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Manufacture and Design of an 180,000 CFM Odor Control Biotrickling Filter System

Author: M. D. Lessmueller*
Co-Author: C. Aviles* and B. Ngo*
Authorized by: T. Malki*

* Daniel Company Research Department, 1939 W. 11th Street Ste D, Upland, CA, USA
(E-mail: *markl@danielmechanical.com*; *caviles@danielmechanical.com*; *bngo@danielmechanical.com)*

Abstract
One of the largest biotrickling filter systems in the history of the United States, at Orange County Sanitation District's Waste Water Treatment Plant 2 Headworks Facility in Huntington Beach, California, will be starting up in the fall of 2010. This multi-stage system, manufactured by Daniel Company, designed by Carollo Engineers, and installed by J. F. Shea Construction will treat 180,000 CFM of air contaminated primarily by hydrogen sulfide. The system consists of 16 biotrickling vessels (each 10-feet diameter and approximately 42-feet tall) that provide a roughing stage for the odor control system (utilizing *Acidiothiobacillus* genus bacterium) and are estimated to reduce the chemical use of the polishing stage (8 chemical scrubbers of similar size) by 90 percent. Due to the massive scale of the project, Daniel Company had to overcome multiple engineering and manufacturing obstacles - including designing the scrubbers to withstand a full PSI of vacuum in seismically-challenging Southern California and to operate with only two seconds of empty bed retention time.

Keywords: Odor control, *Acidiothiobacillus*, Manufacturing, Waste water treatment, Daniel Company

BIOTRICKLING FILTER DESIGN

Background. All of the biotrickling filters employ the use of chemoautotrophic microorganisms, primarily of the *Acidiothiobacillus* genus. A well-designed biotrickling filter will create a hospitable environment for these pollutant-degrading bacteria. The genus tends to immobilize itself on biofilms within a porous media, and thrives in a humid, acidic environment. While the bacterium derives energy through oxidation of hydrogen sulfide into sulfuric acid, external nutrients are required for the bacterium to thrive (Cox and Deshusses, 2002).

OCSD System Design. This system's biotrickling filters utilize a suspended random packed porous media, and fed nutrients and water via the recirculation system. Because of the reactions, the biofilms create an acidic solution that forms a hospitable environment to the bacteria. The media and the vessel must be resistant to the corrosive effects of this acidic solution. Typical biotrickling filters operate at a gas contact time of 10 to 40 seconds, (Deshusses and Gabriel, 2003) while these roughing stage vessels are designed to remove 90 percent of the hydrogen sulfide within 2.2 seconds of contact time (ibid).

Research. Due to extensive research in biotrickling filters, the low contact time has been observed in small-scale testing at the Orange County plants under ideal conditions. This system attempts to mimic those conditions in every possible instance to create a large-scale representation of the tests at the Orange County plants (Deshusses *et al*., 2004), (Deshusses *et al*., 2004)

ODOR CONTROL SYSTEM DESIGN

Vessel Design. The biotrickling filters were made of filament wound corrosion-resistant fiberglass reinforced plastic (FRP) construction using the highest quality vinyl-ester resin. In order to meet the pace of the construction schedule, Daniel Company manufactured one vessel per week. Careful design and coordination was required to allow access to the vessels' access ports from the 50-foot by 280-foot platform structure that surrounds the train of vessels (see Fig 1.). In addition, the vessels were computer modeled to withstand a near PSI of vacuum, support the heavy media beds and withstand a Southern California earthquake.

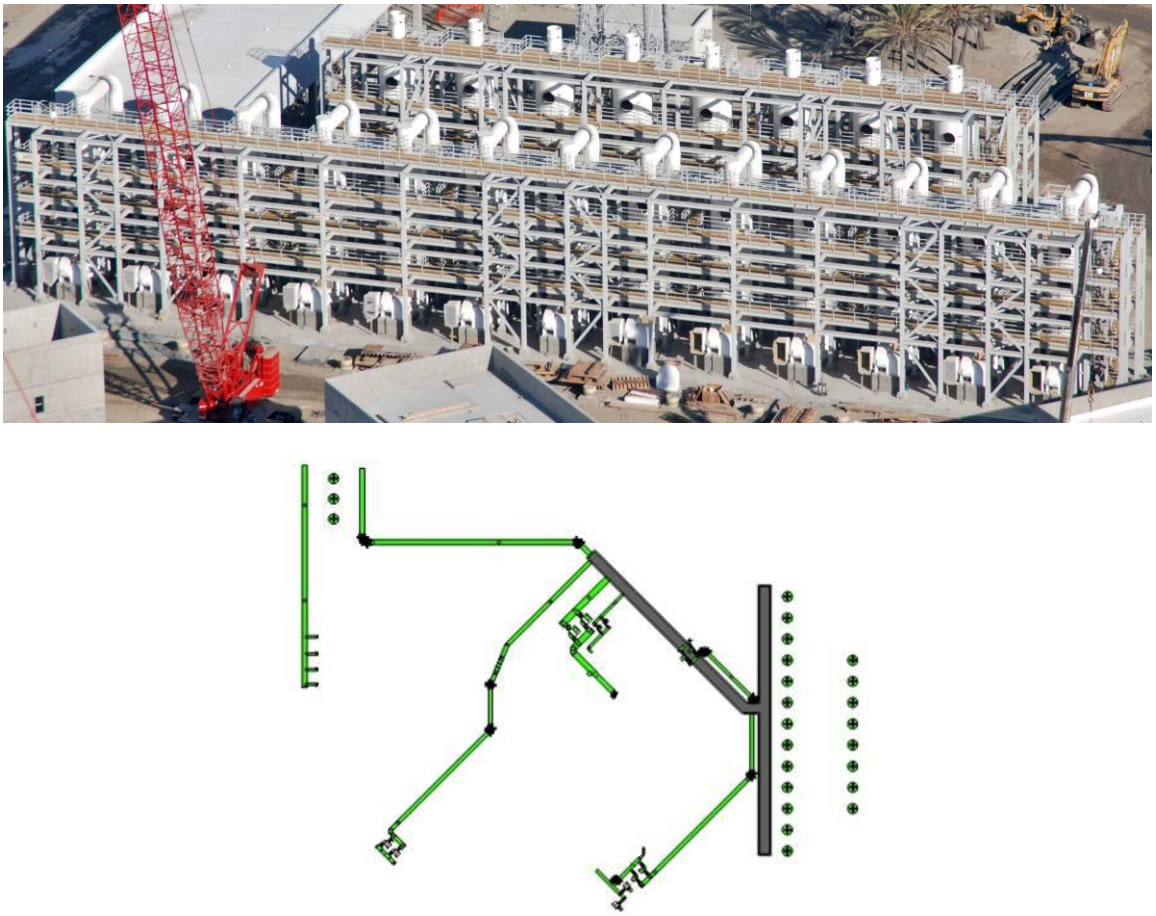

Figure 1. OCSD System in Construction (Top), Basic Layout of the OCSD System (Bottom). (Top) This image of the odor control facility during construction shows the individual blowers for each biotrickling filter, as well as the large access platform. Each level of the access platform allowed access to at least a single access port. (Bottom) The green lines depict ducting. The three circles in the left corner are the preliminary biotrickling filters that run at slightly slower than two seconds retention time. The gray plenum connects all the green lines and supplies the thirteen circles (biotrickling filters) on the right, which pass the foul air to the eight chemical scrubbers on the extreme right (also green circles)

Process Design. The biotrickling filters utilized a parting box and trough liquid distribution system, to reduce the pumps energy requirements and allow a clog-resistant system. The entire distribution system was built out of FRP to ensure a corrosion resistant design. The manufacturing process included a full-scale test of the FRP liquid distribution system (see Fig. 2) to ensure even distribution of the nutrients across the media bed. The liquid in the pump is collected via a stilling well and runs back to the recirculation pump train.

Figure 2. Photograph taken during the full-scale test of the liquid distribution system for a vessel on the OCSD 180,000 CFM odor control system. The test was done to ensure full coverage of the vessel bed below by liquid streams.

Accessibility Design. Additionally, the vessels required a unique bed limiter system due to the low-density biotrickling filter media and the high volume of air flowing through each vessel. Each bed limiter can be installed and removed from the access ports as a single unit, to allow complete access while limiting unnecessary media contamination (see Fig. 3).

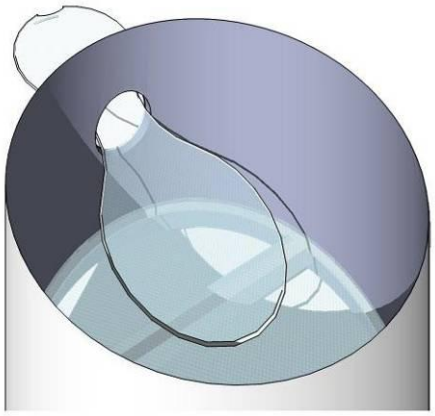

Figure 3. This image demonstrates the installation procedure for the innovative bed limiter used in the biotrickling filters at the OCSD Headworks facility. With this unique design, installation and removal does not require vessel entry.

Scale Design. One challenge in scaling up from the small scale tests was the weight of the biotrickling filter media. At full size, the now nine-foot media bed would crush the developing biofilms under its own weight. In order to prevent this problem, the media bed was split in half. Each half has its own unique support system, fully accessible from the access platform. Also, a single large buried plenum gathers all of the foul air, where a unique blower for every biotrickling filter distributes the air through the filters. For redundancy, up to three of the vessel trains can be turned offline for servicing. The biotrickling filter outlet gathers in a second large buried plenum and discharge to the chemical polishing stages. The vessels are currently installed and filled with media at OCSD Plant 2, ready for startup.

STATUS

System Status. Although it was a major manufacturing challenge, the vessels were built and were completed ahead of schedule. This includes the biotrickling filters, chemical scrubbers, chemical storage tanks, ductwork, zero leakage isolation dampers and accessories. System startup and testing is set to begin in the fall of 2010. Within the next year, Daniel Company expects to have performance data available to report on this massive biotrickling filter system.

REFERENCES

Cox, H.H.J., and M.A. Deshusses. 2002. The effect of starvation on the performance and the re-acclimation of biotrickling filters for air pollution control. *Environ. Sci. Technol.* 36: 3069-3073

Gabriel, D., and M.A. Deshusses. 2003. Performance of a full-scale biotrickling filter treating H2S at a gas contact time of 1.6-2.2 seconds. *Environ. Prog.* 22: 111-118

Gabriel, D., H.H.J. Cox, and M.A. Deshusses. 2004. Conversion of full-scale wet scrubbers to biotrickling filters for H2S control at POTWs *J. Environ. Eng.* ASCE 130(10): 1110-1117.

Gabriel, D., and M.A. Deshusses. 2004. Technical and economical analysis of the conversion of a full-scale scrubber to a biotrickling filter for odor control. *Wat. Sci. Technol*. 50(4):309-318