



*Technical Bulletin 132*

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Diffused Air Mixing Requirement

by:

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Considerable confusion exists about the ability of diffused aeration systems to mix basins for various treatment processes. In particular, it seems the use of 20-30 cfm/1000 cf of reactor volume is a common criterion without many people realizing how the numbers were derived. For diffused aeration systems, this criterion can create a very unrealistic mixing requirement unless the fundamental criteria are understood and properly applied.

Some examples will demonstrate the problems associated with universally applying cfm of air/1000 cf. "Ten State Standards" for aerobic digester requirements suggest 30 cfm/1000 cf. A key point is the Ten State Standards are guidelines that will ensure proper function in almost any design, and is not always the most optimized solution. The application of these criteria is subject to engineering and analysis interpretation. EDI has been very successful in getting consideration at regulatory agencies for "rational" mixing design criteria.

Let us consider a two basin geometries and the airflow requirements of each:

1. Basin Dimensions = 10ft x 10ft x 10ft (Length x Width x Depth)
  - a. Volume = 1000 cubic feet
  - b. Mixing Airflow per 30scfm/1000ft<sup>3</sup> = 30 scfm of air
  - c. Mixing Airflow = 0.3 scfm/ft<sup>2</sup> of floor area
  - d. Energy requirements = 1.0 BHp<sup>1</sup>
  
2. Basin Dimensions = 10ft x 10ft x 20ft (Length x Width x Depth)
  - a. Volume = 2000 cubic feet
  - b. Mixing Airflow per 30scfm/1000ft<sup>3</sup> = 60 scfm of air
  - c. Mixing Airflow = 0.6 scfm/ft<sup>2</sup> of floor area
  - d. Energy Requirements = 4.0 BHp

The energy requirement to mix the 20 ft deep basin has increased by a factor of almost 4 while the tank volume and air volume was only increased by a factor of 2. As the basin gets deeper, this criterion becomes even more unrealistic due to spatial constraints across the tank floor.

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<sup>1</sup> Based on rule of thumb efficiencies for rotary positive blowers.

The criterion of  $\text{cfm}/1000\text{ft}^3$  has a history that must be recognized before it is applied. This criterion was developed assuming:

1. Water depth of 8 to 10 ft deep was normally associated with the early package plants in this industry.
2. The diffusers were coarse bubble diffusers.
3. The diffusers were arrayed along one side of the tank only.
4. Diffusers 2 ft off the floor.

Using the above assumptions the  $30 \text{ cfm}/1000 \text{ cf}$  was a value that worked well for these package plant units. Broad application of this criterion without reference to depth of tank, type of diffuser, or diffuser location is not appropriate. To utilize this same criterion for all mixing applications does not optimize the design and power requirements of the plant.

By comparison, surface or mechanical aeration systems are based on approximately  $1.0 \text{ Hp}/1000 \text{ cf}$  reactor volume which is a directly proportional factor rather than a squared factor. In many cases, this is the analysis used to justify energy savings for mechanical mixing devices versus diffused air by using deep tanks and an apparent savings based on criteria only.

An example of the type of mixing energy EDI would expect to be required for any aeration system is given in the ASCE and WPCF MOP for wastewater treatment plant design. For fine bubble diffusers applied in a grid or floor cover configuration, they indicate  $0.12 \text{ cfm}$  of air would be required per square foot of floor in activated sludge reactor (Requirements of  $0.05$  to  $0.12 \text{ cfm}/\text{ft}^2$  are suggested by the EPA Fine Pore Aeration Manual). Using this value, you can see our  $10 \text{ ft} \times 10 \text{ ft}$  reactor would have only  $12 \text{ cfm}$  of air total required for mixing regardless of how deep the basin. The value of  $0.12 \text{ cfm}/\text{ft}^2$  is also developed for a given set of conditions.

1. Fine bubble diffusers.
2. Full floor cover application.
3. Typical biological activated sludge system.

EDI suggests the  $\text{cfm}/\text{ft}^2$  is the proper design basis for diffused aeration systems. In applying this  $\text{cfm}/\text{ft}^2$  the following items must be recognized:

1. What type of diffuser is employed?
2. The density and geometry of the diffuser application.
3. What type of material is being pumped, i.e., is the installation in an aeration basin, aerobic digester, sludge holding, etc.?

EDI recommends supplying a maximum flow rate based on scfm per 1000 cubic feet of basin volume to provide a completely mixed environment at peak conditions. It is proposed that the average design condition and recommended operating condition be based upon a basis of scfm per square foot. As a result, EDI would suggest typical mixing values for fine bubble diffusers would be in the general criteria outlined below:

1. Design Conditions
  - a. Aeration basin with primary treatment = 0.12 scfm/ft<sup>2</sup>.
  - b. Aeration basins w/o primary treatment = 0.15 scfm/ft<sup>2</sup>.
  - c. Aerobic digesters with less than 3% sludge concentration = 0.25 scfm/ft<sup>2</sup>.
  - d. Aerobic digester with greater than 3% sludge concentration = 0.3 scfm/ft<sup>2</sup>.
2. Peak Conditions
  - a. Aeration basin with primary treatment = 15 scfm/1000ft<sup>3</sup>.
  - b. Aeration basins w/o primary treatment = 20 scfm/1000ft<sup>3</sup>.
  - c. Aerobic digesters with less than 3% sludge concentration = 30 scfm/1000ft<sup>3</sup>.
  - d. Aerobic digester with greater than 3% sludge concentration = 45 scfm/1000ft<sup>3</sup>.

It is recognized these above values are general guidelines and each design must be evaluated independently. Using the above values as guidelines allows a realistic and rational design basis to be developed for mixing any reactor. Using this scfm of air/ft<sup>2</sup> allows a directly proportional energy level to be used in design regardless of basin depth. This is both realistic and rational because any evaluation of diffuser mixing can demonstrate that vertical mixing is easily achieved, i.e., the bubble will always go up regardless of how deep it is released. Horizontal mixing is much more difficult and requires the same scfm regardless of water depth; therefore, the scfm/ft<sup>2</sup> of floor is a rational design basis.

Coarse bubble diffusers will tend to require slightly more air per square foot of reactor than fine bubble diffusers. This higher air volume is required because the surface area of the bubbles is less, as a result, there is less pumpage of liquid per scfm of air applied. Coarse bubble diffusers create greater turbulence but not as much pumpage per unit of air volume applied. See Technical Bulletin 105 for discussion of mixing capabilities of coarse bubble versus fine bubble.

