

What can you do with Adaptive Mixers?

Flygt introduced the first submersible mixer in 1951. Today, more than 250,000 Flygt mixers have been deployed and are reliably doing their jobs, operating mainly out-of-sight and out-of-mind.

Often given little consideration in the overall design and operation of wastewater facilities, submersible mixers are generally selected for worst-case scenarios, based on flow or loading. Because the need for mixing varies greatly in the course of a given treatment cycle, the result is overmixing, a practice often employed to address the worst-case scenario. In other words, to avoid the risk of under-mixing, engineers design for seldom-occurring peak conditions of maximum plant flow or maximum load, setting aside more common average conditions, and mostly ignoring minimum conditions. Unfortunately, this practice wastes energy and oftentimes results in sub-optimal process.

Seeking more efficient mixing, wastewater treatment plant operators are increasingly turning to mixers with

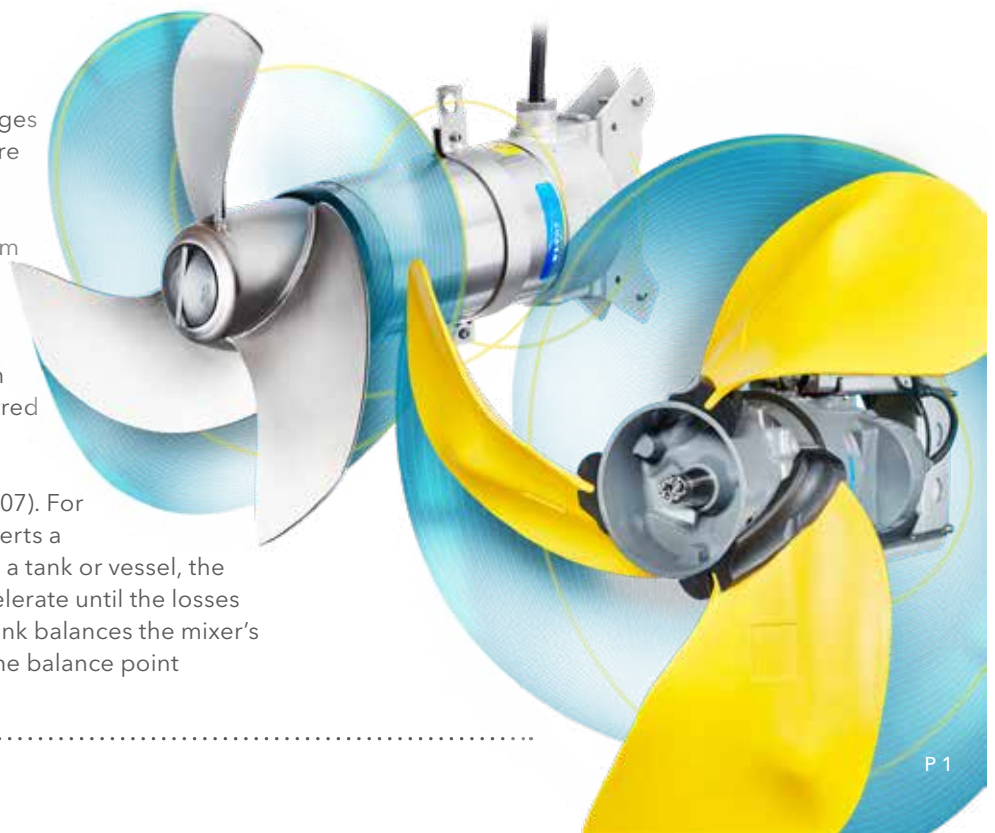
integrated variable speed control, which can dramatically lower energy use and reduce wear. Unlike traditional single-speed mixers that always have to be operated at 100% capacity, regardless of how much mixing is actually needed, Flygt adaptive mixers are designed to automatically adjust to wide range of operating conditions.

With a growing focus on nutrient removal, energy management and optimization, mixers present an extraordinary opportunity for improvement for most wastewater treatment facilities (WWTF). Mixers are a tool that allow operators to optimize treatment, especially for nutrient removal, and save energy.

“Based on the widespread use of mixers in industries and public utilities, it has been estimated that mixing consumes some 5% to 10% of the world’s electric power.” - Handbook of Mixing for Wastewater and Similar Applications, Lars Uby

MIXING BASICS

Mixing is performed in many stages of wastewater treatment to ensure blending, suspension and/or distribution. In order to provide adequate mixing, the energy from the mixer must be imparted to the liquid to create a bulk flow loop throughout the tank. The amount of energy is measured in terms of newtons (N) and is referred to as thrust (the standard for measuring thrust in submersible mixers is ISO Standard 21630:2007). For example, as a mixer propeller exerts a thrust on liquid contained inside a tank or vessel, the liquid will start to move and accelerate until the losses associated with the flow in the tank balances the mixer’s thrust. The velocity attained at the balance point



is the “equilibrium velocity.” Higher thrust equates to higher equilibrium velocity, resulting in more intense mixing.

It should be noted that mixing can be achieved with almost any rotating device, provided that unlimited power is available. The thrust produced by a mixer and its associated power draws, however, are the key performance parameters of a submersible mixer. Among a set of comparable mixers, the mixer that produces the most thrust using the least power is the most efficient mixer. Efficient mixing, using the lowest amount of power, requires an optimally designed mixer.

Feature: IE4 equivalent synchronous permanent magnet motor

Energy efficient

Synchronous permanent magnet motors are super premium according to international standards. When compared to lower classifications such as IE3 – often based on conventional asynchronous technology – motors with IE4 efficiency use less energy.

Extended life

The integrated control electronics of Flygt Adaptive Mixers are sealed inside a dust-free, non-oxidizing environment, reducing the risk for drive failure. Since the mixer is submerged in cooling media, no fan is needed, which otherwise is the most fail-prone component of a traditional VFD systems. This integrated design also eliminates potential errors from sizing, set-up and wiring.

WHAT IS ADAPTIVE MIXING?

To put it simply, adaptive mixing is adjusting the mixer’s speed so that the required output (thrust) matches the changing conditions. With adaptive mixing, the mixer is NOT always running on one previously determined set speed. The speed varies as the need changes.

WHY ADAPTIVE MIXING?

Wastewater treatment is not a static process and therefore a mixer’s thrust shouldn’t be either. Mixing requirements vary over time depending on a range of factors including flow rates, input aeration rates, seasonal variations, etc. Conventional mixers that operate at a fixed output often results in turbulence, wasted energy, unnecessary wear on the mixer, and increased maintenance due to inefficient operation of the mixer.

Adding variable thrust technology to a submersible mixer allows operators to efficiently adjust mixing thrust to meet varying application demands, thereby enhancing operational capabilities while reducing mixing energy costs. Variable speed capability allows for continuous thrust variation to be acquired while operating more reliably than manual “switch-on/ switch-off” practices. Energy savings may be gained through automated operation of mixers when the produced thrust is set to what is required. The thrust can vary to meet changing conditions, such as:

- When flow rate into a tank is reduced, or
- When the risk of a bypass increases, or
- When 100% activated sludge suspension is not required 100% of the time, or
- When diffused aeration is reduced or turned off.

With an adaptive mixer, a mixer’s thrust (and associated power draws) can be simply increased or decreased to meet the current thrust requirements.

Why Flygt Submersible Mixers?

Energy Savings up to 50%

- Larger Propeller Diameter
- Lower Speed
- Increased Reliability
- Optimized Propeller Blades
- Highest Mixer Efficiency
- IE4 PM Motor

Speed-Change Energy Savings

- Adjust to actual process conditions

Auto Mixing Control

- Adjust Continuously



Figure 1: Flygt 4220

FLYGT ADAPTIVE MIXERS VS. EXTERNAL VFD

Compared to a single speed mixer, a variable speed submersible mixer makes it possible to adapt mixing to each current situation. Operators can modify the output by way of a tank-side control panel, a programmable controller or plantwide SCADA system to match mixing needs. With a Flygt Adaptive Mixer, the unit also delivers comprehensive information about the mixer's performance and status: speed, power, alarms, runtime and energy consumption.

While some plants install tank-side VFDs to achieve some operational flexibility in a single speed mixer, Xylem has engineered a significantly more effective approach - a drive integrated with the mixer's submerged motor. Xylem's Flygt brand introduced its first adaptive mixer, the Flygt 4320, in 2015. The low-speed submersible mixer is the first mixer to provide variable speed mixing without using an external, tank-side VFD. This revolutionary adaptive mixing technology provides for continuous thrust variation to allow for energy-efficient and demand-based mixing.

With adaptive mixers, operators can have control over the mixer's thrust, thereby enabling continuous process results and reducing energy consumption. On account of the integrated drive technology, electromagnetic compatibility (EMC) issues and other installation, commissioning and operational issues often associated with installing external, tank-side VFDs are eliminated. Integrated drive technology coupled with the mixer's hydraulically optimized propeller work effectively to meet process objectives.

In addition, installing a submersible mixer with tank-side VFD operations is no simple task. The VFD must be carefully matched to the mixer's motor, which involves selecting the proper rating of the VFD - a task requiring sufficient knowledge of the expected process variations in the mix tank. Matching further involves programming the VFD's parameters so the VFD/motor combination is optimized. The Flygt 4320 mixer's built-in VFD is pre-designed and pre-optimized for its motor. Also, with the adaptive mixer the controls are enclosed inside the mixer, protected from harsh conditions including dust and varying humidity. And, temperature control is also automatically supplied by the mixer's submergence.

INCREASED ENERGY AND COST SAVINGS

While the name focuses on the adaptability of the mixer, one of the principal benefits is the mixer's IE4 equivalent motor. The IE4 equivalent permanent magnet motor can produce the equal amount of thrust as a standard compact mixer's direct drive motor with up to 50% less energy input.

Energy savings

Varying thrust in response to process demand - over both shorter- and longer-term time horizons - can lead to substantial energy savings.

Integrating the variable frequency drive into the mixer makes the mixer/VFD combination very compact plus simplifies operation, installation and commissioning. By adjusting mixing to actual process conditions, the integrated VFD also results in a more efficient mixer, resulting in the lowest life cycle mixing energy costs.

Cost savings

Reduced energy consumption also results in substantial cost savings. With efficiencies of up to 1,700 newtons of thrust per kilowatt of input electrical power, Flygt adaptive mixers can reduce power consumption by up to 50%, resulting in significant cost savings compared to a conventional single-speed mixer.

In addition to effective and efficient mixing, adaptive mixers also provide low maintenance and low operating costs ultimately resulting in a low life cycle cost.



CASE STUDY

Vernon Hills, Illinois

The village of Vernon Hills, located in Illinois, encountered chronic issues with its existing mixers, which frequently broke down resulting in frequent downtime and costly repairs.

Xylem proposed the facility switch to Flygt 4220 adaptive mixers for more reliable operation and reduced energy consumption. The Lake County Public Works (LCPW) department agreed to a “try and buy” solution.

At the end of the trial period, data showed the Flygt 4220 mixer used 50% less power than the utility’s existing mixers. Additionally, the Flygt mixer ran during the trial period without incident and required no maintenance.



As a result, LCPW has ordered six more mixers with six monitoring and control panels. LCPW also has long-range plans to replace a total of 12 mixers with the Flygt adaptive mixers.

Improved process resiliency

Flygt adaptive mixers let you adjust output, manually or automatically, to achieve the required mixing process result. This gives operators unprecedented possibilities to operate the mixer consciously and adaptively. A small control panel can be mounted in series with the mixer’s power cable, enabling the operator to locally change mixing effect as easily as dimming a light in a conference room.

With the Flygt Dirigo® technology platform, adaptive mixers can self-monitor. When an adaptive mixer senses a near overload condition, instead of shutting off, it slows itself down, so the process is still up and running. That’s a great benefit in terms of process resiliency and compliance.

CASE STUDY

Globe, Arizona

Globe, Arizona, located about 90 minutes east of Phoenix, is a small-town jewel with a rich mining history. The existing aeration system at the Pinal Creek Wastewater Treatment Facility that serves the city of Globe had been in use since the 1980s. By 2019, the aging equipment had compromised flow circulation and significantly reduced energy efficiency.

Recognizing the need to upgrade the WWTP’s existing system, the Globe Public Works Department worked with engineers at JCH, Inc. and Xylem to design and install a complete solution, which included the Sanitaire Bioloop oxidation ditch with Flygt adaptive mixers and the OSCAR process performance optimizer.

The Bioloop oxidation ditch uses dedicated Flygt adaptive mixers and Sanitaire aeration devices to provide flexibility and energy efficiencies that traditional mechanical aeration/mixing systems can’t match.

The OSCAR process performance optimizer continuously regulates the Bioloop oxidation ditch, matching the precise amount of energy consumption to the dynamic treatment process. The OSCAR system identifies the amount of air going into the treatment process and in

response, the speed of the Flygt adaptive mixers adjusts automatically to the correct thrust to keep the necessary velocity in the ditch and keep all of the solids in suspension.

According to current facility manager Vince Mariscal, the WWTP has seen several benefits from using the adaptive mixers, including an increase in energy efficiency and savings, less time spent maintaining the mixers and improved quality of effluent.



Increased mixer uptime

From the reduced wear and tear of the mixers themselves – thanks to their variable output – to their advanced motors, ActiveSeal™ technology and durable hydraulics, Flygt adaptive mixers are designed to handle the harsh demands of wastewater treatment with long maintenance intervals.

Adjusting for actual thrust requirements also reduces wear and stress on the mixer during lower power periods, for longer life and reduced maintenance. And the addition of advanced automated process capabilities further supports long mixer lifetime with low maintenance.

Mixer inventory reduction

Flygt adaptive mixers cover a range of duty points and can easily be deployed across different applications, reducing the need for inventory of back-up mixers and spare parts and also lowering capital investment for rebuild or mixer replacements.

During a process redesign or upgrade, Flygt adaptive mixers can even be exchanged among different tanks – avoiding the need to rebuild or replace existing mixers.

CASE STUDY

Chandler, Arizona

One of the fastest growing communities in the nation, Chandler, Arizona, has transformed from a small agricultural town at the turn of the 20th century to the innovation and technology hub of the Southwest.

Ocotillo Brine Reduction Facility (OBRF) is a water reuse facility that supports a microchip manufacturing facility in the city of Chandler. The treatment operation processes 1.5 million gallons daily of water the facility uses in its manufacturing processes. Treated to drinking standards, the water is then reused by manufacturer minimizing its need for potable water from the city.

To treat the manufacturing facility discharge, OBRF uses a cold lime softening process, which removes water hardness, silt, alkalinity and other constituents. But lime softener sludge was constantly building up and settling in the equalization basin, which resulted in having to shut down the treatment process operation for at least two days every four months. Each shutdown carried a \$15,000 price tag and forced the manufacturing facility to rely on potable water.

OBRF reached out to Xylem representative JCH, Inc. for a solution. Because the level of the equalization basin fluctuated several times per day by as much as 15 feet, JCH recommended Flygt adaptive mixers to scale the level of the varying amounts of thrust required to keep the lime sludge in suspension.



Using the adaptive mixer's built-in process control functions, operators at OBRF were able to build a level versus thrust curve by varying the speed based on input from a transducer directly into the process controller so that the thrust varied with the water level in the tank.

Since installing a Flygt adaptive mixer in March 2020, OBRF has not experienced any shutdowns.

CASE STUDY

California

When a coastal city in southern California, was looking to upgrade their Water Reclamation Facility they considered various mixers for their BNR and RAS tanks. Because these tanks had different dimensions, depths, and volumes, and therefore different thrust requirements (See Table # 1), the city was looking at different size/models of mixers.

The city then learned about adaptive mixers and realized that one model, the Flygt 4220, could provide the adequate amount of mixing without overmixing in all of the tanks.



CALIFORNIA WRF TANK AND MIXER SUMMARY

Tank	Length (ft)	Width (ft)	Depth (ft)	Volume (gals)	Required Thrust (N)
BNR	20	10	19	28,426	116
RAS	19	6	9	7,675	22

APPLICATION OPPORTUNITIES

Mixers of different designs deployed in aeration basins, sludge storage tanks and other treatment processes have varying degrees of effectiveness. They can also be significant consumers of energy, especially if operated in an “always on” mode.

Because treatment processes are variable, mixers should be too. Adaptive mixing technology is an effective solution for a variety of water and wastewater treatment processes. With the introduction of full automation capabilities, plant owners and operators are assured simplicity and reliability in a variety of treatment processes, including:

Secondary Treatment

Biological secondary treatment is the most energy-intensive phase in the wastewater treatment process with aeration consuming between 25% and 60% of the total energy used in a municipal plant. According to a report by the Environmental Protection Agency in the U.S. (EPA) these costs are increasing due to rising energy prices and more stringent requirements for effluent quality.

Secondary treatment of wastewater is designed to substantially degrade the biological content of the waste through aerobic biological processes.

Completing secondary wastewater treatment allows for safer release into the local environment, reducing common biodegradable contaminants down to safe levels.

Air flow has become a crucial parameter used to control the level of treatment and also to reduce the amount of energy needed for aeration applications. As load increases, air increases and as loads are reduced, air flow is reduced and with that, mixing energy can also be increased or decreased to save energy.

In mixing limited basins, mixers can be added to reduce the demand on the aeration equipment. This not only reduces the amount of energy used, it also decreases the amount of air in the tanks and improves processes.

Enhanced Biological Phosphorus Removal (EBPR) / Side Stream EBPR (S2EBPR)

Enhanced Biological Phosphorus Removal (EBPR) is utilized when phosphorus discharges below 1 mg/l are required. Side Stream EBPR (S2EBPR) is a type of EBPR where a portion of the RAS is conveyed to a separate tank to allow for fermentation. Whether the EBPR is performed within the process flow or in a side-stream, the creation of VFAs and anaerobic zones are paramount for successful P removal.

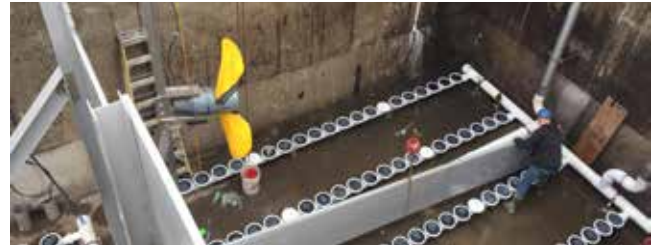
Adaptive mixers provide process control in these systems by providing slow, non-air-introducing mixing. In addition, the thrust from adaptive mixers can also be increased to re-suspend and move fermenting sludge blankets, when needed.

Biological Nutrient Removal (BNR)

Biological nutrient removal (BNR) is the most common application for mixers in wastewater treatment. Proper mixing within anoxic and anaerobic zones can help ensure improved treatment efficiency and lower effluent nutrients.

Nutrients such as nitrogen (N) and phosphorus (P) are the primary cause of eutrophication in surface waters resulting in algal blooms, low dissolved oxygen, and fish kills. Efforts to reduce nutrient impairment have brought about more stringent effluent limits for wastewater treatment plants, often necessitating Biological Nutrient Removal (BNR) processes to ensure compliance.

BNR is carried out through the use of microorganism selection and controlled environmental conditions within the treatment process, characterized by the arrangement of unaerated (anoxic/anaerobic) zones upstream and/or downstream of aeration zones. Mixed liquor recycle and sludge return streams are arranged to make best use of the organic content and activated sludge in the system. With these processes in place, WWTF can efficiently and effectively remove nutrients through biological methods.



The objective of mixing in anoxic and anaerobic zones is to maintain optimum conditions for nutrient removal. Maintaining anoxic/anaerobic zones requires mixing of the basin contents and influent streams while avoiding the introduction of free oxygen. The sludge must be kept in suspension in order to utilize the designed tank volume.

Feature: Integrated soft start and stop

Soft start/stop technology increases the stability of the mixing system and reduces wear on mechanical and electrical components for longer life and reduced maintenance.

Why mixing is needed

- To prevent settling / stratification
- To maintain suspension
- To blend
- Force contact between microbes and wastewater
- For heat transfer
- To maintain concentration/heat consistency throughout a liquid - maintain complete mixed state
- To increase detention time / reduce short circuiting
- Liquid Circulation

Advanced automated process capabilities

Advanced automated process capabilities bring a new level of precision, enhancing the customer benefits in terms of energy savings, optimized treatment processes, ease of use and supporting longer mixer lifetime with low maintenance, thanks to reduced wear and tear.

Overload protection - When overload conditions are imminent, Flygt adaptive mixers automatically sense the danger, adjust output accordingly and trigger an alarm, preventing motor burnout.

Phase correction - The mixers always rotate in the correct direction, no matter how they are connected to power wiring.





Feature: Optimized propeller design

The adaptive mixer's unique propeller design maximizes thrust while minimizing energy consumption. The specially designed impellers are engineered for hydraulic excellence with high-strength materials, providing exceptional thrust and high bulk flow along with excellent energy efficiency. The Flygt signature propeller with its backswept design is engineered to be self-cleaning and ensure clog-free operation, even in the presence of fibrous materials.

Optimum mixing must provide:

- **Off-bottom Suspension.** Solids bulking on the bottom reduces volume and may result in undesired anaerobic effects.
- **Sufficient Solids Distribution.** Uneven, insufficient bacterial contact with liquid throughout the entire tank is in essence, a loss of process volume.

Stricter nutrient effluent limits are not a passing fad for wastewater treatment plants. BNR is a proven method for reaching lower effluent limits. Being able to vary the speed of the mixing in your treatment processes will improve the BNR process, reduce energy requirements, and save money.

Sludge holding

As wastewater treatment plants become larger and more sophisticated, so do the demands for handling large amounts of sludge, which is an expensive and complex operation.

For tanks at wastewater treatment plants that contain solids slurries, either for anaerobic digestion or sludge storage, mixing is a key factor in the proper design, operation and maintenance of the system. Submersible mixers are often used in sewage treatment plants to keep solids in suspension in the various process tanks and/or sludge holding tanks.

Adaptive mixers can be used to increase and decrease the applied thrust based on fluctuations in sludge concentration and/or sludge levels in the tanks.

Digestion

Digestion is a natural process; however, producing biogas efficiently requires effective mixing of often difficult substrates.

In digestors, there are varying sludge levels and concentrations, so it's important to have adjustable thrust mixing.

Mixing duties include:

- Provide homogeneous substrate as food for biogas producing bacteria
- Prevent crust and foam formation
- Maintain stable and optimum temperature throughout the digester
- Blend the entire tank contents
- Release biogas bubbles at all depths of the digester, pushing them to the surface for collection
- Prevent sedimentation

Feature: Integrated monitoring and data logging

With comprehensive monitoring and auto-correction functions, Flygt adaptive mixers introduce a new level in mixing reliability. Integrated monitoring functions include power consumption, energy meter, running time, drive temperature, phase loss alarm and overload.

Others

Beyond BNR applications, adaptive mixers are increasingly being used in less common applications like retention basins, stormwater basins and pump stations. In all of these applications, the adaptive mixers help to prevent settling and provide suspension.

Applications for mixing

Wastewater Treatment

- Sludge digesters
- Holding tanks / Equalization tanks
- Treatment lagoons
- Biological treatment tanks
- Sludge blending
- BNR
- Flocculation
- EBPR

Other Industrial Uses

- Agricultural biogas
- Pulp & paper
- Drilling mud
- Fish ladders
- Mining
- Amusement parks
- Aquaculture

3 levels of application

AD (Standard control)

Standard system with pre-set control incorporates many built-in valuable features providing energy savings, key autonomous protection features, and scalability for ADF or ADC functionality at a later stage.

ADF (Flexible control)

Gear up your adaptive mixer for tank-side and remote operation by adding the Flygt FPG 415 gateway with analog input/output and fieldbuses. Easily connected operator panels or SCADA systems allows for fully integrated monitoring functions, so you can be assured of optimal mixer operation wherever you may be.

ADC (Automated control)

Realize automated control and multiple mixer operation for aerated processes by adding the Flygt APP 412 pre-engineered controller. Available speed control functions include:

- Setpoint control: Mixer speed based on whether the aeration system is on or off.
- Airflow meter control. Mixer speed adapted to data from an airflow meter.
- Input curve control: Mixer speed adjusted based on any available input that can be defined via five or less points, such as tank level or input flow rate.
- Oxidation ditch control. Mixer speed control based on internal sensing of the aeration system's output. Patented method measuring airflow via propeller torque. Not external airflow meter needed.

Flygt adaptive mixer rental offering

To help utilities avoid unplanned downtime and enable continuous operation of critical plant processes despite maintenance requirements of permanently installed mixing equipment, Xylem offers Flygt Compact Adaptive Mixer rental units.

Featuring a specially designed stand for easy installation, the temporary mixing solution can be lowered into a full tank without any existing mounting infrastructure to begin mixing quickly and efficiently.

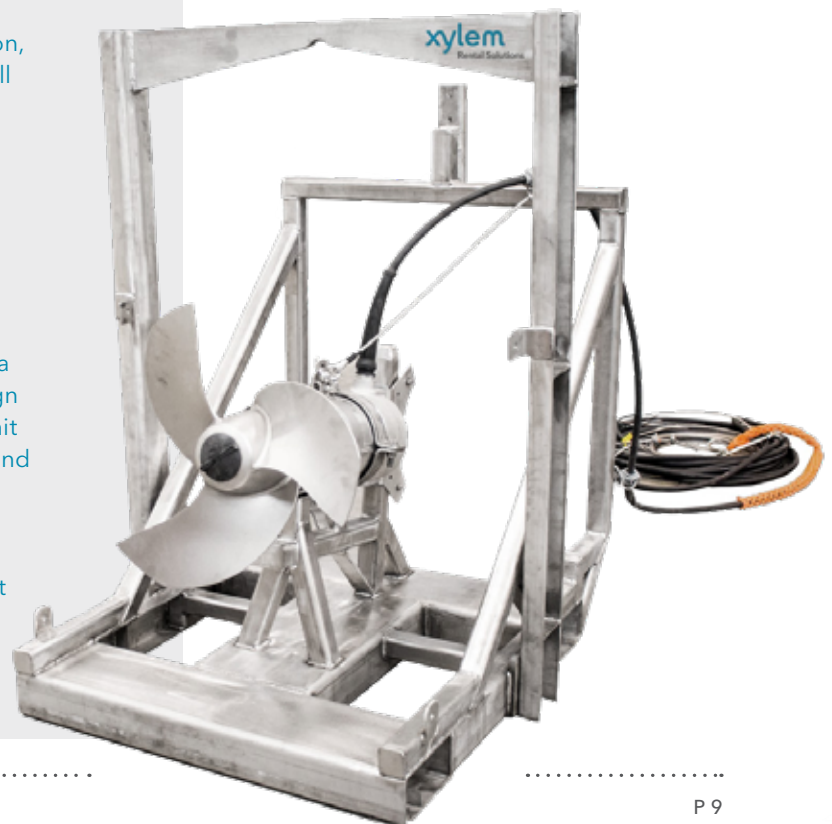
Xylem Rental Solutions' standardized adaptive mixer rental package includes:

Portable mixer stand: The custom-designed stainless steel mixer stand features a sled-like design to provide stability and portability, enabling optimal operation in a horizontal configuration. The overhead lifting bar design aids in tank installations and integral fork pockets permit easy truck loading and unloading for shipment. The stand is optional as the Flygt adaptive mixer can also be mounted directly on existing rail or mast systems.

Adaptive compact mixer: The Flygt adaptive compact mixer built with cast iron and stainless steel features includes a 3 horsepower, 3-phase synchronous permanent magnet motor, and a 3-blade propeller.

Feature: Control electronics inside a dust-free, non-oxidizing environment

- Fairly constant temperature environment
- Eliminate potential errors from sizing, setup and wiring overload.





Feature: Time control

This function is intended for anoxic and anaerobic applications in wastewater treatment processes. To decrease energy costs, this function continually cycles the propeller speed between high speed and low speed.

In a system that has multiple mixers, this function sets the propeller speed for all the mixers to the same value. The function is used on its own, or with one or both of the following subfunctions enabled:

Water shortcut prevention

This function runs the mixer on the highest speed when a maximum input flow is signaled, thus preventing the tank from short circuiting.

Clear layer

The function uses a signal from the analog input of the controller to detect when a clear layer has formed. The signal comes from, for example, a turbidity sensor. The sensor is put around 20 cm (8 in) under the surface, unless another distance is more suitable.

CONCLUSION

The only constant in wastewater treatment is change. Whether because of daily variation or long-term population growth, the process demands of wastewater treatment shift constantly. By controlling the output of their mixers, plants can not only realize significant energy savings, but they can be prepared to adapt their mixing to variations and future changes.

Flygt adaptive mixers are simply designed to do more.

