142

Close

"Bugs" Used to Treat FGD Wastewater

Tough regulation of heavy metals may justify a bioreactor approach in addition to chemical treatment of FGD wastewater.

By Steve Blankinship, Associate Editor

Treatment for the wastewater produced by power plant flue gas desulphurization (FGD) systems (also known as scrubbers) is essential because scrubbers generate substantial amounts of effluent that must be retained and treated before it can be released to streams, lakes or rivers. Selenium is one pollutant that is collected in scrubbers. And because selenium is both in the scrubber wastewater as well as having restrictive water quality standards, it has to be treated prior to discharge to protect waterways.

A new approach has been successfully implemented at four North Carolina power plants that use a biological reactor tem to increase selenium removal to levels not achievable by existing scrubber wastewater systems. Duke Energy and Progress Energy cooperated with each other in helping test the system and integrate the technology to meet North Carolina environmental standards.

Allen Sation wastewater treatment system. Photo courtesy Duke Energy.

Click here to enlarge image

To date, the new biological reactor systems have been installed on two Duke Energy coal-fired plants: Belews Creek and Allen. Duke's Cliffside Unit 5 will receive a new FGD WWTS in 2010. Progress Energy, also based in North

Carolina, has installed the new WWTS on its largest coal generating unit—the four-unit, 2,443 MW Roxboro Station—and the single-unit Mayo Station.

Duke Energy reached an agreement to add scrubbers as part of North Carolina's Clean Smokestacks Act, said Greg Augspurger, technical manager at Duke Energy's Allen plant. The law requires power companies in the state to reduce smog and haze-forming emissions by about 75 percent over 10 years. The agreement calls for retrofitting wet flue gas desulphurization on 12 of the company's largest units by 2010. Duke is required to cap in its NC stations to no more than 150,000 tons/year by 2009 and 80,000 tons/year by 2013, said Augspurger.

Duke came up with standardized sizes for each major FGD system in compliance with the Clean Air Program of 2002. The systems were designed by Alstom. The design philosophy matches the absorber, reagent preparation and dewatering systems to the size of the units and the station as whole. Belews Creek station has multiple absorbers per unit while Marshall and Allen have multiple units per absorber. For the WWTS, each station will have a single system; some redundancy and backup capability is available.

Progress Energy contracted with Babcock & Wilcox to provide its wet flue gas desulphurization (WFGD) technology to achieve better than 97 percent SO_2 removal. At full design capacity, the WFGD scrubbers are expected to produce 1,400 gallons a minute of blowdown flow at the Roxboro Station.

The ash basin discharge at Duke's Belews Creek plant initially had restrictive selenium limits of 26 parts per billion, said Robert Wylie, senior environmental specialist with Duke Energy. One problem was the lack of a technology capable of achieving those limits. We partnered with Progress Energy and the bioreactor technology was discovered. Duke Energy and Progress Energy teamed up and did pilot testing with the technology's supplier, GE with their ABMet technology, and saw that it was sound."

Chemical treatment would not do, said Wylie, because Belews had to get 99 percent selenium removal. "We talked a lot of vendors and no one could commit to achieving that standard," Wylie said. Progress Energy expressed a lot of confidence in GE's ABMet treatment system.

Tim Pickett, senior product manager for GE and inventor of ABMet, said the system can achieve high levels of selenium removal in a short time, so it can accommodate the high blowdown flowrates of an FGD system. "Selenium removal is achieved in a matter of hours, generating minimal sludge," he said. ABMet removes nitrate and selenium in a single-step process. By eliminating the need for additional treatment equipment it can reduce capital and operational costs for sites that are regulated for both pollutants.

Pickett said ABMet's scalability enables it to fit the needs of most sites. Its modular trains can be multiplied to achieve any flow rate. The largest full-scale ABMet system currently treats about 1,400 gpm, but can easily be expanded to treat higher flows.

"FGD wastewater is an oxidizing environment and can contain high levels of selenate," Pickett said. "ABMet can achieve the same high level of selenate removal as selenite: 99 percent."

The new bioreactor wastewater treatment system at Allen Station.
Click here to enlarge image

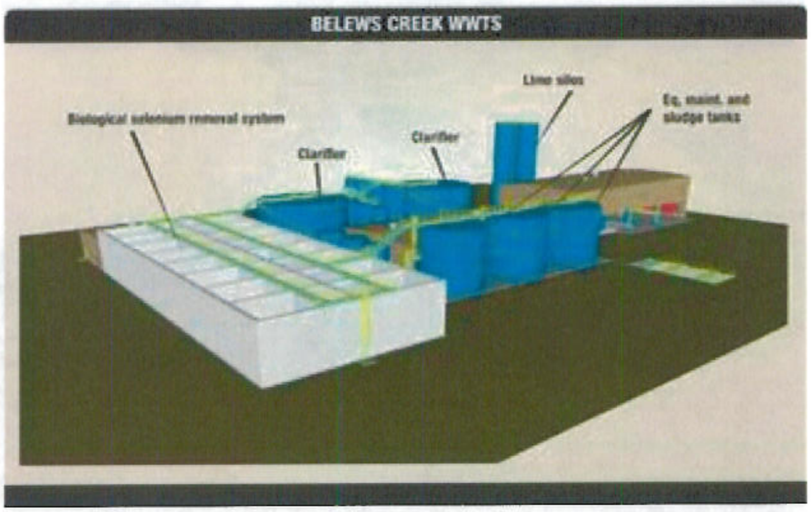
The Allen plant has a five-acre plot specifically dedicated to wastewater treatment, said Bill Kennedy, project consulting engineer for Duke Energy. The physical footprint of the equipment takes up about half of those five acres.

A consortium of Siemens Water Technologies and Crowder Construction Co. was selected to provide the FGD WWTS on all the stations completed after Marshall. Siemens Water Engineering also served as the engineering, procurement and construction contractor. GE Water Process and Technologies supplied its ABMet biological system selenium reduction. GE Water Process and Technologies/ABMet provided the microorganisms, activated carbon for the microbes to attach to and grow on, nutrient or "food" source for the organisms and specifications for the biological system. The construction consortium provided the process and mechanical design for the biological system and built the concrete biological reactors.

Typical FGD Wastewater Treatment

In a typical FGD wastewater treatment system, water is pumped to a reaction tank where alkali is added (usually hydrated lime) for pH adjustment and gypsum desupersaturation of the wastewater. Recycling seed sludge from the downstream clarifier provides nucleating sites for crystal growth and aids in the desupersaturation process, important in preventing or reducing scale from forming on downstream equipment. Adding an alkali also causes precipitation of abundant metals (such as aluminum, iron and manganese) as metal hydroxides.

Some heavy metals will also precipitate as hydroxides in this reaction step, but metal sulfides have much lower solubility. Thus, to meet the low effluent requirements for heavy metals, organic sulfides are dosed into the stream in a second reaction tank to further precipitate many of the heavy metals as metal sulfide. Heavy metals are actually a subset of elements that exhibit metallic properties, including transition metals, metalloids, lanthanides and actinides.



Belews Creek WWTS

Click here to enlarge image

The Marshall FGD units were brought on line between October 2006 and May 2007 and new wastewater system (wetlands, rather than a bio-reactor) started in December 2006. Although it experienced some expected startup challenges, the Marshall staff reports the system is providing excellent results. They note that suspended solids in the FGD purge to the WWSRS were lower than expected and removal in this system was higher than expected. The design basis was for total suspended solids (TSS) at 16,000 ppm in the feed and 1,000 ppm in the effluent of the WWSRS. Actual values have been about 6,000 ppm in the feed and less than 50 ppm in the WWSRS effluent. This could be attributed to a difference of operation in the FGD absorber resulting in lower TSS as well as more efficient solids removal than forecasted for the two stage hydrocyclone system in the gypsum dewatering process.

Expectation are that the hydrocyclones will wear over time and the TSS likely will increase somewhat. As a result, a capability (in the sludge tank and filter presses) to handle higher TSS levels at that time will be appreciated. The lower TSS level in the WWSRS effluent is attributed to higher efficiency of the clarifier and polymer flocculating effect than had been expected. The net effect of lower solids coming to the WWSRS is that the filter presses operate at fewer cycles per day and less solids cake is produced for disposal.

While the specific FGD wastewater treatment system must meet current wastewater composition and discharge requirements, it must also have some flexibility for meeting future requirements – either as designed and constructed or with modifications. A basic building block in the WWTS has been an integrated physical chemical treatment system, as shown in Figure 1. This assumes the FGD purge originates from the hydroclones of the gypsum dewatering system. From a two-stage hydroclone system, the stream will contain about 0.5 – 2 percent suspended solids (primarily gypsum and some fines of un-reacted or inert materials) and be directed to an equalization tank, which provides a means to even out the purge's flow and chemistry.

A positive impact in the WWSRS was the higher reduction of mercury and selenium in the clarification stage than had been expected. This is explained by more of the mercury (Hg) and selenium (Se) being in a suspended form than was expected in the design. This enabled it to be reduced by clarification. The net effect is that less load is placed on the constructed wetlands allowing them to function as a polishing process. Based on initial data, the WWSRS removes 74 percent of total Se and greater than 98 percent of total Hg.

Bioreactor Pilot Plant

From May through December 2007, Duke's Marshall plant was the site of a pilot test of the fixed film biological treatment system to be used to remove selenium and other metals at Belews Creek and Allen. An opportunity to test the technology on actual FGD purge waters would provide valuable operating experience for startup of the Belews Creek WWTS and provide potential design improvements for the Allen WWTS, still under construction.

Among the results of the pilot study:

- Selenium removal below 100 ppb (the performance guarantee for Belews Creek and Allen) was achieved for the entire test period.
- Selenium speciation had no impact on bioreactor performance, including organic forms and dissolved selenate
- Effective selenium removal was achieved during significant changes in influent water characteristics.
- Use of DBA in the FGD scrubber reduced the amount of nutrient addition required and had no negative effects on selenium removal efficiency.
- Station upsets and shutdowns had no significant impacts on performance.

Siemens was the system integrator for Belews Creek and Allen. The two-unit Belews Creek station in Stokes County, N.C. has made significant improvements to reduce emissions from Duke's coal-fired plants. Both Belews units have been equipped with SCR to reduce nitrogen oxide emissions. The Belews plant has more stringent discharge targets than Marshall, particularly for Se and Hg. After evaluating a number of treatments methods, the decision was made to proceed with a combination of physical chemical treatment combined with bioreactor system. Since the biological system was unproven in commercial operation treating flue gas desulphurization wastewater, it was decided to also have a constructed wetlands treatment system following the biological system to act as a polishing step for final heavy metals reduction, if necessary.

Allen has to meet stringent selenium discharge targets as well; therefore the wastewater system is similar to the one at Belews Creek, except at a 35 percent lower flowrate. Based on successful pilot test performance of the biological treatment system, the Allen system does not have a constructed wetlands treatment system following the selenium-reducing biological treatment system.

"The anaerobic environment created in this bioreactor allows bacteria to go after the various oxidized forms of selenium, the selenites and selenates," said Duke Energy's Kennedy. An advantage with the system is that selenate is a difficult form of selenium to precipitate and that's where chemical treatment traditionally has been marginal. By biologically treating the material, the selenate can be reduced first to selenite and further to elemental selenium, Kennedy said. The bacteria actually generate what is called selenium nanospheres, or amorphous selenium nanospheres, which "appropriately looks very much like Carolina red clay."

The carbon in the bioreactors is activated carbon, similar to what is used in other industries. The carbon is nothing more than a medium on which the bacteria can attach themselves and grow. The system is a six-bed reactor where the bacteria colonize the activated carbon and attach themselves. It differs from a suspended growth reactor commonly used in municipal water treatment plants and in which bacteria are washed out of the system.

"These bacteria actually have a structure to which they can attach themselves," said Kennedy, "which allows them to respond to upsets. If something changes in the system, they're actually protected down inside the carbon structure and the bacteria will not be washed out even in extreme conditions."

Kennedy said that the system is effective for anyone who has issues with selenium or any number of heavy metals such as arsenic or nickel, at reducing these metals and precipitating them out of the water. It's also effective for denitrification, so a number of companies around the Chesapeake Bay (that have nitrogen restrictions into the receiving waters have expressed an interest in the technology.

More Power Engineerimg Issue Articles

To access this Article, go to:
http://www.powergenworldwide.com/powergenportal/en-us/index/display/generic-article-tools-template.articles.power-engineering.volume-113.issue-9.features.ldquobugsrdquo-used-to-treat-fgd-wastewater.html