Lantec Products Case Study 53

Compact Scrubber for Biosolids Odors Saves $500,000

Two stages in one 12 ft (3.7 m) tower treat 68,500 cfm (116,400 m³/hr) using high-capacity packing

A new scrubber at a Camden, NJ biosolids processing facility uses advanced technology to cut the cost of odor control. The system was designed, built and installed by Bay Products with process design assistance from Lantec Products.

A single tower is used to remove malodorous gases from air in two stages having separate sumps for the recirculated scrubbing solutions. The lower stage absorbs ammonia using sulfuric acid to neutralize it. The air then passes up the tower into a second stage where hydrogen sulfide is neutralized with caustic soda and converted to harmless sulfate by a hypochlorite bleach solution. A mist eliminator and a sealed collector tray between stages prevent mixing of the two liquids, while allowing air to pass. Odor-free air exits the stack to atmosphere.

The space saving scrubber was started up in March 2006. Performance has been well within design criteria. Note in the photo that the tower fits well into the very limited space available at the plant.

System Operator Dan Rourke reports:
"The system is performing as designed by Bay Products. Never a problem — every time we measured outlet concentration the result was just about zero."

Compact Design Cuts Costs

The cost of a new scrubber was reduced dramatically by using a single-tower configuration with Q-PAC® packing from Lantec Products. The high flow capacity of this packing allows air to be treated at a superficial velocity of 606 fpm (3.08 mps) — roughly twice as fast in many old scrubbers using lower-capacity packings. For example, the Water Environment Federation's Manual of Practice 25 describes a conventional odor-control scrubber sized for a superficial velocity of 350 fpm (1.78 mps). If the Camden facility's scrubber had been sized using that historic technology, it would have been 16 ft (4.9 m) in diameter and even taller.

Modern tower packing allowed designers to downsize the scrubber without sacrificing performance, at a cost less than one third that of competing bids for the project. Savings to the city of Camden exceeded $500,000.

Design Basis		
Air Flow	68,500 cfm	116,400 m³/h
Maximum Temperature	80°F	27°C
Maximum NH_3 Content	50 ppm$_v$	38 mg/Nm³
Maximum H_2S Content	10 ppm$_v$	15 mg/Nm³
Tower Diameter	12 ft	3658 mm
Superficial Gas Velocity	606 fpm	3.1 m/s
Stage 1	**for 99% removal of NH_3**	
Scrubbing Solution	Water with H_2SO_4 added	
Sump pH	~3.0	
Recirculated Liquid Flow	1,000 gpm	227 m³/h
Packing Height	5 ft	1524 mm
Packing Type	Q-PAC® from Lantec Products	
Packing Pressure Drop	1.2 in.WC	3.0 mbar
Stage 2	**for 99% removal of H_2S**	
Scrubbing Solution	Water with NaOH and NaOCl added	
Sump pH	~9.5, +600 mV	
Recirculated Liquid Flow	1,000 gpm	227 m³/h
Packing Height	7 ft	2134 mm
Packing Type	Q-PAC® from Lantec Products	
Packing Pressure Drop	1.7 in.WC	4.2 mbar

How It Works

In a scrubber, ammonia and hydrogen sulfide are converted to odorless byproducts by the chemical reactions:

[1] $2\,NH_3 + H_2SO_4 \longleftrightarrow (NH_4)_2SO_4$

[2] $H_2S + NaOH \longleftrightarrow NaHS + H_2O$

[3] $NaHS + 4\,NaOCl + NaOH \longrightarrow Na_2SO_4 + 4\,NaCl + H_2O$

Reaction [2] serves to hold absorbed H_2S in the water, where higher sulfide concentrations increase the rate of reaction [3]. Ammonia and H_2S can be absorbed with 99% efficiency in a fraction of a second because steps [1] and [2] are extremely rapid acid-base reactions. How fast a base can neutralize an acid is just a matter of how quickly they can be mixed; as soon as they come in contact, they're gone! But when the base (NaOH) is dissolved in water and the acid (H_2S) is dispersed in a large volume of air, mixing them quickly without expending much energy is easier said than done. That's where tower packing technology comes in.

Older packing types such as saddles or Pall Rings work mainly by spreading the liquid over an extended plastic surface to promote contact between the liquid with the passing air. Rings or saddles with more surface area create additional liquid surface, but more plastic surface also means more obstacles to air flow. Note that this model is very much based upon a two dimensional concept. A thin film of liquid spread over a packing surface only has its upper surface – the surface exposed to the passing gas – available to support mass transfer from liquid to gas phase. The surface of the liquid that faces the surface of the packing does not participate in mass transfer to the passing gas phase. A major consequence of this outmoded design model is to require the sizing of conventional scrubbers to low gas velocities, both to achieve the required scrubbing efficiency as well as to avoid excessive pressure drop and fan power costs.

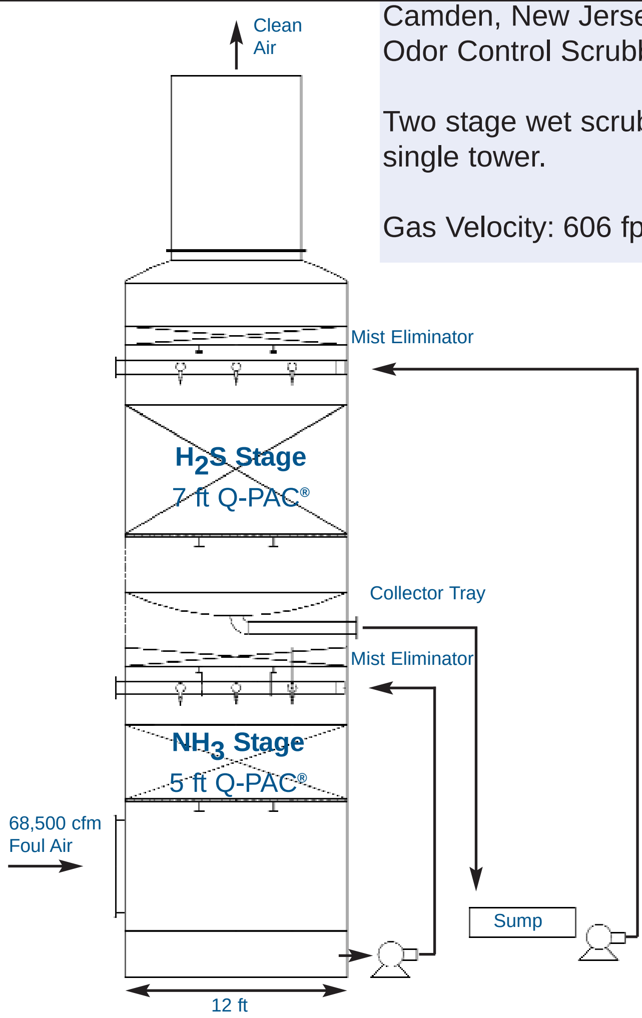
Q-PAC® works differently. The flow – through structure of thin grids and rods provides "drip points" that break a stream of water into a torrential rain of tiny droplets, whose total surface area far exceeds that of the dry plastic. With no broad surfaces to block it, air can flow through Q-PAC® at high velocities with little resistance. Turbulent gas flow helps to break the liquid into even smaller droplets with more surface per unit volume. It's the liquid — not the plastic — that absorbs contaminants so the liquid surface area is what counts. Note in the photo of Q-PAC® that the droplets fill three dimensional space, with each droplet presenting its entire surface area to the passing gas phase. Therefore much more efficient mass transfer from liquid to gas phase is supported by QPAC® versus 'traditional' tower packings.

The Q-PAC® concept of mass transfer tower design is much more closely aligned with what exists in nature. As an example, a day of heavy rain is both a curse and a blessing in Los Angeles, California. A curse – because everyone misses a day of southern California sunshine. But the rainstorm is also a blessing as well, as the rain scrubs the dirty air over greater Los Angeles. So much so that the two or three days immediately following the day of heavy rain are commonly days of excellent air quality in Los Angeles. This is because during the day of rain the many droplets that fall scrub the air above Los Angeles very efficiently – because nature bypasses the "thin film" design concept completely.

Camden, New Jersey WWTP
Odor Control Scrubber

Two stage wet scrubbing in a single tower.

Gas Velocity: 606 fpm (3.1 mps)



Q-PAC® Advanced Tower Packing
US Patent #5,458,817
Worldwide patents pending

Biological vs. Chemical Odor Control

Bay Products also provides biological odor control equipment, so this option was considered for the Camden project, as well. Biological scrubbers or “biotrickling filters” cultivate naturally occurring bacteria that utilize H_2S as food. The microbes use oxygen in the air to convert H_2S to odorless sulfuric acid and also consume carbon dioxide, CO_2, or carbonate ion in solution to form organic cell structure so there is no need for caustic or hypochlorite to destroy H_2S as in a traditional chemical scrubber. Several species of this type of autotropic bacteria are known to exist in nature. One example is Thiobacillus thiooxidans. This species is always of particular interest in biological odor control systems as it is known to tolerate the extremely acidic condition that sets up at steady state in a properly designed and operated system due to the formation of acid as the result of the respiration of the organisms.

However, biochemical oxidation is a slow process, so biological scrubbers must be sized to much lower air velocities versus chemical scrubbers to allow enough residence time for microbes to consume nearly all the H_2S. Biological odor control is less effective when the air is cold or if H_2S levels are sometimes so low that the microbes starve, and it doesn’t work as well for organic sulfur compounds (for example, methyl mercaptan) as for H_2S. The byproduct sulfuric acid can also neutralize ammonia efficiently, but only when the foul air contains more H_2S than NH_3.

In general, biological odor control is advantageous when:
- H_2S concentrations in air are consistently high
- The volume of air is small to moderate
- The odor is due almost entirely to H_2S

Under these conditions, the higher installed cost of a large biological scrubber will soon be repaid by the savings in operating cost of chemicals.

Conversely, chemical scrubbers are preferred when

- Large air flows have to be treated
- Concentrations of smelly gases are low
- Much of the odor is due to organic sulfur compounds or ammonia

Under these conditions a chemical scrubber can be far more compact, yet its consumption of neutralizing chemicals is not excessive. Treatment efficiency is not impaired if the system is occasionally shut down or H_2S levels become very low. Odors caused mainly by ammonia, or by mercaptans and dimethyl sulfide, can also be removed efficiently.

At the Camden biosolids facility, the large air flow to be treated, the low odorant concentrations, and the predominance of NH_3 made chemical scrubbing the best choice, and experience has proved it.

*__Bay Products, Inc.__, P.O. Box 4859, Stateline, NV 89449
(800) 429-0150, www.bayprod.com, martin.crawford@bayprod.com