The Orbal® System
For Biological Treatment

Advanced Treatment for Enhanced Nutrient Removal

Water Technologies
Orbal® Technology
Reduces Energy Costs & Provides ENR Capabilities

Flexible, Efficient, Reliable & Simple

The Orbal® multichannel oxidation ditch from Siemens Water Technologies is well-suited for conventional activated sludge, advanced secondary sludge treatment, simultaneous nitrification-denitrification, enhanced nutrient removal and storm water treatment.

It is a complete mix, looped reactor system. Its principle benefits include:

Process Adaptability
The Orbal® basin can easily be expanded to accommodate for future load conditions, either by adding on additional aerator assemblies to the existing channels, or by adding on an additional channel to the existing channels. State standards for multiplicity are met with single basin designs—since the Orbal® process has dual basin capability in a single basin.

Dual Basin
The Orbal® process can be easily modified to meet a wide assortment of influent conditions and effluent requirements, giving it exceptional process flexibility.

Easy Maintenance
Only routine greasing of bearings is required. Aerator discs are non-fouling.

Operator Convenience
The Orbal® basin, with its complete mix characteristics and its ability to operate at high MLSS concentrations, has a high buffer capacity for shock loads. The varying food to microorganism ratio (f:m) across its multi-channels promotes an MLSS with a low SVI and prevents sludge bulking.

Energy Savings
The Orbal® process requires less power to operate than any other oxidation ditch system. Supplying much of the process oxygen requirement at near zero DO results in an overall reduced energy cost. When coupled with SmartBNR™ controls, the Orbal® process consumes an average of 30% to 40% less power when compared with conventional systems.
A typical Orbal® system uses the 0-1-2 punch for enhanced nutrient removal. The Orbal® basin has three concentric channels, with the outer channel having approximately 50% of the total volume. After screening and grit removal (optional), influent enters the outer channel which is operated under an oxygen deficit condition to promote simultaneous nitrification-denitrification. Though the actual oxygen demand of the first channel might be as high as 75% of the total, the aeration discs allotted to this channel supply only 30% - 60% of the system’s overall oxygen requirements to ensure a constant oxygen deficit condition and an operating DO of zero throughout the channel. The simultaneous nitrification-denitrification environment of the first channel results in an overall denitrification performance rate of 80%, without internal recycle. The first channel, where the majority of the process “work” takes place, is classified as an aerated anoxic reactor. Despite the zero DO conditions, the majority of the system’s nitrification takes place in this channel.

The DO of the second aeration channel operates in a “swing” mode. Although designed for 1 mg/l DO, the actual operating DO varies with the daily load conditions, being reduced to near zero during the peak loads of the day, and rising to 2 mg/l during low load conditions.

### Enhanced Nutrient Removal

To maximize enhanced nutrient removal, the oxygen delivery in the first channel of the Orbal® basin is reduced to levels lower than normal, allowing the oxygen deficit condition to become much stronger. This strong deficit condition in the first channel, coupled with an elevated sludge yield rate, will allow most plants to achieve effluent phosphorus levels of 1 mg/l or lower without chemical addition.

When both TN & TP removal are required an anaerobic selector can be added. An anaerobic selector will improve luxury P uptake. Influent flow is directed to the anaerobic selector, while the RAS from the clarifier is returned to the outer channel. Denitrified MLSS is pumped at 200% of the influent flow to ensure nitrates do not interfere with the enhanced nutrient removal mechanism. Typical Orbal® systems with an anaerobic selector generate an activated sludge with 5% to 6% by weight phosphorus and can achieve effluent TP values of 0.3 to 0.5 mg/l without chemical addition. As with any enhanced nutrient removal system, chemical polishing and backup is recommended for reliability.
Sim-Pre® Mode For Total Nitrogen Removal

The DO of the last channel is designed for 2 mg/l, keeping this channel in a "polishing" mode to remove any remaining BOD and ammonia before the flow exits to final clarifiers. Since the oxygen demand of the last channel is only a fraction of the first, only a small amount of oxygen needs to be delivered to maintain a high DO. Adding internal recycle to the Orbal® process (from the third channel to the first) allows 95% or greater total nitrogen removal performance results. Design recycle rates vary from 1:1 to 4:1 (internal recycle flow to raw flow) depending upon application. This arrangement offers a combination of simultaneous nitrification-denitrification (the conditions that prevail in the first channel) and predenitrification (where the majority of nitrates formed in the second and third channel are sent back to the first channel).

Orbal® systems operated in the Sim-Pre® simultaneous pre-process mode have produced monthly average effluent TN levels lower than 1 mg/l and lower than 1 mg/l P (without chemicals). See Chart for performance data.

Second Anoxic

The second anoxic zone further polishes nitrates for ultimate nitrogen removal. Sufficient BOD is needed to drive denitrification. The BOD can be provided through endogenous respiration or supplemental carbon addition. Supplemental carbon will decrease the volume required for denitrification.

The main purpose of the re-aeration zone is to strip any nitrogen gas formed in the 2nd anoxic zone that could negatively impact sludge settling in the secondary clarifiers. A secondary purpose is to polish any residual BOD added in the previous zone. The re-aeration zone, particularly at start-up will be mixing-limited so it will not necessarily be controlled to a DO level. The generally accepted standard to ensure mixing with coarse bubble aeration is 30 SCFM/1000ft³.

<table>
<thead>
<tr>
<th></th>
<th>Orbal Sim-Pre® System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hammonton, NJ</td>
<td>Monthly Average - July, 1996</td>
</tr>
<tr>
<td>TKN</td>
<td>NO₃-N</td>
</tr>
<tr>
<td>INF.</td>
<td>38.0</td>
</tr>
<tr>
<td>ENF.</td>
<td>0.47</td>
</tr>
</tbody>
</table>
The Orbal® Process Disc Allows Unparalleled System Tuning

The mechanical backbone of the Orbal® system is its unique aeration disc with its high oxygen transfer efficiency and unmatched mixing efficiency.

The aeration and mixing is provided by triangular nodules on the face of the disc. The nodules have a base-face or an apex-face; changing the rotation direction of the disc will change the delivery and power characteristics.

Delivery and power also vary with changes in immersion (from 9" to 21"), changes in speed (from 30 to 60 rpm) or with discs added on or removed from individual assemblies.

The disc is split into two half sections and can be directly attached to the aerator shaft at any location. This makes it easy to add on discs to existing shaft sections for future purposes.

Individual assemblies span one or more channels, the number of discs allotted per each channel being a function of the oxygen delivery requirements. In larger Orbal® process designs, multiple assemblies are provided.

Daily fluctuations in oxygen demand are handled by changes in the disc immersion or varying rotation speed. Long-term variations or sudden surges in demand are handled by turning on/off individual assemblies.

Requires Less Energy, Yet Achieves Optimum Efficiencies

Mixing efficiency, defined as the number of gallons mixed per 1 hp to maintain a 1 fps channel velocity, is an extremely important feature of the Orbal® system. It allows the Orbal® basin to continue to keep a zero DO in the first channel during underloaded conditions—while still keeping a velocity sufficient to keep solids in suspension. Independent mixing devices are not needed to maintain anoxic conditions in the first channel.

The mixing efficiency of the aeration discs in an Orbal® basin is unmatched by any other aerator device. As an example, an outer channel with 1 million gallons of volume, requires only 5 hp of disc aerators to maintain a 1 fps channel velocity. The high mixing efficiency of Siemens aeration discs in the Orbal® system ensures the ultimate in biological process performance under almost all load conditions.

The Orbal® process disc is manufactured of a molded thermoplastic compound immune to the effects of wastewater. The discs are 4-1/2 feet in diameter.
Low Energy Requirements

The discs are designed to provide a low-level oxygen delivery intensity within the Orbal® basin, the delivery rate typically being less than 2 lbs O₂/hr per foot of shaft. This ensures maximum transfer efficiency under field conditions. In the first channel, where the operating DO is kept at zero and the oxygen demand is the highest, DO is zero entering the aerator and approximately zero leaving the aerator. However, due to the high circulation rate and multiple aeration locations, the average flow particle will pass through an aeration zone more than a thousand times, ensuring a high degree of oxygen transfer. Single channel ditches, with only one or two high delivery intensity aerators, saturate the liquid leaving the aerators with higher DO levels, resulting in lower oxygen transfer efficiencies.

The Orbal® process, with its natural high level of denitrification, its stratified DO levels across its three channels, and its low delivery intensity, will typically require 35% less oxygen delivery than a standard, single channel ditch.
Stormwater Treatment Mode

Excessively-high flows during storms are the bane of many treatment plants, causing clarifier solids washout and long-term loss of treatment performance. To prevent this type of problem, many plants design larger, more expensive clarifiers—or, operate at reduced MLSS levels (requiring larger aeration basins to maintain the same solids inventory)—or, add expensive equalization basins in front of the aeration tanks.

With the Orbal® process, none of these remedies are needed. Stormflow rates five times the average flow can go through the Orbal® basin without the danger of clarifier solids washout—or loss of process performance. This is accomplished by redirecting the influent flow (including stormflow) to an inner channel (typically the last) while keeping the return sludge flow in the first channel. The result is a quick increase in solids concentration in the first channel and a dramatic drop in MLSS in the last channel, which allows the solids loading on the clarifier to be dropped below design levels. When flows return to normal, the influent is returned to the first channel and the Orbal® process shifts back into its conventional mode.

This treatment mode has been successfully used in hundreds of Orbal® plants. These plants have experienced extremely low levels of BOD, SS and ammonia despite excessively high clarifier overflow rates when switching to this mode during storms.

Options for Smaller Flows

The Orbal® process can be provided for applications at any point on the flow spectrum, including package plant applications.

Small Flow Orbal® systems are created specifically for small wastewater flows in the range of 0.035 to 0.5 MGD.

The design package of the Small Flow Orbal® system consists of: a standard Orbal® multi-stage aeration system, two (2) scraper clarifiers, an aerobic digester, SmartBNR™ controls, and associated pumps, blowers, and control valves.

Siemens has used a “complete solution” approach in developing the designs in recognition of the need to provide cost effective wastewater treatment solutions for smaller communities that have limited financial resources.
Most plant controls are nothing more than a controller connected to a DO probe, programmed by someone who may be unfamiliar with your actual process. Siemens provides a control system designed by our process engineers who have a thorough understanding of the complete process.

**SmartBNR™ Controls Offer Capabilities Unmatched By Any Other Available System**

- Precise control of simultaneous nutrient removal in a single reactor.
- Predictive aerator response to reactor conditions.
- Integrated control strategy using both oxidation-reduction potential (ORP) and dissolved oxygen (DO).
- Automated sludge wasting maintains an optimum sludge age.
- Automated stormflow response ensures that no solids are lost over the weirs.

**SmartBNR™ Systems Deliver Unparalleled Performance**

**Guaranteed Process Performance**

- Highly reliable SmartBNR™ systems include a process performance warranty.

**Minimum Power Costs**

- SmartBNR’s power usage is guaranteed to deliver absolute minimum power costs.
- Automated SRT controls and stormflow modes allow for reliable hands-free operation.

**Untended Plant Operation**

- SmartBNR’s ability to interface with existing automation makes dependable untended plant operation a reality for any system.

![Graph showing relative power cost reduction](image)