FINE BUBBLE DIFFUSED AERATION SYSTEM DESIGN FEATURES

FLOW CONTROL ORIFICE

The porous ceramic and flexible membrane disc diffusers include a factory drilled flow control orifice in the diffuser holder to control and balance airflows. The orifice is sized to create additional headloss so that air flows uniformly throughout the distribution system and air exits each diffuser at nearly the same air flow rate per diffuser.

Flowing gasses take the path of least resistance and flow to a point of lower pressure. Lower pressures exist in long distribution systems near the dropleg as opposed to the farthest point from the dropleg because of the friction headloss in the distribution piping. Lower pressures can exist at other points in the system when some diffusers are higher than the common reference plane (varying static submergence). Lower pressures can also exist from diffuser to diffuser due to slight differences in manufacturing. Without orifice flow control, air will flow through the distribution piping and exit at the diffusers with the lowest pressure. Excess air will exit the lower pressure diffusers until the increased headloss equals the total remaining system headloss.

To prevent or minimize this undesirable situation, orifice flow control (additional headloss) is added at the diffuser. Experience has shown that the individual orifice headloss at each diffuser should be at least 2.5 times greater than the distribution header friction headloss with a minimum of 1.0 inches water column (actual compressed conditions). This criterion will help ensure that the individual diffusers and orifice will control the airflow rate rather than the relative position of the diffusers on the distribution header.

TAPERED AERATION SYSTEMS
(See drawing 99-107)

OXYGEN GRADIENT
In an activated sludge process, oxygen demand can vary dramatically throughout the aeration basin. In a basin with a high length to width ratio, oxygen demand will typically be greatest at the head of the basin, where the concentration of organics is the highest. As the waste travels the length of the basin, organics are oxidized and oxygen demand drops off, reaching a low point at the tail end of the basin. This declining oxygen demand is defined as the oxygen gradient. Oxygen gradients can also exist in basins that utilize non-uniform step feed, contact stabilization processes and advanced Biological Nutrient Removal (BNR) processes.

NON-TAPERED AERATION
In a non-tapered aeration system, the density of diffusers on the basin floor is uniform throughout the entire basin. This type of configuration is suited for complete mix reactors. When a non-tapered aeration system is applied in a reactor that is not complete mix, valves must be throttled to match the oxygen gradient and prevent over-aeration at the tail of the basin. Once the valves are throttled, any change in the overall blower output will require re-throttling of the aeration valves.

In a non-tapered aeration system, with valves throttled to match the oxygen gradient, the unit air rate per diffuser will be high at the head of the basin and low at the tail of the basin. Oxygen transfer efficiency of fine bubble diffused aeration system increases as the unit air rate per diffuser decreases. Therefore, the aeration system will be operating least efficiently at the head of the basin, where the majority of the air is being distributed.

TAPERED AERATION
In a tapered aeration system, the distribution of aeration equipment is varied proportional to the oxygen demand gradient. The use of tapered aeration results in “passive air distribution”. In other words, the unit air rate per diffuser is the same throughout the entire basin. More consistent oxygen transfer efficiency, throughout the entire basin, optimizes the overall system efficiency. A change in the overall blower output results in an apportioned change throughout the entire basin.

BENEFITS OF USING TAPERED AERATION
Fine bubble diffusers are designed to operate over a certain range of unit air rates. For example, the SANITAIRE® 9” membrane disc diffuser has a recommended operating range of 0.5 – 4.0 SCFM/diffuser. In a non-tapered aeration system, high and low unit air rates per diffuser, at the head and tail end of the basin respectively, limit the turn-up and turndown capacity of the system. With passive air distribution, there are no diffusers operating at excessively high or low unit air rates. Thus, the overall range of operation is maximized, while conforming to both the recommended operating range of the diffusers and the oxygen gradient of the wastewater.

Design approaches using tapered aeration with passive air distribution result in a higher overall system transfer efficiencies, lower air requirements and minimized blower pressure. Tapered aeration minimizes the need for valve throttling, which is both ineffectual and a heavy burden on the plant operator. Ultimately, tapered aeration provides a substantial reduction in power consumption and operating expenses.

AUTOMATED DISSOLVED OXYGEN CONTROL
One benefit of apportioned changes in air distribution is that automated D.O. control can be accomplished through simple changes in blower output, either through varying motor speed or modulation of the blower inlet valve. Automated D.O. control, in a system which does not utilize tapered aeration and passive air distribution, requires the addition of modulating butterfly valves, at each aeration dropleg. Achieving a balance between the blower output, to match system oxygen demand and modulation of the

individual butterfly valves to equalize system pressure, is cumbersome and oftentimes ineffective.

OTHER CONSIDERATIONS

Diffused aeration systems serve the functions of oxygen supply and solids suspension. At sufficient air rates, enough turbulence is imparted to keep solids in suspension. Normally, the mixing air rate defines the lowest air rate for the design. Commonly accepted mixing criteria, for a fine bubble aeration system, is defined as 0.12 SCFM/ft^2 (2.0 NM^3/M^2).

In basins with a high length to width ratio or applications treating waste with low organic strength, the air required for mixing may exceed the air required to satisfy oxygen demand at certain points within the basin. This condition is defined as "mixing limited". Under mixing limited conditions, even a tapered aeration system may require some valve throttling. However, valve throttling is minimized through the use of tapered aeration.

Please contact Sanitaire to obtain current information regarding diffuser and orifice headlosses or for a customized tapered aeration system design.