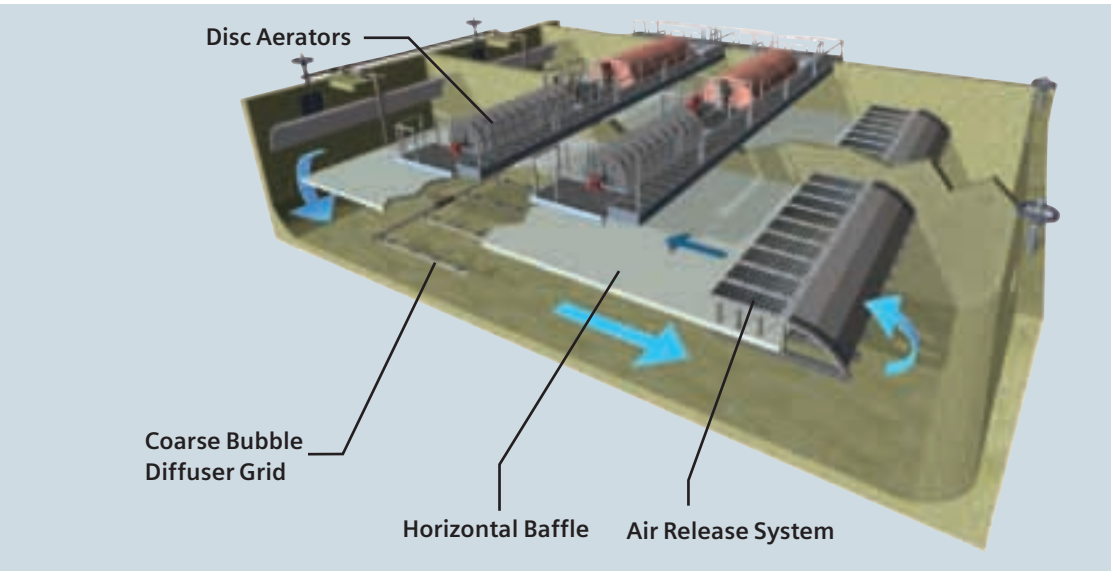
VLR® Systems for Biological Treatment

Water Technologies

SIEMENS



The basins of the Vertical Loop Reactor system share common walls, reducing construction costs.

The Vertical Loop Reactor

The Siemens VLR® system is a vertical loop reactor design based on the placement of looped reactors in series that allows DO stratification. As such, it is suited for simultaneous nitrification/denitrification, biological phosphorus removal and storm water treatment.

The VLR® system is installed in a rectangular tank, and is similar to an oxidation ditch flipped on its side. There is an upper and lower compartment, separated by a horizontal baffle running the length of the tank. Commonly, three basins make up a system. The VLR® system is adapted from the proven Orbal® system and uses the same surface mounted discs to provide mixing and to deliver oxygen.

The construction cost of a VLR® system is less than that of a comparable conventional oxidation ditch. Because the horizontal baffle is a structural cross beam supporting the side walls, side walls can be designed 12 inches (305 mm) thick for 20 feet (6.10 m) deep tanks.

VLR® System Operation

The typical system has two or more rectangular tanks placed side by side and operated in series. Like the Orbal® system, the first tank is used as an aerated anoxic reactor in which an oxygen deficit is maintained and the DO level kept near zero.

In designs with three or more tanks in series, the aerated anoxic conditions may extend beyond the first tank. The last tank is operated with a DO level of 2 mg/l or higher.

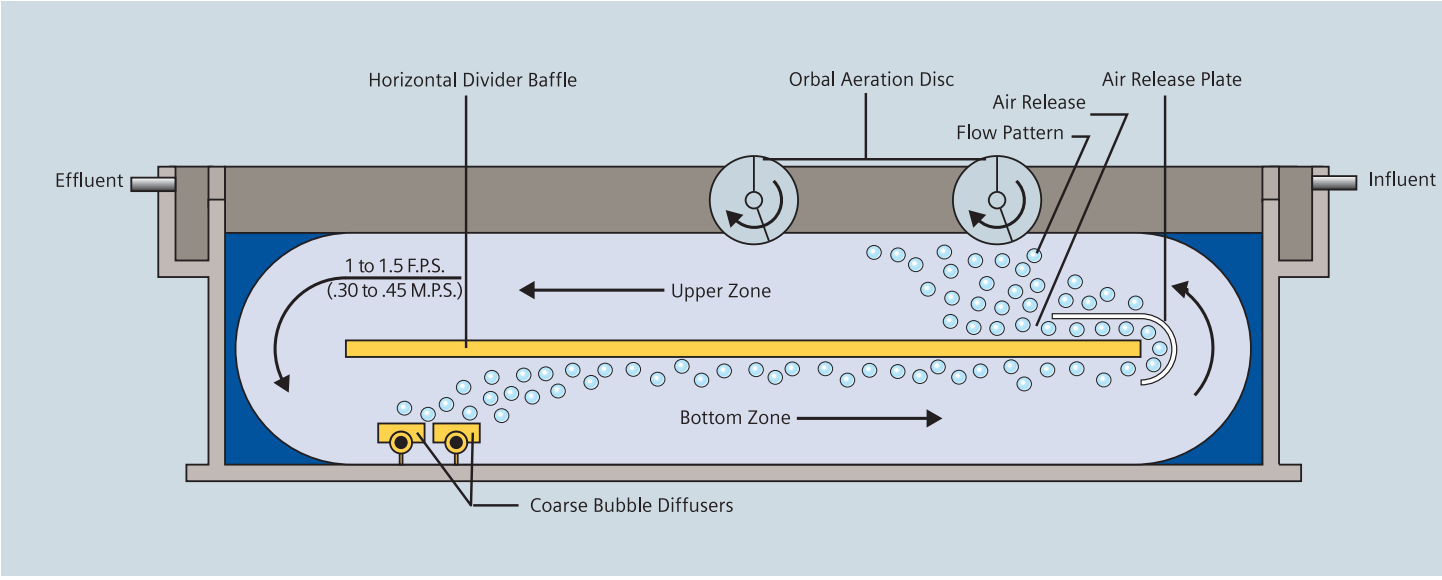
Most VLR® systems are designed for liquid depths greater than 20 feet (6.10 m). The horizontal baffle is located about mid-depth so that both upper and lower compartments are about 10 feet deep (3.05 m). The surface aeration discs establish an "over and under" mixing pattern, with the flow direction on the surface opposite the flow direction on the bottom.

The surface discs are typically sufficient for mixing the entire tank. Coarse bubble diffusers in the first quadrant of the lower compartment supply any additional oxygen required by the process.

The horizontal baffle prevents the coarse bubbles from immediately rising to the surface. Instead of a retention time of only a few seconds, the air bubbles must travel the full length of the tank and then be released through a special perforated air release plate.

Benefits

- Common wall construction - lower construction cost.
- Small footprint - less land area required.
- Dual aerator design - operating flexibility.
- Lengthy aeration retention time - low power costs.
- Coarse bubble diffusers - easy to meet peak oxygen demands.
- DO stratification - process adaptability.



VLR® System Operation

The VLR® system provides an overall retention time of from one to two minutes. This raises the SAE of the coarse bubble diffusers to 4 lb O_2/bhp.h (1.35 kg O_2/kW.h), more than twice their rating in a conventional aeration tank.

In effect, the one time cost for the baffle reduces the on-going power costs of the blowers. At the same time, it allows the process to deliver fine bubble efficiency with coarse bubble reliability.

First introduced in 1986, there are more than 70 VLR plants in operation ranging from 0.2 mgd (.7 MLD) to 41 mgd (155 MLD). Typically, however, the VLR® system is recommended for flows of more than 1.0 mgd (3.8 MLD). To reduce aeration disc requirements, designs with BOD loadings above 16 lb BOD/1000 ft^3/d (0.26 kg/m^3/d) are suggested. The VLR® system is most economically attractive in the loading range of 20 – 40 lb BOD/1000 ft^3/d (0.32 – 0.64 kg/m^3/d).

VLR System Applications

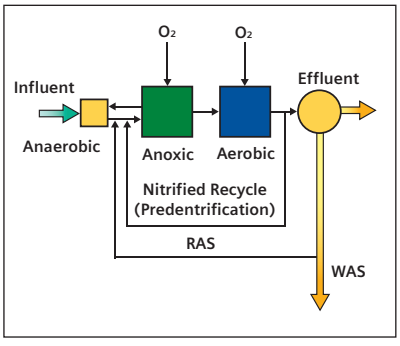
Plants utilizing the VLR® system have been designed for stringent biological nutrient requirements. A number of VLR® plants have been designed for excessive storm water treatment, with peak flows five times the design flow.

The VLR® system is also beneficial in industrial applications, especially when flows and loadings vary. Peak oxygen delivery demands can easily be handled without designing in a major amount of additional mechanical aeration equipment. Peak demands are handled by turning on additional blowers and increasing the air flow rate through the coarse bubble diffusers.

This system should be considered when land area is limited, when biological nutrient removal requirements are present, when stormflow rates are high and BOD loadings fluctuate widely.

Existing rectangular tanks can be retrofitted to VLR® system tanks. Tanks should be at least 40 feet long (12.2 m) and 12 feet deep (3.6 m).

For purposes of total nitrogen removal or for biological phosphorus removal, VLR® system tanks can be added in front of existing aeration basins and used as aerated anoxic tanks. The VLR® system is excellent for operating under anoxic conditions since it requires minimal power draw for obtaining channel velocities.



Aerated Anoxic with Anaerobic Selector Nitrogen and Phosphorus Removal

VertiCel® BNR System: The World's Most Energy Efficient Biological Nutrient Removal System

The VertiCel® System Combines Time-Tested and Innovative Designs

The VertiCel® biological nutrient removal system combines mechanical aeration in the anoxic tank with diffused aeration in the aerobic zones. Process aeration efficiency is optimized with this arrangement.

Proven VLR® System Technology

A key element of the VertiCel® system is its use of the VLR® system, a technology that has been successful in over 70 installations. Among the benefits of the VLR® system:

- Combines advantages of our Orbal® disc aerators with the instant turn-on of diffused air systems.
- Low intensity mixing capabilities of the disc aerator reduces power costs.
- Deep, high rate reactor with small footprint minimizes space requirements.
- Easily retrofits into rectangular basins.

Advanced SmartBNR™ Process Controls

The SmartBNR™ process control system integrates our unique knowledge of process with a PLC-based instrumentation/control package. Intelligent control functions include:

- Aerator control with dissolved oxygen (DO) and oxidation-reduction potential (ORP).
- Automatic sludge wasting control.
- Automatic control of stormflow operating mode.
- Oxygen input is varied based on signals from DO and ORP probes. This maintains the proper environment for simultaneous nitrification/denitrification and enhanced biological phosphorus removal.
- Built-in safeguards prevent erratic operation even in the event of instrument failure. Other optional inputs/outputs include flow and level controls. Our SmartBNR™ control system interfaces with any SCADA or DCS system.

DualAir® Diffusers double the bubbles

Our DualAir® fine bubble membrane or ceramic disc diffusers in dual saddle holders allow twice as many diffusers per foot of pipe, reducing capital and installation costs.

Benefits.

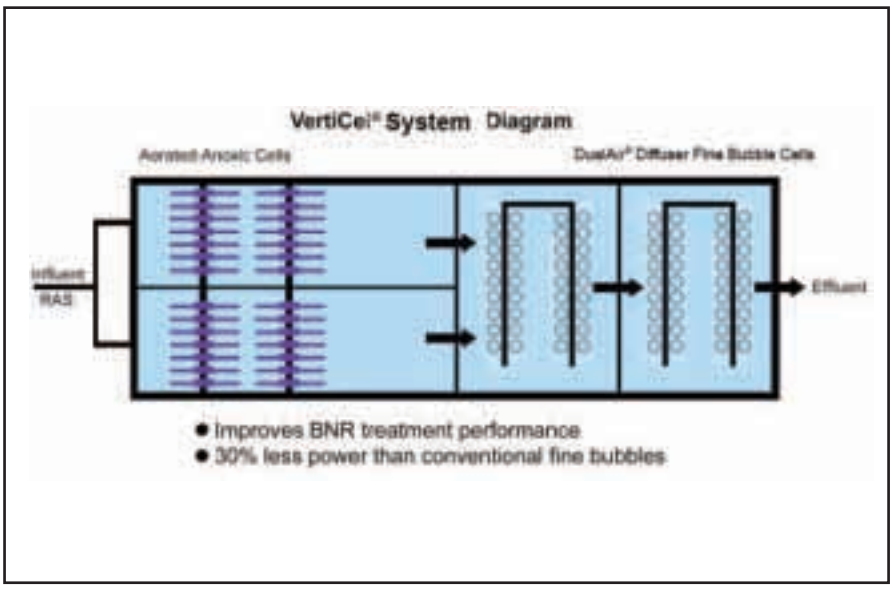
Effluent quality. VertiCel® systems are designed to achieve:

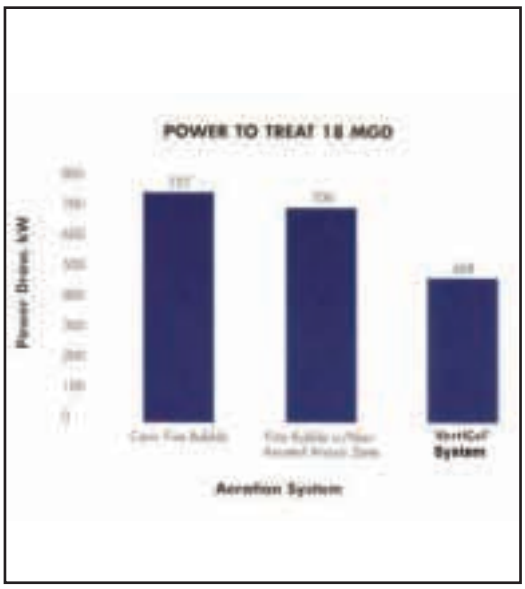
- BOD: 5 mg/l
- TSS: 10 mg/l
- NH3-N: 0.5 mg/l
- Total-N: 5 mg/l
- Total-P: 1 mg/l

Easy, reliable operation. The SmartBNR™ Process Control System optimizes operation, minimizes power usage and frees operators from constant monitoring.

VertiCel® System Description

The VertiCel® System is a suspended growth activated sludge process designed to minimize energy consumption and designed to accomplish biological nutrient removal (BNR). A unique aspect of the VertiCel® System is its ability to reduce aeration energy requirements by effectively dealing with the effects of surfactants in wastewater upon the oxygen transfer efficiency of aeration devices. Fine bubble diffusers are very





efficient in clean water but surfactants reduce this efficiency by forming a viscous film on the surface of air bubbles. Devices that rely upon turbulence to transfer oxygen to the mixed liquor like disc aerators are less efficient in clean water; however, they deal much more effectively with surfactants. When computing aeration oxygen transfer requirements, alpha ( ) is a measure of how effectively a device transfers oxygen in mixed liquor as opposed to clean water. The higher the value of for an oxygen transfer device, the less impact surfactants will have upon its oxygen transfer efficiency. Surface aeration devices such as the disc aerators used in the VertiCel® System have substantially higher values than diffused aeration devices.

The VertiCel® System uses a combination of aeration devices to take advantage of the strengths of each device. Initial aeration and mixing in the VertiCel® System is accomplished using disc aerators due to their relative insensitivity to the presence of surfactants. A unique coarse bubble aeration grid is used in combination with turning vanes to augment the disc aeration by releasing compressed air beneath the horizontal baffle in the VLR® system. By releasing air at this location, the coarse bubbles obtain maximum bubble contact time to maximize oxygen transfer efficiency. The VLR® system is designed to operate under aerated/anoxic conditions where an oxygen deficit occurs and simultaneous nitrification and denitrification can take place.

Once the surfactants have been dissipated due to treatment in the VLR® system with its disc aerators and coarse bubble aeration, fine bubble aeration can be applied much more efficiently in the down stream fine bubble aeration tanks.

Raw wastewater passes progressively though the VLR® system tanks (aerated/anoxic tanks) and the fine bubble aeration tanks before passing on to secondary clarification. Return activated sludge (RAS) is recycled back to the VLR® system tanks. VLR® system tanks and fine bubble aeration tanks are arranged to make use of common intermediate walls. Flow controls are arranged for independent operation of any single tank or operation in conjunction with an adjacent tank.

Benefits

Aerated/Anoxic Nitrification – The VertiCel® System's series of reactors promotes nitrification through alternate pathways at near zero dissolved oxygen levels. The aerated/anoxic nitrification concept was pioneered by Siemens and its advantages in terms of aeration power savings and biological nutrient removal will be addressed in the proposal.

Lowest Energy Costs – The VertiCel® System combines mechanical aeration in the aerated/anoxic zones with diffused aeration in the aerobic zones to optimize the process aeration efficiency. VertiCel System designs consume an average of 30% less power when compared with fine bubble aeration systems.

Unique Disc Aeration – The discs have highly effective mixing and aeration characteristics and provide rapid turnover of the entire tank contents while transferring oxygen very efficiently to minimize power costs.

Flexibility in Aeration – Changes in oxygen demand can readily be met by varying disc rotational speed and/or air flow in the aeration tanks.

Effectively Managing Peak Flows – Surge flows are managed within the VertiCel® System without solids washout. No auxiliary peak flow facilities are needed and a more economical final clarifier design can be employed.

High Quality Components – Drives, bearings, and shafting are all oversized and constructed in a rugged fashion to extend the life of the equipment while reducing maintenance requirements.

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