

Flue Gas Desulfurization Fact Sheet

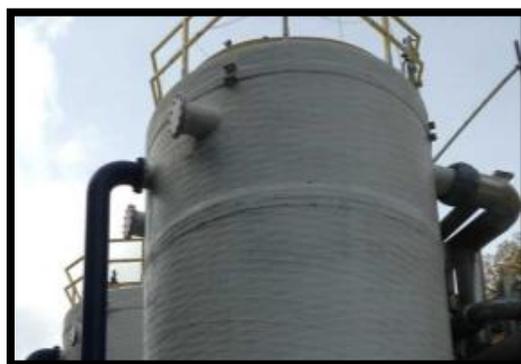
Final Revision of EPA’s ELGs

On August 31, 2020, the U.S. EPA Administrator signed the final rule revising the 2015 Effluent Limitations Guidelines and Standards (ELGs) affecting wastewater management from steam electric power plant flue gas desulfurization (FGD) scrubbers. The net results are that arsenic and selenium limits got relaxed; mercury and nitrate/nitrite-N limits got more stringent; and the compliance window got pushed back 2 years to December 31, 2025.

In addition, a number of plants that have either low utilization boilers, high FGD wastewater flow, planned retirement or will be converting fuel sources away from coal will be allowed to comply with less stringent limits. Many plants will choose the EPA’s Best Available Technology Economically Achievable (BAT), advanced biological treatment, for treating selenium, while others may opt for membrane processes.

Envirogen Solution and Experience

Envirogen has established the industry standard for selenium removal using advanced biological treatment with the Fluidized Bed Reactor (FBR). With many full-scale installations for treating selenium in mining operations, as well as piloting success in FGD wastewater, Envirogen’s proprietary FBR is a proven technology that will work in your installation. We back our systems with performance guarantees* to remove the risk of noncompliance.



Application	Constituent	Feed Concentration	Effluent Concentration
Multiple – Mining and Refining	Dissolved Selenium	50 to 250 µg/L Se	< 20 µg/L maximum filtered Se
Appalachian Coal Mine	Dissolved Selenium	20 µg/L Se	< 4.7 µg/L maximum filtered Se
Power Plant Flue Gas Desulfurization Wastewater	Dissolved Selenium	50 to 300 µg/L Se	< 29 µg/L maximum filtered Se

In total, Envirogen has completed over 80 FBR projects including 33 FBR projects with high performance reduction of oxyanions (selenate, selenite, nitrate/nitrite, chromate, perchlorate, other), with some systems hitting 5 µg/L targets consistently for over 10 years. For selenium specifically, 14 pilot studies are

*For systems operated by Envirogen

now completed in mining, refining and power industries, proving for all three industries that this technology is capable of meeting the latest industry standards.

FBR Technology

The Fluidized Bed Reactor (Figure 1) is an active, fixed-film bioreactor that fosters the growth of microorganisms on a fluidized bed of fine granular media (sand or granular activated carbon). 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 electron donor to the system, selenite and selenate are reduced to insoluble selenium that is readily removed along with biomass and other suspended solids by downstream liquid/solids separation. In addition, nitrate and nitrite are reduced to nitrogen gas in the FBR and other metals such as mercury are reduced to insoluble metal sulfides.

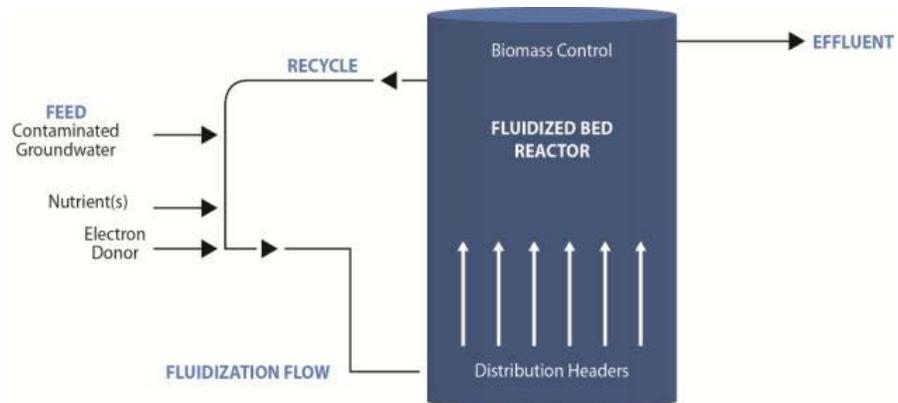
Figure 1 – Fluidized Bed Reactor

FBR installations typically feature one or more vessels in single-, two- or three-stage configurations, depending on influent water characteristics and discharge limits.

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 other fixed-film technology. This vertical orientation is also one of the factors that contribute to the FBR's smaller footprint.

Overall system packages typically include pumps, piping, valves, and controls that may be field assembled or pre-assembled on one or more skids to minimize installation costs. Most FBR systems are equipped with programmable logic control and may be provided with a SCADA package, telemetry and motor controls options.



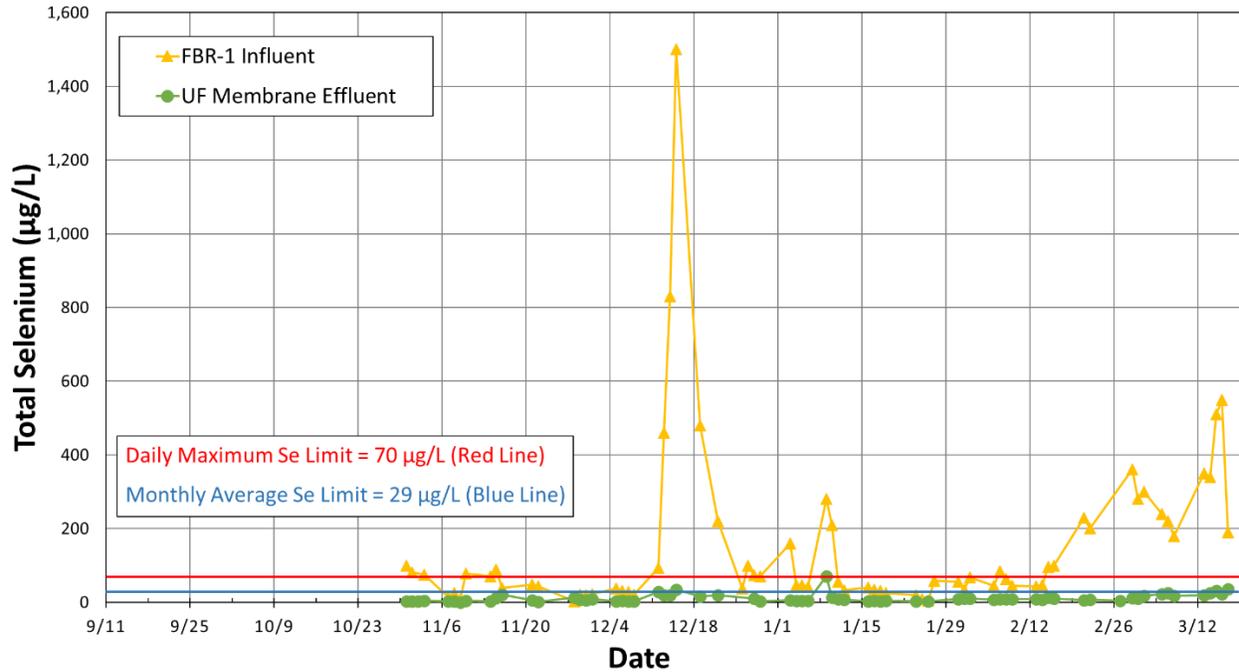
FGD Pilot Success

During a six-month validation study conducted from August 2016 to March 2017 at a South Carolina power station, Envirogen successfully demonstrated removal of selenium and nitrate/nitrite from pretreated FGD wastewater down to ELG limits using a two-stage FBR treatment system followed by Ultrafiltration (UF) membranes.

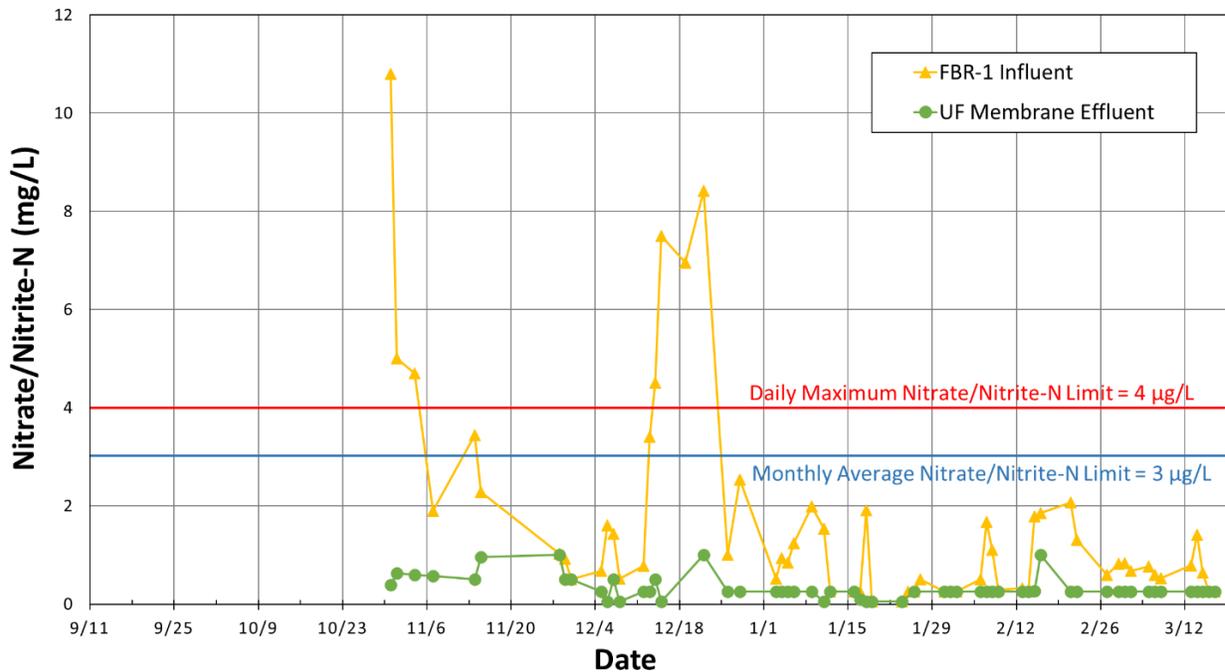
As shown in the graphs below, the Envirogen FBR system:

- Produced near non-detect of nitrate/nitrite in the effluent
- Achieved selenium effluents that met the established limits both on a daily maximum and monthly average basis throughout the entire study

Influent and Effluent Total Selenium



Influent and Effluent Nitrate/Nitrite-N



During a subsequent validation study conducted in the second half of 2017 at a Kentucky power station, Envirogen successfully demonstrated removal of selenium and nitrate/nitrite from pretreated FGD wastewater down to ELG limits for a period of 8 straight weeks using a single-stage FBR treatment system followed by multi-media filtration.

Even though the FBR is a proven success, Envirogen continues to innovate and improve its FBR design with main focus on reduced fluidization velocity for better kinetics and performance, fewer stages/smaller systems and ultimately lower capital cost for the customer.

Unmatched for Denitrification

Envirogen's FBR is unmatched for treatment of high concentrations of nitrate. Complete disengagement of nitrogen gas occurs due to full media fluidization, so the FBR remains effective and efficient even at elevated nitrate concentrations. Pilot testing of mine wastewater over a 9-month period has proven that the FBR is capable of sustained 100% denitrification at feed nitrate-N concentrations between 50 and 110 mg/L and loadings between 2 and 5 kg N per m³ per day.

Why the Envirogen Solution?

- **High Reaction Rates** in a compact design due to tall reactors and steady-state operation.
- **Complete Disengagement of N₂ Gas** due to media fluidization, so no plugging, channeling or "burping", even at high nitrate loads.
- **Superior Off-line Readiness** via sodium nitrate addition to the recycle when FGD scrubbers are idled.
- **Lower Installation Costs** by pre-assembling equipment and instrumentation on one or more 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 for our customers.
- **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.

For a more detailed data review and discussion of Envirogen's experience in selenium 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).
