

TETRA® Denite® System

DeepBed Denitrification

Severn Trent Services offers the TETRA Denite® System, a practical process for the removal of nitrate-nitrogen (NO₃-N) and suspended solids (SS) in a single treatment step. Denite is a fixed-film biological denitrification process that also serves as a deep bed filtration system capable of removing suspended solids to virtually any final effluent requirement. The TETRA Denite system integrates well with other plant treatment processes to provide superior total nitrogen (TN) and phosphorous removal. Denite is used as the final treatment step in the total nitrogen removal process to help each facility meet stringent TN discharge limits of 3 mg/l.



Denite Process Description

Biological denitrification processes can be of the fixed-film or suspended growth type. The TETRA Denite system requires one-tenth of the space used with suspended growth systems, greatly facilitating expansion or retrofitting requirements. With Denite, the denitrification process and the filtration process are combined in a single system and provide superior process synergy. NO₃-N is converted to nitrogen gas and captured within the media bed along with suspended solids and biomass formed from the denitrification reaction. The Denite gravity filter system operates in a downflow mode to maintain excellent suspended solids removal, thus avoiding the necessity for clarifiers or additional effluent polishing filters.

The specially sized and shaped granular media used in the fixed-film biological reactors is an excellent support medium for denitrifying bacteria and the deep bed environment is conducive to efficient NO₃-N and solids removal. The specific surface of the 2-3 mm sand is high, 300 square feet per cubic foot. A 4-6 foot depth of media is used that prevents short-circuiting and premature solids breakthrough. The contact between wastewater and biomass is excellent and hydraulic short-circuiting is negligible even during plant upsets.

The media allows for heavy capture of solids of at least 1.0 pound of solids per square foot of filter surface area before backwashing is required. The high solids capture permits operating for extended periods of time and easily handles peak flow periods or plant upsets.

As solids are captured increasing the head loss in the filters, a backwash is required to remove the solids. Because of the heavy loading capacity and media depth, DeepBed vessels require heavy-duty backwashing. Concurrent backwash air and water are used during the backwash cycle. The solids slurry removed from the filter media are typically returned to the upstream biological process. Due to the filters high solids loading capacity, the percent of return is less than 4% (<2% typical) of the plant's forward flow.

During the denitrification reaction, nitrogen gas accumulates in the media bed and wastewater is forced to flow around the gas bubbles in the media voids. This reduces the apparent size of the media and also improves the biomass contact and filtration efficiency. The effect of the gas bubbles increases head loss and requires periodic removal in between backwashes. Removing a reactor from service and applying backwash water for a short period of time accomplish this. This nitrogen release cycle, or bump, releases the entrapped nitrogen gas into the atmosphere, reducing the head loss. The TETRA SpeedBump® technology is utilized to conduct a complete system bump cycle without stopping flow to the reactors.



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Suspended Solids Removal

The removal of suspended solids from wastewater effluent also lowers BOD since each mg/l of TSS contains 0.4-0.5 mg/l of BOD. Effluent suspended solids also contain nitrogen, phosphorous, and heavy metals. The removal of these solids often decreases 1 mg/l or more of these materials. With proper chemical treatment, effluent total phosphorous concentrations <0.3 mg/l are consistently achieved. Denite filters can easily meet <2 NTU or < 5 mg/l TSS (<2 mg/l TSS typical). Table 1 demonstrates the final effluent quality reported by the City for the Howard Curren AWTP in Tampa, Florida during the period of 1980-2001 where the Denite system is operating.

Table 1: Howard Curren AWTP – Tampa, FL (100 MGD)

Period	MGD	BOD (mg/l)	SS (mg/l)	TN (mg/l)	TKN (mg/l)	NH ₃ -N (mg/l)	NO _x -N (mg/l)
1980-1988	51.3	3.4	2.8	2.8	1.7	0.17	1.06
1989-1998	55.5	2.4	1.6	2.4	1.56	0.18	0.87
1999	50.45	2.6	0.9	2.52	1.46	0.13	1.01
2000	48.5	3.1	0.7	2.24	1.29	0.14	0.95
2001	49.7	2.3	0.8	2.28	1.21	0.15	1.06
Average	51.0	2.76	1.4	2.4	1.5	0.15	0.99

Nitrogen Removal

The denitrification reaction is time-dependent, and the time required for a specific removal efficiency varies according to the temperature of the wastewater being treated. In practice, filtration rates of 1-3 gpm/ft² are designed for water temperatures down to 8 degrees Celsius and 2-5 gpm/ft² in warmer waters. Table 2 demonstrates the Denite system's capability to denitrify to low NO₃-N concentrations at low wastewater temperatures. Table 1 demonstrates the consistency of yearly Denite operations for NO₃-N and SS removal.

Table 2. Cold Weather Performance Data – Northeast US (Monthly Averages)

	MGD	Wastewater Temperature degrees C	Influent NO ₃ -N mg/l	Effluent NO ₃ -N mg/l
Nov 2003	1.01	14.9	11.56	0.45
Dec 2003	1.77	11.6	8.25	0.47
Jan 2004*	1.13	8.5	10.91	0.48
ADF Design	1.0	8	13	0.5
Peak-Day Design	2.36	8	11	0.5
* 15 days were measured <8 degrees C with average effluent NO ₃ -N of 0.45 mg/l @ 1.09 MGD				

Denite System Components and Specifications

- **Filter Vessel:** concrete or steel, round or rectangular- usually 18-20 feet deep with free board.
- **Filter Bottom:** Nozzleless design; stainless steel air headers and pipe laterals; plastic jacketed 5000 psi concrete T Block underdrains.
- **Filter Media:** monomedia granular sand with 2-3 mm effective size at depths of 4-to-6 feet.
- **Support Layers:** gravel in five layers totaling 18 inches deep in a reverse graded fashion.
- **Filter Controls:** consist of split flow influent over Curvilinear Weir™ blocks and standpipe effluent control. The mode is a uniform rate with open or closed valves.
- **Backwash Air:** distributed across the entire area of the filter bottom, supplied by a positive displacement blower at a rate of 3-5 icfm/ft²
- **Backwash Water:** supplied at a rate of 5-6 gpm/ft² with a low head centrifugal pump. The head loss across the filter bottom is 4.0 inches water column.
- **Filter Valves:** pneumatic or electric control valves with double acting cylinders. Isolation valves can be included.
- **Chemical Feed Systems:** includes a methanol storage and feed system with TetraPace™ automatic dosing control. This can be used for other chemical feeds as well.
- **Instrumentation:** PLC with human machine interface and multiple screens included. Also includes outputs for a centralized computer control and/or SCADA system. It also includes flow meters, analyzers, level switches, local panels and system alarms.
- **Filter Operation:** automatic with manual overrides. Backwashing and bumping are time based.
- **Head Requirement:** typically 6-8 feet of water but can be more or less depending on the specific application.
- **System Integration:** works well with other treatment plant processes such as overall nitrogen removal, phosphorous removal and virus removal.