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AERATION SYSTEMS—RESPONSIBILITIES OF MANUFACTURER, DESIGNER, AND OWNER

Over the past 20 years, aeration system design and operation have become more important and have received increased scrutiny among environmental engineering professionals. Aeration systems are an important requirement for normal activated sludge plant operation and may comprise 40–60% of the energy cost of running a treatment plant. The development of the ASCE Clean Water Standard (1983, 1991), U.S. EPA's fine pore diffuser handbook (1989), the recent ASCE Standard Guidelines for In-Process Water Testing (1996), and the upcoming ASCE Guidelines for Quality Assurance for Installed Fine Pore Aeration Equipment have provided badly needed information to help design and operate aeration systems.

In the 1970s clean water performance tests were routinely performed with precision of replicate tests as low as 20%. Different manufacturers and consultants used different procedures that biased results. The choice of a single parameter in the commonly used log-deficit estimation procedure of this period could bias a test result by 25%. If the current Standard and due care are used, it is common to achieve precision of 10% and test results with precision as high as 13% are not rare. Improvements have also been made in process water testing procedures, and the introduction and refinement of the off-gas test procedure have provided a significant advancement in evaluating diffused air systems. Methods have also been developed for testing diffuser materials prior to and after service.

Nevertheless, a number of uncertainties and problems still exist in successful aeration system design and operation. Problems remain in translating clean water results to process conditions. The specification of alpha factors (the ratio of the transfer coefficient in process water to clean water) must be done with the utmost care. A second and newer problem is the interaction of wastewater constituents with diffuser materials.

What is known about alpha factors is that they are functions not only of wastewater characteristics, which was their original intended use, but also of aeration method and process operating conditions. We now know that in municipal wastewater fine-pore diffusers have lower alpha factors than the commonly used "0.8" found in older and some current textbooks. The alpha factor varies with process conditions, including long-term parameters such as the sludge age or F/M. There are spatial and temporal variations in alpha that are dictated by wastewater characteristic variation and system configuration. Coarse-bubble aerators and surface-mechanical aeration devices often exhibit higher alpha values than fine-pore diffusers or other devices that generate fine bubbles. In fact, at high power density, some surface aerators can produce alpha factors that approach 1.0.

It is also evident that temporal changes in aeration system performance may be due to changes in the properties of diffuser materials and/or their fouling in process wastewater. An attempt to account for these changes was initially made in the fine-pore aeration design manual with the use of the fouling factor, *F*. This factor is a dynamic measure and is a function of diffuser material and wastewater characteristics.

The responses of manufacturers, designers, and engineers to the improved knowledge are mixed. Most manufacturers are now more accurately characterizing their clean water performance. Unfortunately, in some cases, the improved testing knowledge has resulted not in improved design and operation, but in allegations of liability for the various parties for failed systems. This raises the question "who is responsible for each aspect of aeration systems design?" Some owners and consultants want to make it entirely the responsibility of the manufacturer. Such attitudes are incorrect and produce indifferent attitudes during the design process ("it is their job—why are we worrying about it?") and wasteful litigation. Manufacturers must be held responsible for the aspects of aeration design that they control. This means clean water transfer performance and mechanical integrity. Manufacturers have no control over wastewater characteristics, process design, or the way their equipment is operated and maintained. Design engineers must anticipate a range of operating conditions and their effects on the aeration system. Alpha factors are strongly affected by process design and operation and by system configuration, as well as wastewater characteristics. Alpha factors cannot be specified by the manufacturer: they must be determined by the design engineer for the range of operating conditions anticipated by the owner. Alpha factors for design are not a single value but ranges of values that occur for different process conditions, times, and locations within aeration tanks. Owners must know and accept responsibility for their operating decisions; for example, dramatically reducing sludge age decreases oxygen transfer efficiency in most aeration systems, which should be considered before making process changes. Information on alpha must be obtained through in-process testing experience or carefully documented data from the literature or other credible sources. Small-scale testing such as laboratory testing has not been a reliable source of data. Both owners and designers should not accept alpha factor claims by manufacturers. In most cases it will be very difficult to hold manufacturers accountable for the alpha factors they might claim, because they cannot control process operation or wastewater characteristics. Consultants who accept manufacturers' recommendations without verifying them are not protecting their clients.

Another important issue that remains the responsibility of the design engineer is the compliance specification of the aeration equipment and the provision of any required scale-up to the actual installation. Typically in the United States, clean water compliance specifications are used. For process water, compliance specifications require considerations of wastewater variability and process loading that lead to substantial uncertainty. If left to the manufacturer, extremely conservative and costly systems will result for obvious reasons, because the manufacturer has little knowledge of the wastewater and process operating conditions. In this situation, it is incumbent on the designer to specify alpha and other process variables within the specification.

Another issue in compliance testing is scale-up. If shop tests are to be performed, it is up to the designer to specify the shop test and to provide the necessary scale-up to field conditions. Manufacturers may be consulted on issues, but it is ultimately the designers' responsibility to ensure proper scale-up. To avoid this problem, some designers specify clean water compliance testing in the field system.

The selection of fine-pore diffuser materials is another important consideration. A variety of materials are being used that have different responses to the contaminants in wastewater—both domestic and industrial. It is remarkable to learn that membrane diffusers are installed in wastewater without prior testing to determine membrane compatibility. Each wastewater can have a different impact on membrane characteristics and life. Unfortunately, membrane compatibility tests cannot be performed quickly. Owners routinely expect membrane life of 3–5 years. Subtle changes in membrane properties that can destroy it in 2–3 years cannot be detected in short-term testing. When planning aeration system design or upgrading, owners and designers must allow sufficient time for testing material compatibility. Manufacturers must become proficient and economical in evaluating their materials. The new ASCE guidelines on quality assurance may be helpful to designers in assuring that materials delivered to the field site are the same as those used in shop tests. Future guidelines may be developed to assist in the evaluation of diffuser materials under a variety of process conditions.

Aeration costs for wastewater treatment plants may continue to decrease as the technology advances and as our understanding of the factors that affect the process is refined and articulated. These cost savings can only be realized, however, if designers, owners, and manufacturers all assume their appropriate responsibilities.

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