ENVIROGEN TECHNOLOGIES

A Lifecycle Performance Company

Denitrification for Flue Gas Desulfurization (FGD) Scrubber Wastewater

Looking to improve FGD treatment reliability? *Envirogen has a drop-in solution with small footprint and low cost to reduce nitrate and improve the effectiveness of downstream selenium treatment. Envirogen's Fluidized Bed Reactor (FBR) is the most reliable treatment for nitrate on the market today.*

THE ENVIROGEN SOLUTION

The USEPA's Best Available Technology Economically Achievable (BAT) for meeting Effluent Limitations Guidelines (ELGs) for flue gas desulfurization (FGD) scrubber wastewater is chemical precipitation to remove metals followed by biological treatment to remove nitrate and selenium. However, some biological treatment options may plug or channel at higher nitrate loads, causing reduced selenium treatment efficiency. Envirogen's biological Fluidized Bed Reactor (FBR) can be inserted into existing chemical precipitation processes to reduce the nitrate load on the downstream biological system, thereby improving selenium compliance. Removing nitrate up-front can also reduce the size and cost of downstream biological treatment. Overall FBR system packages include pumps, piping, valves and instruments pre-assembled on skids to minimize installation costs. Control panels include PLC or DCS based controllers designed to be connected to centralized control and data-logging systems.

UNMATCHED FOR DENITRIFICATION

Envirogen's FBR is unmatched for treatment of high concentrations of nitrate, which can be problematic for static bed biological systems. Complete disengagement of nitrogen gas occurs due to full media fluidization, so the FBR remains effective and efficient even when treating elevated nitrate-N concentrations up to 250 mg/l.

IDEAL FOR PEAKING PLANTS

The recent trend of cycling coal plants from high to low output based on demand will have an impact on blowdown nitrate concentrations. Flue gas temperatures cycle from high to low when electricity output is reduced. Since selective catalytic reduction (SCR) efficiency is lower at reduced temperatures, there will be periods when NOx is higher entering the FGD scrubber. FGD wastewater containing a steady nitrate-N concentration of 15 mg/l during base-load operation may have concentrations as high as 50-60 mg/l after transitioning to low-load operation. This level is not a problem for the FBR. In addition, Envirogen FBRs can be idled in full recycle to keep microbes alive and well when the feed is stopped. A low dose of nitrate solution is provided to keep the microbes active until the feed flow resumes.

INTEGRATION INTO CHEMICAL PRECIPITATION

Envirogen can deliver an FBR system integrated into your new or existing chemical precipitation process to reduce nitrate levels and improve the effectiveness of downstream selenium treatment. The system can be installed after either the primary clarifiers as shown in Figure 1 or after the final clarifiers based on the type of chemical precipitation process and the overall vessel layout. Our FBR can reduce high concentrations of nitrate-N to below 3 mg/l or any desired level.

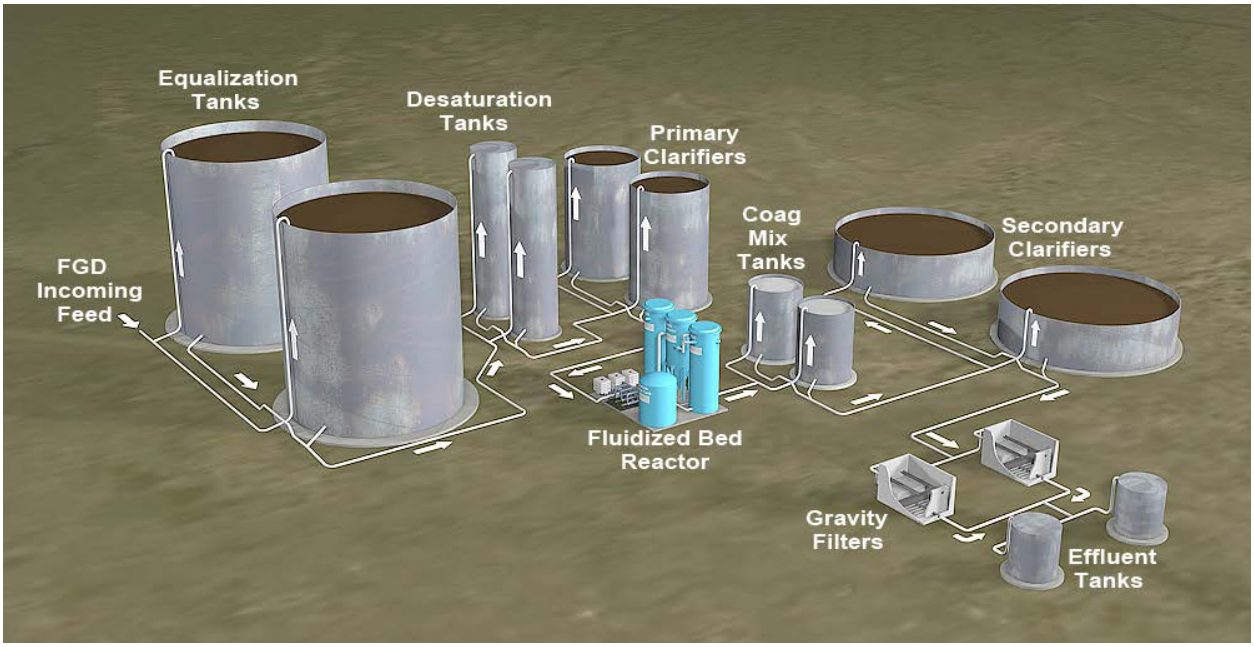

FIGURE 1 – ENVIROGEN FBR SYSTEM, INSERTED IN EXISTING CHEMICAL PRECIPITATION PROCESS, CAN REDUCE HIGH CONCENTRATIONS OF NITRATE-N - EVEN UP TO 250 MG/L - TO BELOW 3 MG/L OR ANY DESIRED LEVEL.

No problem, even if:

- ***Your waste stream has solids*** – Envirogen FBRs can handle solids in the wastewater because the media is fluidized.
- ***The incoming pH is not optimal*** – The pH of the recycle stream is automatically controlled when the FBR is treating water or when idled in full recycle to allow for maximum operational flexibility independent of up-stream conditions.
- ***You have space constraints*** – Prefabricated FBR vessels from 2- to 14-feet in diameter and up to 32 feet in height are available, offering very deep beds in comparison to conventional biologically active sand filter designs. This vertical orientation is one of the factors that contributes to the FBR's smaller footprint. A typical FBR system to reduce the nitrate-N in 600 gpm of FGD wastewater by 40 mg/l would have a footprint of 30 ft x 25 ft (750 sq. ft). This is 25-35% less footprint compared to competing biologically active sand filters using non-methanol electron donors.
- ***You have budget constraints*** – No need to design an entire new system. Just add the Envirogen FBR system for denitrification. Our retrofit packages can be adapted to any plant, so we just need to size for your needs, minimizing engineering costs.
- ***You do not have an existing system to address nitrate or selenium*** – Envirogen can provide a complete solution for both constituents and assure compliance. In this case, Envirogen's multi-stage FBR package for both nitrate and selenium can do it all after the chemical precipitation process whether nitrate concentrations are low, moderate or high.

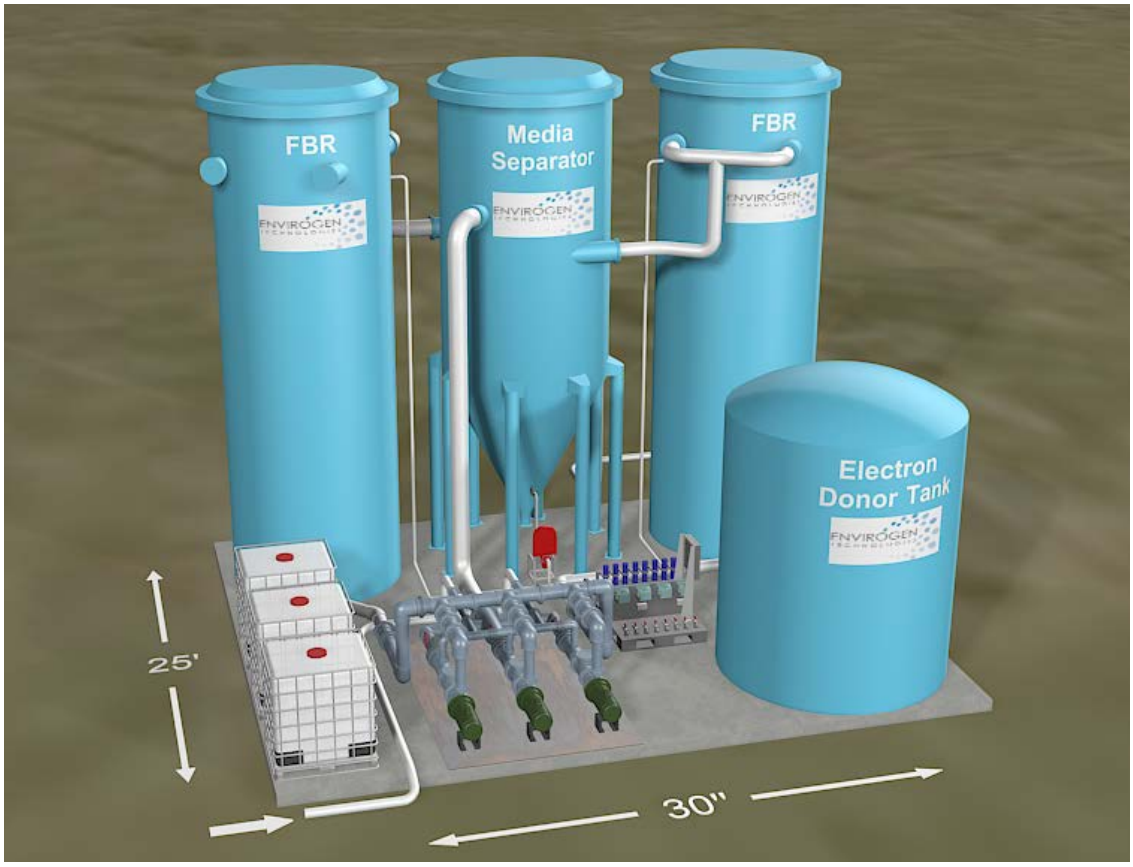

FIGURE 2 – EXPANDED VIEW OF FBR SYSTEM TO REMOVE 40 MG/L OF NITRATE-N IN 600 GPM OF FGD WASTEWATER. INCLUDES CHEMICAL FEED SKID, FLUIDIZATION PUMP SKID WITH SWING-SPARE, AND ELECTRON DONOR TANK. HEAT EXCHANGERS FOR COOLING CAN BE ADDED FOR WASTEWATER TEMPERATURES ABOVE 100°F.

ENVIROGEN'S FBR TECHNOLOGY

The Fluidized Bed Reactor (Figure 3) is an active, fixed-film bioreactor that fosters the growth of microorganisms on a fluidized bed of fine granular media. By fluidizing the bed, the full media surface area is available for microbiological growth as a thin film, reducing mass transfer limitations, eliminating bed channeling and offering high volumetric efficiency. Microbes are fed nutrient, and with the addition of an organic food source to the system (i.e., an "Electron Donor" such as glycerin or acetic acid), nitrate is reduced to nitrogen gas. Treated water flows by gravity from the top of the FBR to the next unit operation. Biological solids are discharged with the effluent and are removed by downstream filters and/or clarifiers.

The recycle flow reduces the incoming nitrate-N safely below the solubility limit of the nitrogen gas formed, which is a distinct advantage compared to fixed bed biological systems. Nitrogen gas bubbles form as the water flows upward through the vessel and disengage at the liquid surface. For high-load denitrification applications, the bubbles can

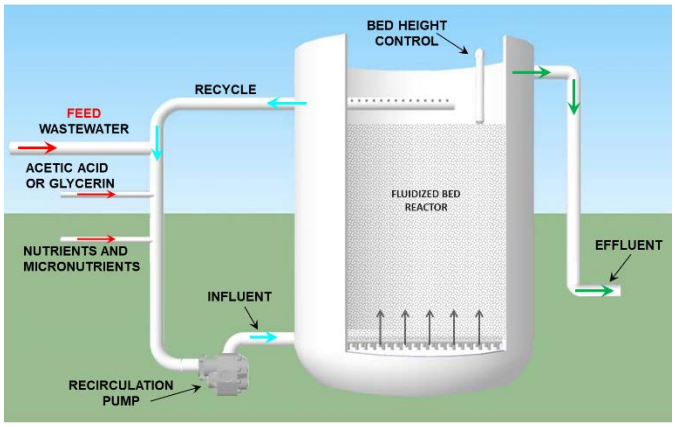

FIGURE 3 – HOW THE FLUIDIZED BED REACTOR FUNCTIONS

carry a small amount of media into the recycle collection header and over the effluent weir. To prevent this, Envirogen passes the recycle flow through a Media Separator where the media is collected and returned to the FBR.

WHY THE ENVIROGEN SOLUTION

- ***High Reaction Rates*** in a compact design due to tall reactors and steady-state operation.
- ***Complete Disengagement of N_2 Gas*** due to media fluidization, so no plugging, channeling or "burping", even at high nitrate loads.
- ***Superior Off-line Readiness*** via nitrate solution addition to the recycle when FGD scrubbers are idled.
- ***Lower Installation Costs*** by pre-assembling equipment and instrumentation on skids. Our FBR tanks vary in number and size to suit specific site requirements and wastewater characteristics. By combining the installation benefits of pre-assembly with the economies of scale from site-specific customization, we are able to lower total installed costs.
- ***Expert Support Service*** during startup and operation tailored to each client's preferences.
- ***Guarantees*** for both mechanical integrity and system performance.
- ***Long-term Service Contracts*** to extend asset and performance guarantees over the life of the system. Our service organization is currently involved in service contracts that extend anywhere from 2 to 10 years, all covered by performance guarantees.
- ***Collaborative and Flexible Team Approach*** on all projects, working directly for, and with, utilities, contractors and EPCM firms as needed. Each project has unique aspects, and we have a demonstrated ability to work well as part of a team that focuses on safety and compliance.
- ***Complete FBR Solutions Available*** to remove both nitrate and selenium for plants without an existing FGD system or for plants with only chemical precipitation.

For a more detailed discussion of Envirogen's experience in nitrate removal, and in FGD wastewater specifically, contact Paul Togna at ptogna@envirogen.com or by phone at 713-212-1944 (office) or 609-306-2388 (mobile).

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