

# Diffused Air Mixing Requirements

## Aeration Systems

### Bulletin Brief

### Technical Presentation

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 to 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 only recommendations. 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 basin geometry of 10 ft long x 10 ft wide as an example. Some of the design criteria used can be explained on this basis. With 10 ft water depth in our 10 x 10 ft reactor, we have 1000 cf. On that basis, "standards" suggest 30 cfm of air in order to mix this basin. Energy requirements to do this mixing would be approximately 1.0 BHp using rule of thumb efficiencies for rotary positive blowers. This 30 cfm of air/1000 cf with only 10 ft water depth results in an air volume of 0.3 cfm of air/ft<sup>2</sup> of basin floor area.

Now using the same reactor shape of 10 x 10 let us assume the water depth is 20 ft. This means we have 2000 cubic feet of reactor volume and the air requirement at 30 cfm of air/1000 cf would be 60 cfm of air. A typical energy requirement to deliver the 60 cfm of air would be approximately 4 BHp! Airflow is now 0.6 cfm of air/ft<sup>2</sup> of basin floor area.

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. This points out the unreasonable nature of using cfm/1000 cf. As the basin gets deeper, this criterion becomes even more unrealistic. The criterion of cfm/1000 cf has a history that must be recognized before it is applied. This criterion was developed assuming:

1. Water depth was 8 to 10 ft deep 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 cfm/1000 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 is unrealistic as indicated earlier.

An inspection of the two conditions outlined above shows the use of 30 cfm/1000 cf of reactor volume takes no credit for the fact that twice as much energy is required to pump air to a 20 ft depth as is required to pump air to a 10 ft depth. The criteria has not only doubled the air volume but doubled the pressure as well; creating an increase of 4 in the energy level as outlined above.

By comparison, surface or mechanical aeration systems are based on approximately 1.0 Hp/1000 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 we would expect to really 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 cfm of air would be required per square foot of floor in activated sludge reactor (Requirements of 0.05 to 0.12 cfm/ft<sup>2</sup> are suggested by the EPA Fine

Pore Aeration Manual). Using this value, you can see our 10 ft x 10 ft reactor would have only 12 cfm of air total required for mixing regardless of how deep the basin. The value of 0.12 cfm/ft<sup>2</sup> 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 cfm/ft<sup>2</sup> is the proper design basis for diffused aeration systems. In applying this cfm/ft<sup>2</sup> we feel the following items must be recognized:

1. What type diffuser is employed?
2. 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.?

As a result, EDI would suggest typical mixing values for fine bubble diffusers would be in the general criteria outlined below:

1. Aeration basin following primary treatment approximately 0.05 to 0.12 cfm of air/ft<sup>2</sup> of reactor floor area.
2. Aeration basins with no primary treatment approximately 0.1 to 0.15 cfm of air/ft<sup>2</sup> of reactor floor area.
3. Aerobic digesters with only bio sludge less than 3% approximately 0.2 to 0.25 cfm of air/ft<sup>2</sup> of reactor floor area.
4. Aerobic digester with some primary sludge and/or solids of 3 to 4% would suggest 0.3 cfm per square foot.

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 cfm 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 cfm regardless of water depth; therefore, the cfm/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 cfm of air applied. Coarse bubble diffusers create greater turbulence but not as much pumpage per unit of air volume applied. See Technical Bulletin Number 105 for discussion of mixing capabilities of coarse bubble versus fine bubble.

For specific information on aeration system selection considerations, contact EDI at 573-474-9456.