dissolved oxygen (DO) wastewater stream into the sewer line to completely convert the bulk sewage in the line from an anaerobic to aerobic environment.

TRIAL APPLICATION

The initial test of the Gener-Ox™ System was performed on a 4.2 mile long section of sewer line to determine the ability to partially replace the excessive treatment costs associated with Bioxide™ at the Rodeo feed point. The sewer line to be treated traversed from the East Cliff Pump Station to another station called Summit, and then on to the city wastewater treatment facility, with segments under low pressure (~10 psi) and gravity flow, resulting in numerous odor complaints.

After obtaining DO uptake rates, wastewater flow rates based on time of day, and lift pump pressure parameters for the force main, a Gener-Ox™ System was designed. IER's Gener-Ox™ System utilizes a simple, proprietary method of converting the wastewater in the sewer line from an anaerobic to aerobic environment. The process involves passing a small percentage of the wastewater flow from a lift station through a macerating jockey pump, and introducing gaseous oxygen into this wastewater via injection ports.

The oxygen required for Gener-Ox™ is not supplied from an oxygen cylinder – that would be another chemical to purchase. Rather, oxygen is generated from air using an on-site oxygen concentration technology called Pressure Swing Adsorption. With PSA technology, specially designed resins in canisters bind the gaseous nitrogen from air, allowing for the delivery of 93% pure oxygen into the wastewater side-stream. The oxygen concentrator for this trial was designed to deliver up to 600 SCFH of oxygen gas, and delivering it as bubbles into a 450 GPM side stream flow of sewage drawn from the lift station's wet well. Once in the wastewater, the oxygen bubbles are driven into the dissolved form by passing through the Mass Transfer Saturator (MTS) tower. The MTS tower is designed in height and diameter for the desired flow rate of wastewater passing through and the desired pressure of the force main to be treated. After passing through the MTS tower, the side-stream containing the extremely concentrated DO was then re-introduced into the total sewage flow, resulting in concentrations of DO within the flowing force main in the range of 10-20 ppm under pressures of 5-10 psi.



No chemical feed is required, as the Gener-Ox™ System simply purifies oxygen from the air and drives it into solution on-the-fly to achieve very high DO concentrations with no bubbles. By ensuring the delivery of dissolved oxygen into the force main, the microorganisms within the wastewater are brought into contact with dissolved oxygen continuously. This is why earlier attempts to blow gaseous oxygen bubbles into force mains were not successful.

Using the inherent pressure of the force main, the injected high DO stream rapidly converts the microbial population from anaerobic to aerobic. In general, the higher the pressure of the lift station pump, the higher the concentration of DO that can be generated by the Gener-Ox™ System. Proper selection of a maceration pump is critical to control the size of the wastewater solids which will pass through the Gener-Ox™ System.

INITIAL TRIAL RESULTS

This trial-sized Gener-Ox™ System performed as designed to deliver a side-stream flow of approximately 7.5% that of the total force main flow. This Gener-Ox™ design represented about 1/3rd of the flow that would be recommended in order to treat the entire force main flow and completely replace the Bioxide feed at Rodeo. It was hoped that if Gener-Ox™ performs to expectations, that the Gener-Ox™ System could be expanded in the future to treat the entire flow and completely replace the nitrate chemical treatment.

During the first year of operation, the 3-times undersized Gener-Ox™ System was able to maintain H_2S at the WWTP head works sample point within control parameters (<1.2 mg/L H_2S) with a 35% reduction in the daily Bioxide™ feed rate. This represented a typical chemical feed reduction of 200-250 gpd. This reduced chemical usage rate, coupled with the minimal amount of energy costs associated with the Gener-Ox System, resulted in a **savings of $200,000-250,000 in annual Net Operating and Maintenance Costs.**

SUBSEQUENT TRIAL

A second Gener-Ox™ System was installed in the Fall of 2012 at Santa Cruz's Esplanade pump station adjacent to a prominent beachfront tourist area. Despite an average feed of about 250 gpd of Bioxide™ the odor control performance was not fully acceptable, with H_2S values typically > 2 mg/L. The wastewater flow rate at this lift station was 1.5 MGD, about five times lower than that at East Cliff. However, the exact same size of Gener-Ox™ System was installed to treat 450 gpm of side-stream flow. By treating a higher percentage of flow, the system capacity allowed for feed of a small side-stream of oxygenated water back into the Esplanade pump station wet well to aid in the suppression of H_2S at the pump station. The great majority of the oxygenated side-stream was then injected into the discharge side of the Esplanade lift pump to provide sufficient DO concentrations to reach the Soquel Lift Station about 5 miles downstream. The first 2 miles of the line was a force main under a pressure of about 60 psi. The last three miles were gravity flow to Soquel.

The following parameters were identified as criteria for success in order to determine effective performance in this application:

1) measurement of > 2 ppm DO and < 1 ppm H_2S at Soquel
2) reduction by 50% of the Bioxide™ feed upstream of the Esplanade lift station.

The Bioxide™ dosing point was located at the Dolphin lift station, about 1-2 miles of force main south (upstream) of Esplanade. Once the Gener-Ox™ installation was completed and commissioned, the key parameters were closely monitored, showing the following results:

1) typical values of > 2 ppm DO and undetectable levels of H_2S at Soquel
2) reduction in Bioxide™ usage to 100-110 gpd, resulting in a **further savings of about $100,000 per year.**

Even at the reduced Bioxide™ feed rate of 100-110 gpd, there was still a positive nitrate residual detected at the Park Avenue manhole monitoring point (near Esplanade), which suggests that the Bioxide™ feed rate could be reduced even further.

CONCLUSIONS

IER Gener-Ox™ Systems have been employed into two highly sensitive and critical municipal collections systems locations for the purpose of improving overall odor and corrosion control performance while significantly reducing chemical feed costs for the Santa Cruz County Sanitation District. An undersized Gener-Ox™ installation into an 8.5 MGD lift station provided 35% reduction in chemical use, as expected, and a properly sized Gener-Ox™ installation into a 1.5 MGD lift station resulted in a 50-60% reduction in chemical use. In both cases, the chemical being reduced was Bioxide™, a nitrate-based treatment. Discussions are currently underway to determine if the Gener-Ox™ application at the 8.5 MGD lift station can be expanded to treat a higher percentage of the flow, and if there are other potentially beneficial application points within the same collection system for Gener-Ox™ to further reduce chemical costs.

While the wastewater flow and force main parameters at a particular lift station may be a strong fit for a Gener-Ox™ System, care must also be taken to review the logistics and space available within the lift station for proper installation. Gener-Ox™ Systems are custom designed to meet specific site application requirements, and can be designed to treat flows ranging from 10 GPM up to 10,000 GPM, by packaging multiple MTS towers to treat higher capacity flows into the tens of millions of gallons per day.

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