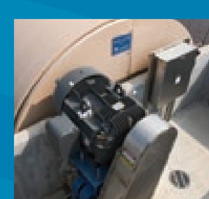
Closed Loop Reactor (CLR) Process

Innovative Technology,
Flexible Orientation and
Energy Saving Designs

LAKESIDE
EQUIPMENT CORPORATION
Water Purification Since 1928

Cleaner Water for a Brighter Future®



Lakeside Biological Treatment Processes

Lakeside's oxidation ditch experience since 1963 has led to the development of today's modern Closed Loop Reactor (CLR) Process. Derived from the original design by Dr. A Pasveer of The Research Institute of Public Health (TNO) in the Netherlands, our CLR Process is featured in more than 2000 Installations around the world.

This CLR Process provides a variety of options for wastewater treatment to meet ever-changing and more stringent effluent standards:

- Lower life-cycle costs than competing technologies
- Energy savings designs
- Multiple operational modes
- Nitrogen and phosphorus removal capabilities
- An adaptable configuration

Closed Loop Reactor Configuration

The Closed Loop Reactor (CLR) Process describes a process, ***not*** the reactor's shape. The reactor can take one of several shapes, including the conventional racetrack, folded U, concentric multichannel and round packaged design with an internal final clarifier. The latter offers the lowest construction and equipment cost for small plants. For larger plants, the racetrack design with common wall construction is the most economical option.

Folded U Design

Lakeside delivers full service support from initial concept and state-of-the-art modeling through the construction stages and subsequent operation. Aided by our experience, plants reliably meet and exceed effluent standards with equipment that requires minimal operator attention and maintenance.

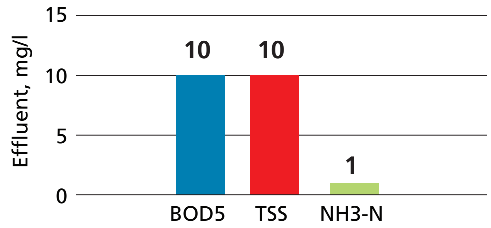
Racetrack Design

The CLR Process

Key Features and Benefits

- Has removal efficiencies equal to tertiary treatment plants.
- Simultaneously nitrifies and denitrifies without structural modifications.
- Handles hydraulic and organic shock loadings.
- Reduces power requirements and energy costs with rotor oxygen transfer turndown flexibility.

CLR Process Performance



Round Packaged

Concentric Multichannel Designs

Spiraflo Clarifier

Conventional Secondary Treatment

The CLR Process is a modified form of the extended aeration complete mix activated sludge process. Its design is based on a single sludge system in a closed loop reactor.

The CLR Process consists of one or more reactors with a single feed point for raw wastewater and return sludge. The basic design uses a simple racetrack configuration that provides a straight line flow pattern for wastewater between the headworks and the final clarifiers.

At the core of the CLR Process is the horizontal Magna Rotor, which sustains a high population of microorganisms in the reactor to provide simple process control. The Magna Rotor provides precise oxygen input into the biological process through adjustment of rotor immersion by raising or lowering the level control weir and by adjusting the rotational speed.

Another key component to successful operation of the CLR Process is the final clarifier. Lakeside's Spiraflo Clarifier uses a peripheral-feed center take-off flow technology proven to be superior for effective solids separation. The Spiraflo Clarifier provides considerable construction cost savings as compared to other circular clarifiers.

The CLR Process is known for its stable operation over a wide range of influent flows and organic loadings, which minimizes the time and effort needed to control or adjust the system. Even in cold weather conditions when microorganism activity is decreased, the process operates efficiently without special attention.

CLR Process Modifications

When the process requires two or more reactors, the CLR Process can be designed to operate in Parallel, Series, or Storm Flow modes of operation to provide maximum operational flexibility. Operational control is provided by a splitter box arrangement for both raw wastewater and return activated sludge (RAS). Typically, slide gates are manually operated. For more sophisticated control, the slide gates can be electrically actuated to meet changing flow and load conditions.

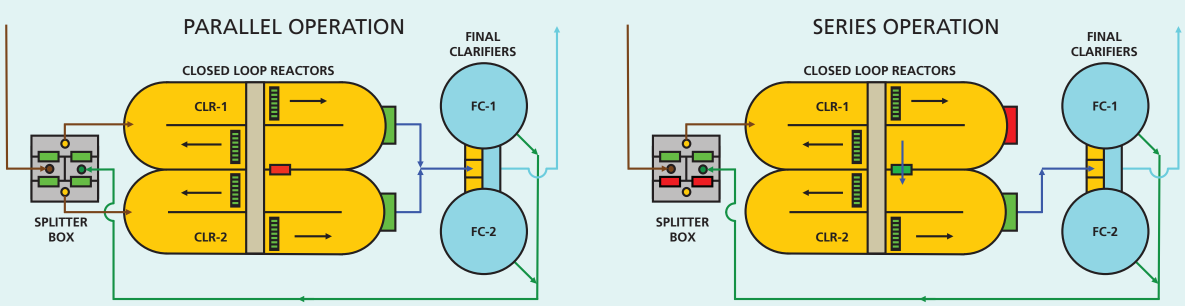
Parallel Operation

Raw wastewater and return activated sludge (RAS) are introduced at a single point in each reactor CLR-1 and CLR-2. A positive dissolved oxygen (DO) concentration is maintained throughout the reactor by controlling both the rotor blade immersion in the mixed liquor and by changing the rotational speed of the rotor using variable frequency drives (VFDs). An adjustable effluent weir is used to control the rotor blade immersion in the mixed liquor level in each reactor. This simple control strategy can achieve high removal levels of BOD5 and TSS to less than 10 mg/l as well as nitrification to reduce effluent ammonia (NH3-N) to less than 1 mg/l.

Series Operation

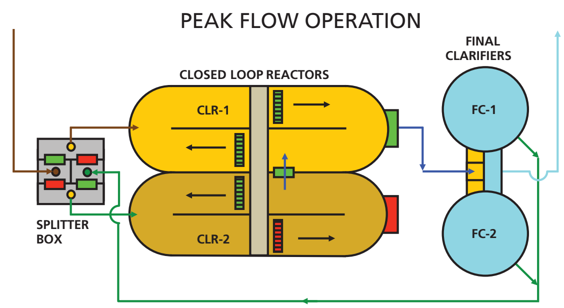
In series operation, raw wastewater and return activated sludge enter reactor CLR-1, then the flow passes to reactor CLR-2. Effluent from the system is discharged out of CLR-2 over the effluent weir. The first reactor is maintained in an anoxic state (negative ORP and/or D.O. less than 0.5 mg/l) by controlling rotor speed and immersion. The oxygen demand of the wastewater is reduced in reactor CLR-1. Reactor CLR-2 is maintained in an aerobic state with a DO of 0.5 to 2.5 mg/l by controlling rotor speed and immersion. The Series operational mode also allows for biological phosphorus removal and total nitrogen reduction.

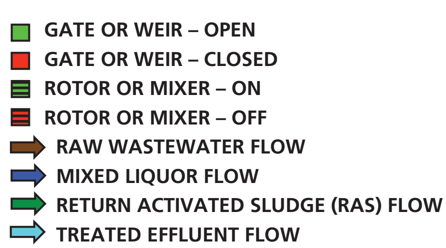
Parallel, series, and peak flow operations offer operators maximum flexibility.



Peak Flow Hydraulic Capacity

During peak wet weather conditions, solids from the reactors can be pushed rapidly into the final clarifiers. Solids will accumulate in the clarifiers to a point where solids washout may occur. To prevent solids washout, the treatment flow pattern is converted to a "contact stabilization" model during the time the peak flow rate exists. All of the influent flow is diverted to reactor CLR-1. All of the RAS flow is diverted to reactor CLR-2 and is "stabilized". RAS then flows to reactor CLR-1 where it mixes with the influent wastewater where "contact" occurs. The RAS flow continues at the same flow rate as it is pumped from the final clarifier. No solids washout from the clarifier occurs because the solids loading rate is reduced. The RAS is conserved in the system and the CLR Process is ready to return to normal operation when the peak flow condition subsides.



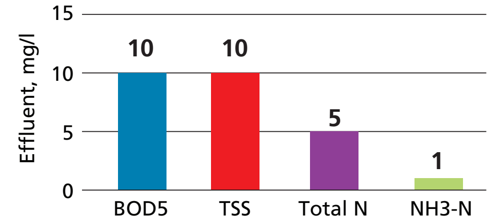


BNR Total Nitrogen Removal

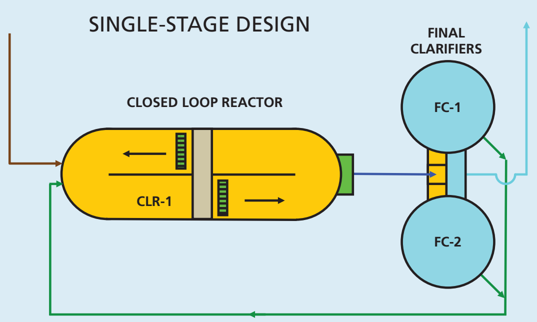
The CLR Process provides the proper environment for both nitrifying and denitrifying organisms. Autotrophic nitrifier populations result in a high MLSS concentration, increased aerobic hydraulic detention time, and long sludge age (20 or more days) to achieve nitrification. CLR plants consistently produce effluent NH3-N levels of less than 1 mg/l with proper control of aerobic conditions and can provide total nitrogen levels as low as 5 mg/l with proper control of anoxic conditions. The denitrification process recovers 50 percent of the total alkalinity lost during the nitrification process, lowers overall energy costs by reducing oxygen requirements and inhibits filamentous bacteria growth.

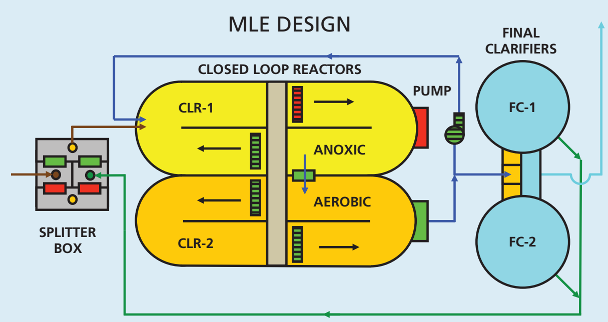
The CLR Process provides the elements for Biological Nutrient Removal (BNR) using non-proprietary designs. Magna Rotors provide mixing and aeration during aerobic operation and submersible mixers provide mixing only during the anoxic operation.

CLR Performance



With single-stage process design, nitrification and denitrification can occur concurrently.





Single-Stage Design

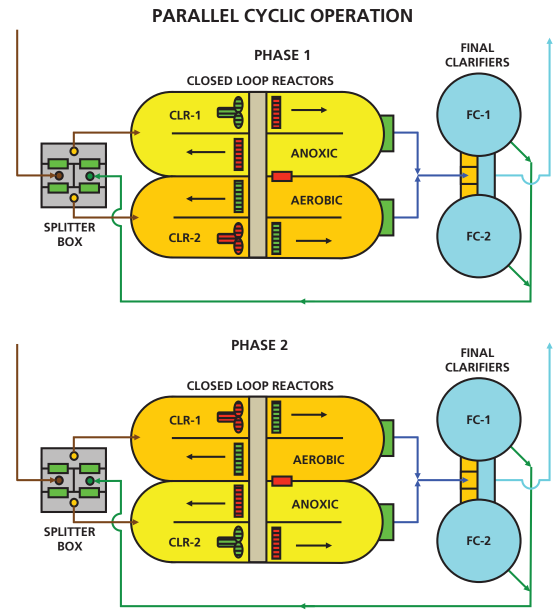
Although nitrification and denitrification are carried out by two distinctive types of microorganisms, both can occur simultaneously in a single-channel CLR design. Denitrification develops throughout the reactor in microzones within the sludge floc particles or through alternate cycles of aerobic and anoxic zones within the reactor.

Parallel Cyclic Design

In the parallel cyclic operational mode, raw wastewater and return activated sludge are introduced into each reactor as an equal flow split. Reactor No. 1 is operated in an anoxic phase and Reactor No. 2 is operated in an aerobic phase. After a designated time period, Reactor No. 1 is switched to an aerobic phase and Reactor No. 2 is switched to an anoxic phase. The number of anoxic and aerobic phases during the day and the time of each phase is completely adjustable to account for changing loading conditions of the plant. This operational mode adds more process flexibility when designing a new plant or when upgrading an existing plant.

MLE Design

In addition to the standard CLR Process operated in series, a common design modification is known as the modified Ludzack-Ettinger (MLE) Process. The MLE Process variation is created by returning nitrate-laden MLSS from the aerobic reactor to the anoxic reactor with mixed liquor recycle pumps.



BNR Total Nitrogen Removal

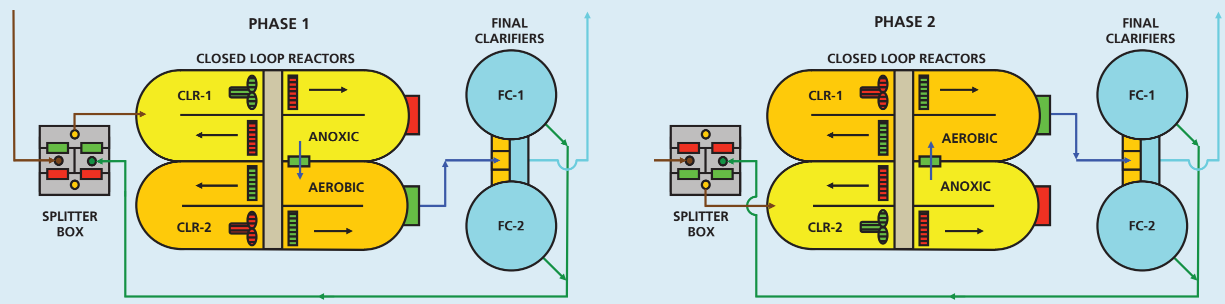
Series Cyclic Design

In the cyclic operational mode, raw wastewater and return activated sludge are introduced into Reactor No. 1 which operates under anoxic conditions as shown in Phase 1. Mixed liquor then flows into Reactor No. 2 where it is processed under aerobic conditions. After a preset time period, the feed and flow are reversed to feed Reactor No. 2, which is now operated under anoxic conditions (shown in Phase 2). Mixed liquor then flows into Reactor No. 1 which now operates under aerobic conditions.

Designs for Enhanced Nitrogen Removal

For enhanced Total Nitrogen removal the CLR Process can be expanded with a second stage aerobic reactor (4-stage) or a combination of a second stage anoxic reactor followed by a second stage aerobic reactor (5-stage).

Series Cyclic Operation



BNR Phosphorus Removal

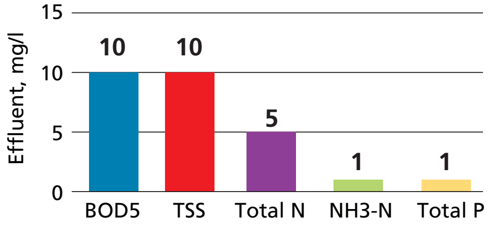
All aerobic biological processes remove some phosphorus. Conventional secondary biological treatment systems use soluble phosphorus from the wastewater to synthesize new bacterial cells. The phosphorus is removed from the system with the waste sludge. Typical phosphorus removal from cell synthesis ranges from 1 to 2 percent.

Enhanced BNR Phosphorus Removal

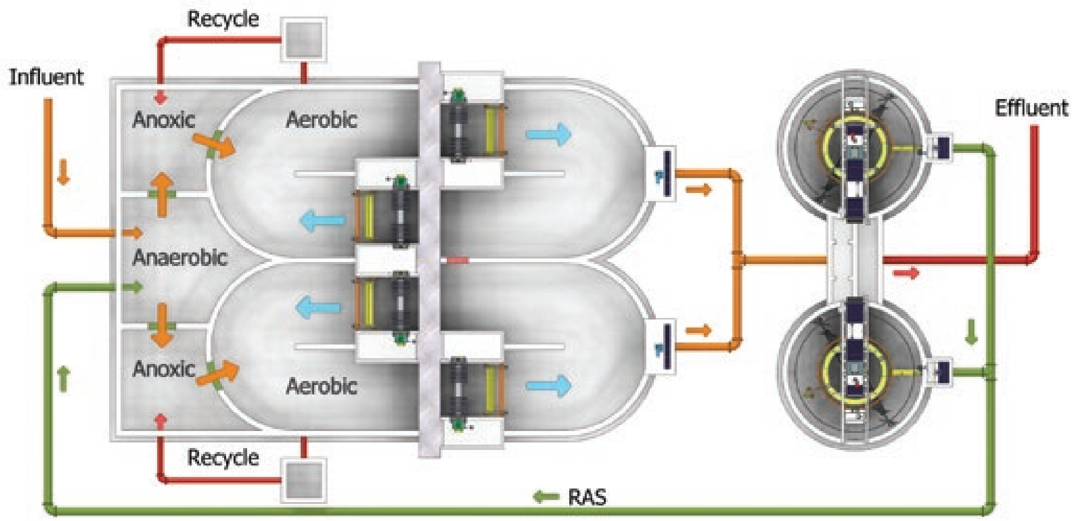
Enhanced biological phosphorus removal occurs in the CLR Process with the addition of anaerobic and anoxic stages ahead of the aeration basin. The anaerobic stage promotes the growth of phosphorus removing bacteria. Typical removal efficiencies for enhanced biological phosphorus removal systems is increased to 4 to 6 percent for cell synthesis.

By introducing raw wastewater and returned activated sludge (RAS) into the anaerobic reactor, phosphorus removing bacteria release stored phosphorus for energy production and use the energy to take up easily degradable BOD5. When these bacteria pass into the aeration tank, they oxidize the stored BOD5 for energy to take up excess phosphorus and synthesize new cells. The stored excess phosphorus in the bacterial cells is removed with the waste sludge, which results in a net phosphorus removal from the wastewater.

CLR Process Performance



With the addition of anaerobic and anoxic stages ahead of the aeration basin, enhanced BNR phosphorus is removed.



High Removal Efficiency

A typical flow diagram for a biological nutrient removal modification of the CLR Process includes an anaerobic stage, anoxic stage and aerobic stage. The BNR process provides total nitrogen, as well as phosphorus removal in a 3-stage, 4-stage or 5-stage process.

By recycling mixed liquor from the aerobic to the anoxic stage, biological nitrogen removal occurs and reduces nitrate levels in both the returned activated sludge and plant effluent. With typical average influent phosphorus and BOD5 levels of 4-6 mg/l and 200-240 mg/l respectively, the BNR modification can produce an effluent phosphorus level of 1 mg/l or less without added chemicals.

BNR Phosphorus Removal

- No Chemicals Required
- High Removal Efficiency
- Separate Process Stages

Magna Rotors

The primary component of the CLR Process is the horizontal rotor aerator. The Lakeside Magna Rotor provides oxygen to the biological mass, mixes microorganisms uniformly and adds mixing velocity to the channel to prevent solids from settling. Constructed of rugged materials, the Magna Rotor offers reliable operation and high efficiency.

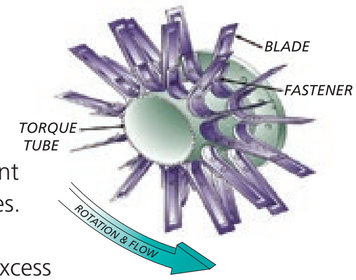
Structural and Mechanical Integrity

The Magna Rotor's design allows a single rotor to span channel widths up to 30 feet, saving significant costs by eliminating the need for additional equipment to join multiple rotor assemblies.

The Lakeside blades are die formed of 10 gauge AISI Type 304 stainless steel to produce greater stiffness and rigidity to take a 250 lb impact load without deformation.

Replaceable stub shafts are provided on each end of the rotor torque tube. Bearings, with an AFBMA L-10 theoretical design life in excess of 100,000 hours, reduce maintenance due to long interval times for lubrication.

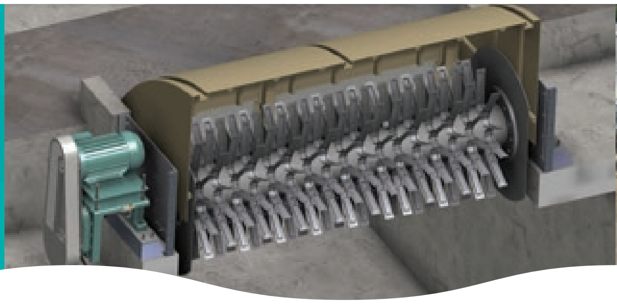
High-efficiency and reliable shaft-mounted drives ensure long life and minimum maintenance.



Mixing Requirements

The Magna Rotor with 3-inch wide stainless steel blades is the most efficient mixer for Closed Loop Reactor processes. Velocity control baffles are mounted downstream of each rotor to prevent excess liquid velocity generated by the rotating blades and to maintain the velocity between 1 and 2 ft/sec. The baffles direct the flow downward into the basin to create a rolling motion.

Magna Rotors



Magna Rotors

Shaft Mounted Drive

This turbulent mixing ensures the uniform distribution of oxygen and biomass throughout the entire tank contents at all liquid depths up to 15 feet. The horizontal Magna Rotor is the most efficient mixer for any oxidation ditch process.

Oxygen Transfer Ability

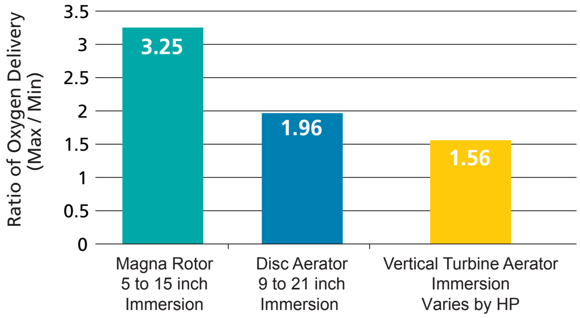
The Magna Rotor provides an oxygen transfer range greater than any other mechanical surface aerator, with a range of 3.25-to-1 at immersion depths from 5 to 15 inches. **The addition of variable frequency drives (VFDs) to allow the full speed range from 37 to 72 rev/min increases the oxygen transfer range to 9.7-to-1.**

The Magna Rotor's wide range of oxygen transfer allows the plant operator maximum flexibility to provide oxygen input (horsepower) to match the demand of the system without the need to reverse direction of rotation.

Oxygen Transfer Efficiency

As with all aeration devices, transfer efficiency varies with transfer rate. With the proper combination of speed and immersion, optimum performance can be maintained to match virtually any set of loading conditions. Optimum performance assures the lowest operating power cost throughout the life of the equipment.

Mechanical Surface Aerator Oxygen Transfer Range



Type D Mounting

The mounting arrangement of Lakeside rotor aeration equipment provides a clean work area free from splash and offers operating personnel easy access to all moving components. Splash walls and effective sealing around the rotating shafts limit intrusion or leakage of mixed liquor into the work area.

Field Replaceable Stub Shafts and Bearings

Unlike competing horizontal aerators with solid shafts, the Magna Rotor is provided with bolted removable stub shafts on each end. This operator friendly design allows replacement in the field while permitting the rotor assembly to remain in position. A large crane is not necessary to replace the rotor bearings and stub shafts. A labyrinth non-wearing seal arrangement isolates the bearings from the mixed liquor.

The Rotor Covers provide a clean working area.

The bearings are self-aligning and rated for outdoor wet duty installations. The drive end bearing is a fixed type and the tail end bearing is an expansion type. The bearings are designed for a minimum AFBMA L-10 theoretical design life of 100,000 hours.

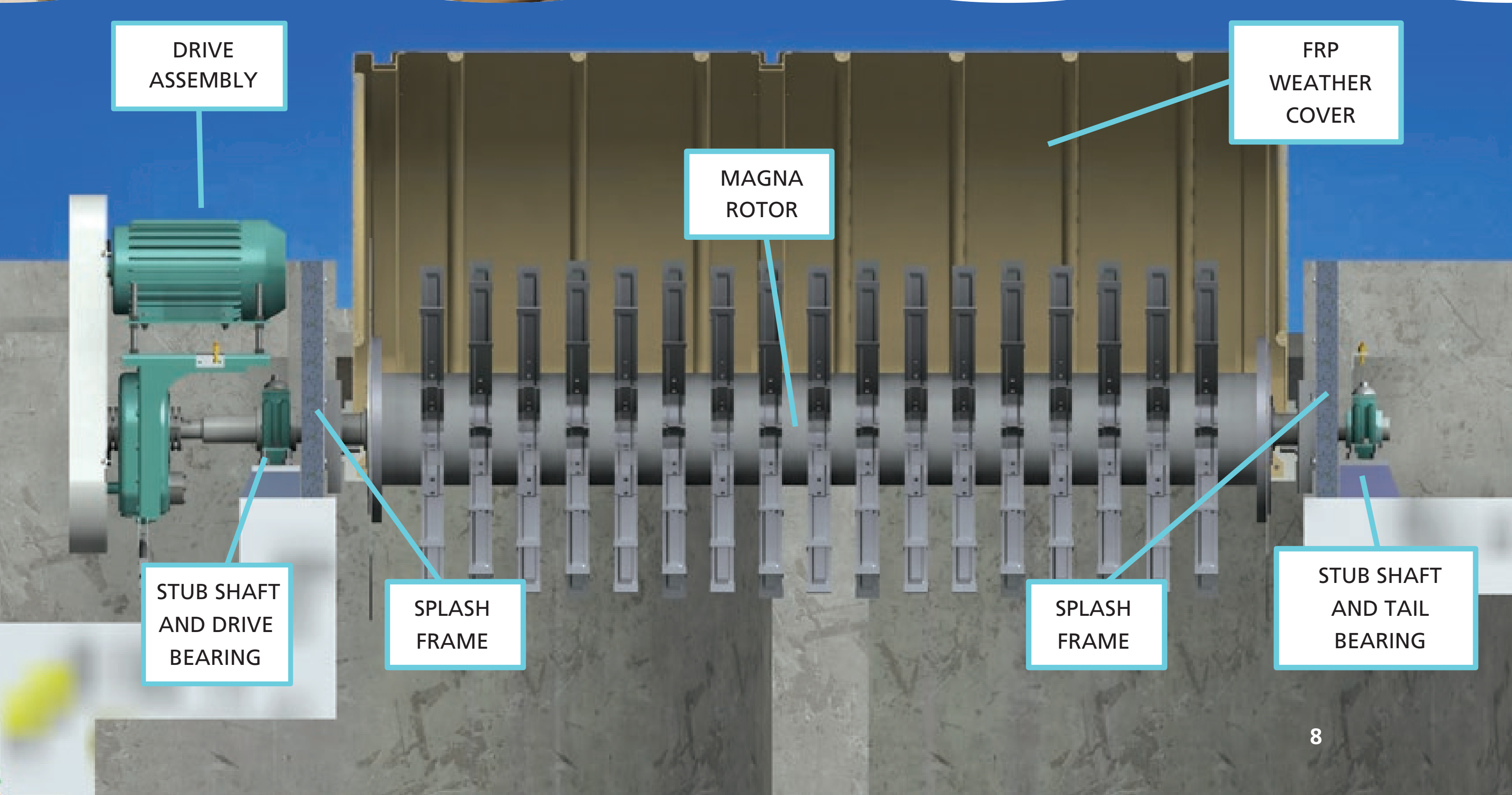
Shaft Mounted/Variable Speed Drive

Each Lakeside rotor is independently supported on both ends by base mounted, pillow block bearings. This allows the use of rugged, compact, shaft-mounted speed reducers. The use of a V-belt drive coupled with shaft-mounted reducers provides maximum flexibility for speed changes. For projects requiring frequent and wide variations in oxygen input, variable speed drives or two-speed motors can be provided.

Rotor Covers

Lakeside rotor covers are constructed of lightweight but sturdy fiberglass panels and provide an attractive addition to many CLR plants. They are especially useful for plants with special needs such as extreme cold where containing rotor spray will reduce icing problems and heat loss; frequent high winds with windblown spray; or locations close to a residential area. Each panel is hinged for easy access.

The Type E Rotor Cover is significantly larger than other cover types, extending beyond the velocity control baffle, and providing increased effectiveness in trapping spray and mist.



Adjustable Weirs

The easy-to-adjust weirs control liquid depth within the CLR channel. Adjusting the weir level and therefore the rotor blade immersion, is one method the operator can control the oxygen input into the reactor to match actual oxygen demands. Excess oxygen wastes power. Lakeside's weir is properly designed with sufficient length, minimizing fluctuations in head over the weir. Controls for the motorized weir can be linked to the total plant control system for continuous positive control of dissolved oxygen. The Adjustable Weir provides rotor immersion variation from 5 to 15 inches to control rotor oxygen input to match process oxygen demand.

Submersible Mixers and Recycle Pumps

Submersible mixers are utilized during the anoxic phase of the CLR Process to provide mixing of the reactor where no aeration is required. Submersible mixers are also utilized for separate anaerobic selectors or separate anoxic selectors.

Submersible recycle pumps are utilized for the MLE Process where a large (up to 400%) mixed liquor recycle flow is required from the aerobic reactor to the anoxic reactor. With a common wall reactor design, this allows the mixed liquor recycle pump to be placed in the common wall between the reactors.

Adjustable Weir

Recycle Pump

Submersible Mixer

Spiraflo Clarifiers

Key to successful operation of the CLR Process is the performance of the secondary clarifier that follows the CLR basin. The Lakeside Spiraflo Clarifier incorporates proven concepts in circulation, sedimentation and separation technology necessary to maintain high quality effluent standards.

The Spiraflo Clarifier employs a peripheral-feed center take-off flow pattern to make use of the total tank volume for more effective solids settling. Wastewater enters the Spiraflo at the outer diameter of the tank.

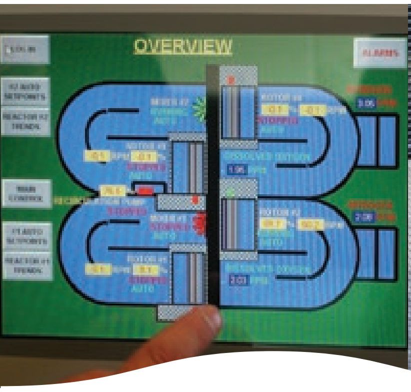
The flow distributes evenly into the center section near the floor level and then rises towards centrally located effluent weirs. This spiraling flow pattern around and under the skirt eliminates short circuiting and ensures maximum use of the entire tank volume. Spiraflo Clarifiers are 2 to 4 times more hydraulically efficient than center-feed peripheral take-off clarifiers.

Spiraflo Clarifier

SharpBNR Process Control

Lakeside offers a full-service system that integrates the entire process, establishing the lowest energy consumption for efficient nutrient removal. Lakeside's SharpBNR Process Control system provides ORP and D.O. monitoring of environmental conditions in specific zones within the CLR plant. ORP is used to monitor the environmental conditions within zones that require anoxic conditions. D.O. is used to monitor the conditions within the aerobic zones in the plant. VFD's are provided for the motors that operate the Magna Rotors within these zones. Reacting to changing loads in each reactor, rotors speed up or turn on if the ORP or D.O. drops, indicating higher oxygen demand in the basin.

When the ORP or D.O. increases, the rotors will slow down or shut off. The objective is to maintain the environment within that zone near the ORP or D.O. set point that the operator establishes. The result is a highly efficient process that produces a steady effluent containing the characteristics that the operator desires.



PanelView Touchscreen

SharpBNR Control System

SharpBNR Control System

DO Meter

ORP and D.O. probes are rugged and reliable, mounted at points recognized as representative of the entire process. Field mounted transmitters send the acquired data to the main control panel that contains a PLC. Operational screens are accessed by an operator interface. Important screens required for each application are designed by Lakeside's engineering team. The screens are used to display measurements made in the process or to monitor operating equipment within the plant. Each screen is created for a specific purpose. Equipment operational status is displayed on a plant overview screen. Measured data is tracked on data tracking screens. Alarms are tracked on the alarm history screens. All data and operational status is communicated to the treatment plant's SCADA system.

Lakeside's engineering team and its project manager work as a group of specialists on the specific requirements of each application. Lakeside's SharpBNR control system uses the latest technology to provide reliable, cost-effective, energy efficient control solutions to meet each project's specific needs. We can assist any design consultant with the process and instrumentation diagrams, wiring diagrams, and SCADA and PLC specifications they need to bring their project to successful completion.

Treatment equipment and process solutions from Lakeside Equipment Corporation

Lakeside offers a wide range of equipment and systems for virtually all stages of wastewater treatment from influent through final discharge. Each process and equipment item that we supply is manufactured with one goal: to reliably improve the quality of our water resources in the most cost-effective way. We have been doing just that since 1928.

Screw Pumps
- Open Screw Pumps
- Enclosed Screw Pumps

***Raptor*® Screening**
- Fine Screen
- Micro Strainer
- Rotating Drum Screen
- Septage Acceptance Plant
- Septage Complete Plant
- Complete Plant
- Multi-Rake Bar Screen
- Wash Press

Screen and Trash Rakes
- Hydronic T Series
- Hydronic K Series
- Hydronic Multifunctional Series
- Hydronic H Series
- Catronic Series
- Monorail Series
- HY-TEC Screen
- CO-TEC Screen
- RO-TEC Screen

Grit Collection
- SpiraGrit
- Aeroductor
- In-Line Grit Collector
- *Raptor*® Grit Washer
- Grit Classifier
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Clarification and Filtration
- Spiraflo Clarifier
- Spiravac Clarifier
- Full Surface Skimming
- MicroStar® Filter

Biological Treatment
- CLR Process
- Magna Rotor Aerators & Accessories
- Sequencing Batch Reactors
- Package Treatment Plants
- Submersible Mixers & Recirculation Pumps

Hauled Waste Receiving Systems
- *Raptor*® Septage Acceptance Plant
- *Raptor*® Septage Complete Plant

Package Headworks Systems
- *Raptor*® Complete Plant
- H-PAC®

Biological Treatment Systems
- CLR Process
- Package Treatment Plants
- Sequencing Batch Reactors

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