Aeration has been a primary method for treating municipal and industrial wastewater for over a century. It is a natural way to reduce biological oxygen demand (BOD) and control odors. In the SBR process, aeration helps foster nitrification by bubbling air through the mixture of wastewater and activated sludge, encouraging the multiplication of aerobic microbes which consume nutrients and convert ammonia into nitrites and nitrates.

The two technologies used for the SBR process are bubble diffused aeration and jet aeration, both of which are among the many types of aeration offered by Evoqua Water Technologies. In bubble diffused aeration, oxygen is introduced in the form of air bubbles pumped through a grid of diffusers arrayed across the bottom of the tank. In jet aeration, this is done at high speed and pressure through a row of mixing nozzles, which provide a mixing capability independent of and in addition to aeration.

Fine bubble membrane diffusers are known for high oxygen transfer efficiency, but...

Bubble diffusion technology has evolved from a simple pipe with air holes to coarse bubble designs to today’s fine bubble designs that use ceramic, membrane and other diffuser materials. Fine bubble diffusion systems tend to be more energy efficient than their coarse bubble predecessors.

Membrane diffusers achieve high oxygen transfer efficiency by producing the fine bubbles which offer more air/water surface interface, and thus more oxygen transfer, than any other aeration device for a given power input. Properly maintained, they provide high efficiency and low energy costs.

However, the activated sludge environment, and SBR particularly, is not kind to diffusers since biomass finds the membrane surface an ideal place to grow. New diffusers lose 35% to 50% efficiency in wastewater compared to clean water. Subsequent fouling will progressively degrade efficiency an additional 30% to 50%. Accordingly, fine bubble diffusers must be monitored closely and cleaned frequently, requiring that tanks be taken out of service and drained at six-month to two-year intervals. In addition, membranes wear out and must be replaced every four to ten years. These operations must be performed in-basin, with associated hazardous confined space and safety requirements.

Jet aeration provides high efficiency with additional advantages.

Jet aeration combines high oxygen transfer efficiency with a wide range of other features that provide significant lifecycle advantages over diffused aeration in SBR applications. Evoqua’s VARI-CANT® Jet Aeration Systems used in OMNIFLO® SBR systems are driven by pumped mixed liquor recirculated through each liquid nozzle of the system’s many compound jet assemblies. Air is delivered to the outer nozzle of each jet by conventional blowers. The jet aeration system thus has the flexibility to either aerate (pump and blower) or mix (pump only). Air to the system can be infinitely varied or completely shut off, and the pumps will provide the required mixing action, enhancing process control. The denitrification achievable can cut total aeration power demands by over 35%.

Flexibility

In applications requiring nitrogen removal (denitrification), fine bubble diffuser systems require a separate mixer(s) for anoxic mixing. Jet aeration’s ability to provide either aeration or anoxic mixing, independently, eliminates this need. Further, jet aerators can receive any amount of air flow from zero to 80 SCFM per nozzle in the normal course of operation.

Fine Bubble diffusion systems offer high efficiency but require frequent (annual) basin draining for membrane cleaning, while influent flow is diverted.
Robustness

Jet aeration can accommodate an extremely wide range of aeration gassing rates without damage. By comparison, the fine bubble diffuser membranes are subject to stretching or tearing if badly fouled or sent excessive gassing rates. Any breach in diffuser membranes or piping can allow mixed liquor to enter the diffuser grid system, causing clogging and potential catastrophic failure as solids plug pipes and other membranes. Further, fouled diffusers impose as much as 0.7 psi additional headloss on the blower discharge pressure, increasing total power over 10%.

Conversely, the jet aeration system (including air line) is designed to be filled with mixed liquor routinely, without adverse effects. The mixed liquor is simply pushed out through the nozzles when the pump and blower are turned back on.

Clean and dirty water transfer efficiency

Fine bubble diffusers are easily the most efficient aeration technology available in clean water. However, much of that efficiency is negated in dirty water (i.e., field conditions). The ratio of field-to-clean-water aeration efficiency is the alpha value. Various factors suppress efficiency of diffusers significantly, including: 1) the surfactants and dissolved organics found in wastewater, 2) increasing MLSS levels, and 3) membrane fouling. This is why diffuser performance is minimal in highly loaded (higher F:M) reactors or during Aerated Fill in Batch Reactors, when soluble organics and surfactants are most concentrated. It is critical to test industrial wastes for the suppressive alpha effect on diffusers, where efficiency reductions up to 75% can occur due to surfactants or defoamers. In these instances, the diffuser efficiency is never greater than that of an old uncleaned membrane system in a municipal aeration basin.

Jet aerators typically exhibit only mild reductions in efficiency in various wastewaters. This is due to the high local liquid velocities in the jet air/liquid discharge plumes, which strips away accumulated surfactants from the air/water interface, allowing oxygen transfer to continue. In fact, some industrial wastes have been shown to actually increase jet aeration efficiency by intensifying jet shearing action and forming massive quantities of micron-sized bubbles.

One of the evaluation methods used in Great Britain applies a standard aeration efficiency test but adds 5 mg/L of anionic detergent to clean test water in order to reproduce actual wastewater aeration conditions as closely as possible. Extensive testing in this medium concluded alpha factors for jet aeration at 0.9 (or 10% suppression of oxygen transfer) and for fine bubble diffusers at about 0.5 (or 50% suppression). The English test data is reflected in the commonly recognized alpha values for fine bubble diffusion of 0.4 to 0.6, compared to 0.7 to 0.9 for jet aeration.

Numerous test results reported by Dr. Mike Stenstrom at UCLA, one of the premier independent experts on aeration in the world, found 40% immediate aeration loss for clean diffusers, followed by a further 30% efficiency loss within the first year of operation. Since jets require a recirculation pump and diffusers require mixers (in SBRs), the net power usage is similar, as long as diffusers are cleaned regularly.

Fine-bubble diffuser efficiency drops over time and as they foul their bubbles become larger. Regularly cleaned diffusers have lower efficiency than new ones, and with time they inevitably require replacement. Adapted from Stenstrom and Rosso, 2009.


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Thus fine bubble diffusers can be significantly more efficient than jets if cleaned annually; according to Stenstrom, associated costs include: 1) typically one-week-per-basin for draining/cleaning/refilling, 2) an extra batch reactor basin or a flow diversion lagoon to serve while the cleaned basin is out of service, 3) a diffuser headloss-and-efficiency off-gas monitoring system to alert the operator as to when cleaning is again required.

**Long-term maintenance**

As stated above, fine pore diffusers lose 40% efficiency the day they are placed into service, and require annual maintenance and cleaning, and replacement every 4 – 7 years to restore transfer efficiencies. The rate of performance degradation depends on temperature, mixed liquor solids concentration, the presence of surfactants or other chemicals in the wastewater, gassing rates, mineral composition of wastewater, and many other factors. Further, the additional mixers required are located in the basin and must be removed for maintenance.

Jet aerators require no routine maintenance other than a 5-minute monthly flushing, which is typically automated and performed when the jets are not required. Flow passages are large and smooth and are not subject to biofouling. Jets are made of FRP or 316 SS and thus have a life expectancy in excess of 50 years with no reduction in oxygen transfer efficiency. Jet recirculation pumps do require occasional oil or bearing changes, and pump impellers sometimes need to be changed after a number of years.

**Site layout**

Because a typical jet aeration system has no electromechanical parts or membranes to maintain within the basin, any routine maintenance can be automated and is performed outside of the basin, with no interruption of SBR operation. In an SBR layout, this feature allows all electro-mechanical equipment including pumps, blowers and valves to be located inside one building near the tanks, along with the process control system. This configuration also allows for flat or domed tank covers when desired.

**CONCLUSION: TWO GREAT OPTIONS – WHICH IS BEST FOR YOU?**

The aeration and mixing system is the heart of any Activated Sludge process. Selection of an aeration and mixing technology for an SBR system must take into account the facility’s effluent permit, its overall requirements for energy use, maintenance costs and implications, and day-to-day performance. Facilities which are particularly sensitive to energy costs may find Fine Bubble Diffusion a necessary choice, but must also commit to:

- Significant maintenance costs (annual basin drawdown, diffuser cleaning, and concurrent influent flow diversion),
- Higher installation costs (which may include a spare basin for service while another is being cleaned), and
- A much shorter system life cycle.

In most applications, however, jet aeration emerges as the choice that combines high operating efficiency with flexibility, minimal installation and maintenance costs, low energy costs, and over 50 years of long-term reliability.
700 SUCCESSFUL SBR INSTALLATIONS & COUNTING

Evoqua’s SBR systems with Jet Tech technology have helped municipalities and industries overcome wastewater challenges for 35 years including 700 successful installations. Today, Evoqua’s OMNIFLO® and OMNIPAC® SBR systems are successfully treating wastewater in plants ranging from 0.01 MGD to 60 MGD. The design flexibility empowers engineers. The simplicity of operation puts operators at ease. Over 700 satisfied customers is just the beginning. For more information, visit www.evoqua.com/jettech.