FALLING INTO AN

AERATION TANK

DO YOU SINK OR SWIM?

Presented at the Annual Conference

Indiana Water Pollution Control Association

August, 1985

by

Patrick L. Stevens

Indianapolis Department of Public Works

FALLING INTO AN AERATION TANK

DO YOU SINK OR SWIM?

Background

One of the most common questions that gets asked at a wastewater treatment plant is "I wonder if a guy would float or sink if he fell into an aeration tank?" The question is usually asked when operators are leaning against the handrail around the tank and at least one of the operators knows someone who knows someone who fell in or they heard about a dog that fell in that tumbled around like clothes in a washing machine. The arguments I have heard seem to involve either the effect of bubbles on the density of the water or the strength of the current overcoming one's ability to swim.

The school of thought on the effect of bubbles on the density of water is that aeration bubbles occupy so much volume that a cubic foot of water would weigh, perhaps, 55 pounds instead of 62 pounds. With such low density the buoyant forces could not keep a person afloat and he would sink.

The people who make the strong current argument say that the circulating current in an aeration tank moves so fast that a person cannot swim against it, and a person would be sucked under when he nears the downward side of the tank.

Of course, people argue both ways on the issue and the nice thing about these arguments is that people rarely fall into the tanks, and no one is convinced that his argument is wrong.

The opportunity to prove or dispel these theories presented itself in 1981 during a performance test to measure the oxygen transfer efficiency of Water Pollution Control Corp. (Sanitaire) coarse bubble diffusers. The test was conducted as part of the EPA funded expansion of the Richmond, Indiana, Wastewater Treatment Plant. Specifications for the air diffusion system are included as attachment A.

The Test Tank

Performance testing is a common requirement for aeration equipment manufacturers, and Sanitaire had constructed a permanent facility for their own equipment testing program and performance tests. The tank was intended to represent a typical aeration tank cross section, and its dimensions were 30 ft. x 6 ft. by approximately 20 feet deep. (Figure 1) The tank and associated equipment was set up to handle a wide range of air flows, water depths, and location of air headers on the side or center of the tank. This test was set up with the header in the center of the tank with a 15-foot water depth and 13-ft.submergence of the diffusers. Tests were to be conducted at air flows of 55, 76.7, and 99 SCFM/1000 cu. ft. The tests were to determine clear water oxygen transfer coefficient (Kla20), percent oxygen absorption and overall oxygen transfer rates (pounds/day/1000ft).

The Static Test

The static test was to determine if water's buoyancy is reduced by the presence of bubbles. The object is to observe how far into the water a body floats with and without bubbles. The theory is that the less bouyant the water becomes, the deeper into the water a body sinks. The same principle is used by a floating hydrometer that is used to measure the sugar content of a batch of beer or antifreeze content in a radiator.

The test was conducted by floating in the water above the diffusers and noting the location of the water line with no aeration and then with aeration. (See Figure 2) The aeration rate used was approximately 76 SCFM/1000 cu. ft. With no aeration, the water line stablized at the bottom of the test subject's ear lobe; and with aeration, the subject sank up to the top of his ear. The average circumference of the subject's head at the ear lobe is 22.25 inches, and the distance from the top to bottom of the ear lobe is 2 inches. The volume occupied by this portion of the subject's head is .045 cu. ft. The subject weighed 175 pounds and the volume of water displaced by 175 pounds at 20 C is 2.8 cu. ft. The reduction in buoyancy is proportional to the displaced volume or:

reduction in buoyancy = .045/2.8 = .016 = 1.6%

This test only addresses the apparent buoyancy experienced by the test subject and does not address the effect of upward water velocity on the apparent buoyancy. A more rigorous analysis would probably show that bubbles occupy more than 1.6% of the water's volume above the diffusers, and the upward velocity of the water offsets a portion of the buoyancy loss.

The Dynamic Test

The dynamic test was to determine if a person can swim against the circulating current in an aeration tank and if he can resist being swept under by the downward current at the wall of the aeration.

The swimming test was conducted at an aeration rate of 76 SCFM/1000 cu. ft and with a tether attached to the test subject. At points nearly above the diffusers, the velocity of the water was predominantly vertical; and the test subject was able to swim faster than the horizontal velocity component. At locations midway between the diffusers and the side wall, the velocity was entirely horizontal; and the test subject was able to maintain his position for periods of 3 to 5 seconds with super-human bursts of swimming strength. At the end of the swimming burst, the subject lost ground and soon arrived at the side wall.

In a zone approximately 4 to 5 feet from the side wall, the circulating velocity was almost entirely downward. The downward forces were so great that even bursts of super-human strength could not prevent the test subject from being swept under water. The test subject submerged to a depth of 7 to 8 feet at which time the tether became taut and resulted in several bruises where the tether was wrapped under his chest. (Figure 3 shows that condition). The test subject extracted himself from this unpleasant position by pulling himself hand-over-hand up the tether; and during this exercise he estimated that 30 to 40 pounds of pull was required. By calculation, the vertical force required to pull out of the water was 13 to 18 pounds. A standard life preserver available at K-Mart (U.S. Coast Guard type II) is rated at a buoyancy of 15 pounds. It appears that the use of the commonly - available life jacket is not adequate for operator protection.

Conclusions

The results of the static and dynamic tests indicate:

1. That apparent loss in buoyancy due to bubbles in the water above diffusers is approximately 1.6% at an aeration rate of 76 SCFM/1000 cu. ft.
2. At this aeration rate, the horizontal velocity of the circulating current matches or exceeds the average person's swimming speed.
3. The downward force of the current at the wall pulled the test subject down with a force of 13-18 pounds. The use of common life jackets may not be sufficient to prevent a person from being swept under at the outside wall of an aeration tank. Vests rated at 20 or more pounds of buoyant life should be used for an average sized male.
4. If a person fell into an activated sludge aeration tank and took no self preserving action, he would circulate around the tank at approximately the same speed as the wastewater.
5. A conscious person who has fallen into an aeration tank could save himself if the aeration tank was equipped with an easily grasped rail attached to the inside of the tank near the water level because the person is swept to the wall of tank before being swept under.

Acknowledgements

This paper would not be possible if not for the assistance and cooperation of Water Pollution Control Corporation, Milwaukee, Wisconsin, makers of Sanitaire air diffusion equipment, and the author's wife, Susan, who held the end of safety tether.

PLS/ddo

0801PS2D

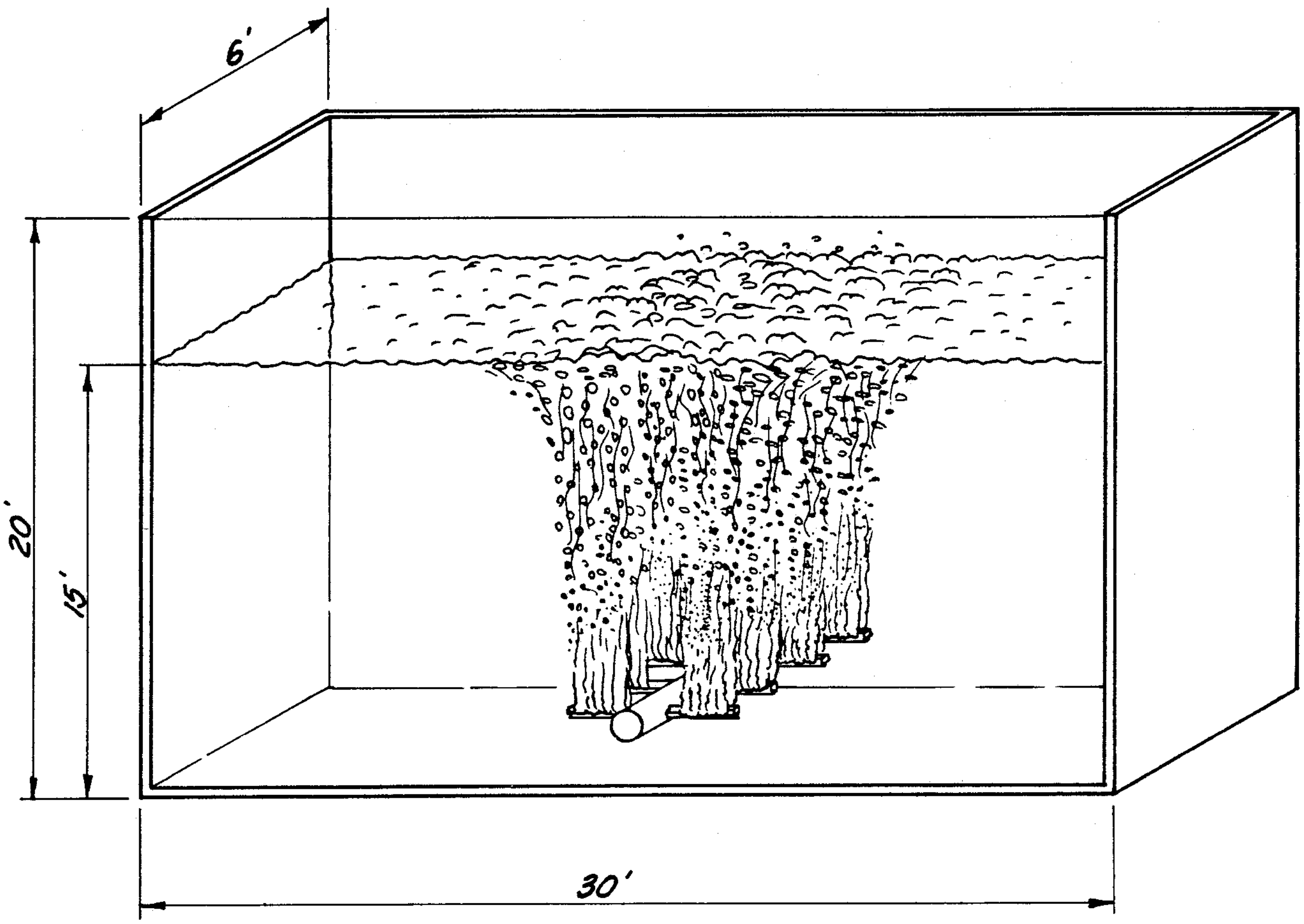


Figure I

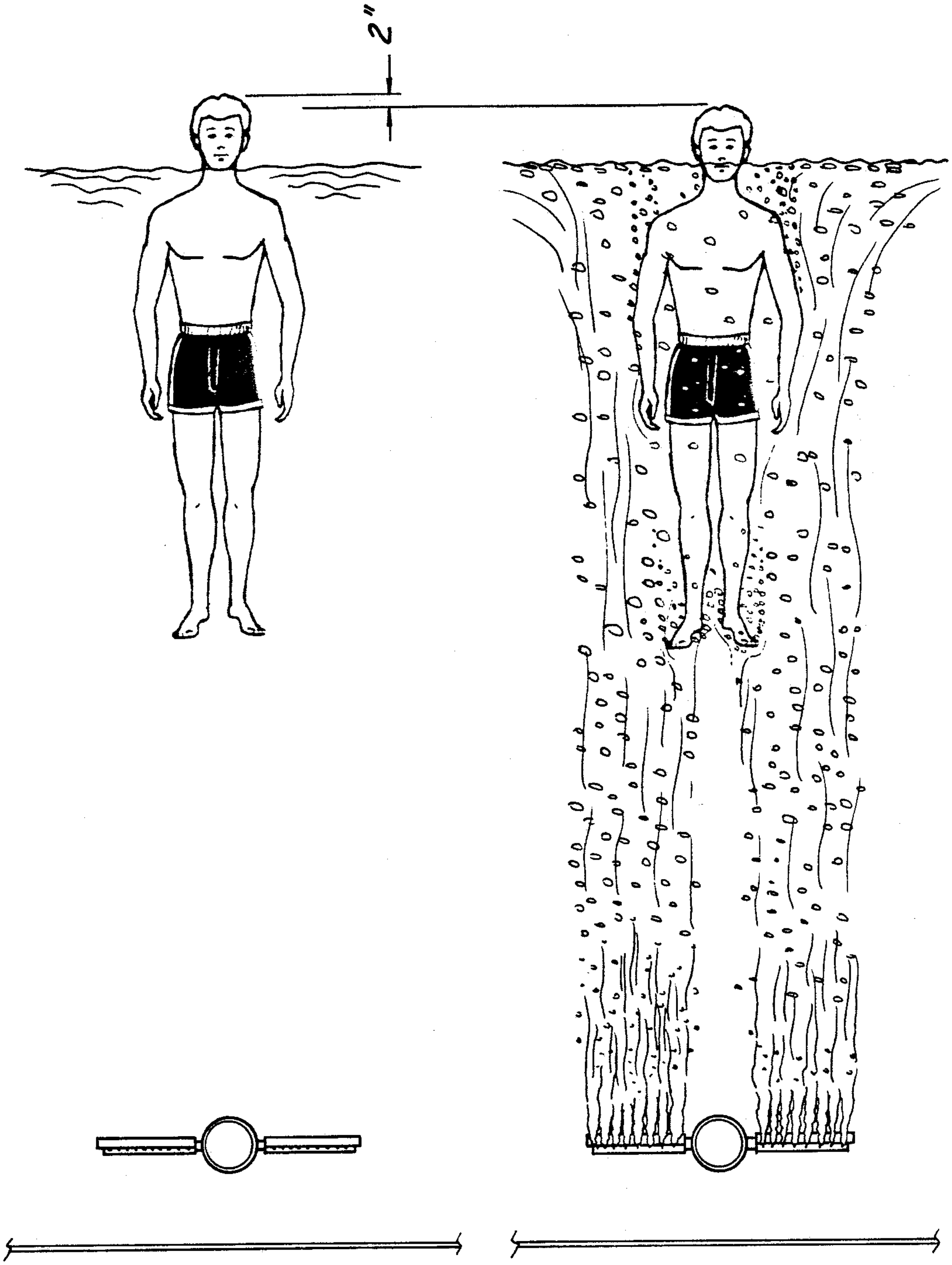


Figure 2

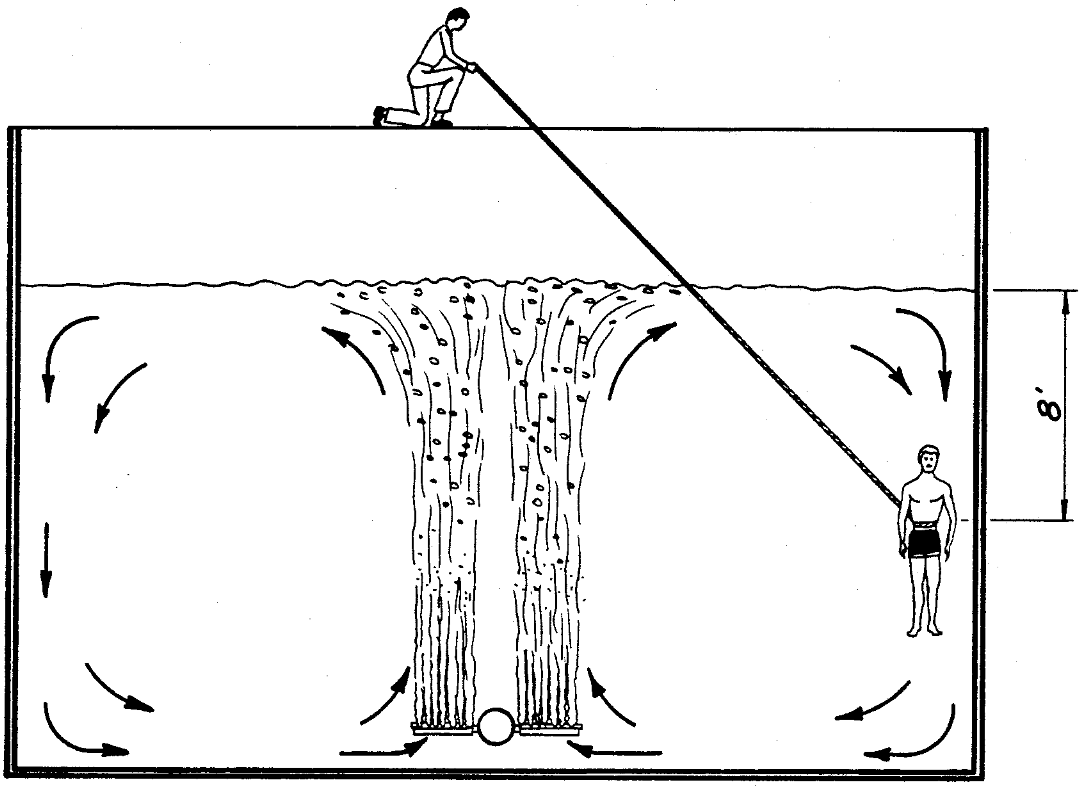
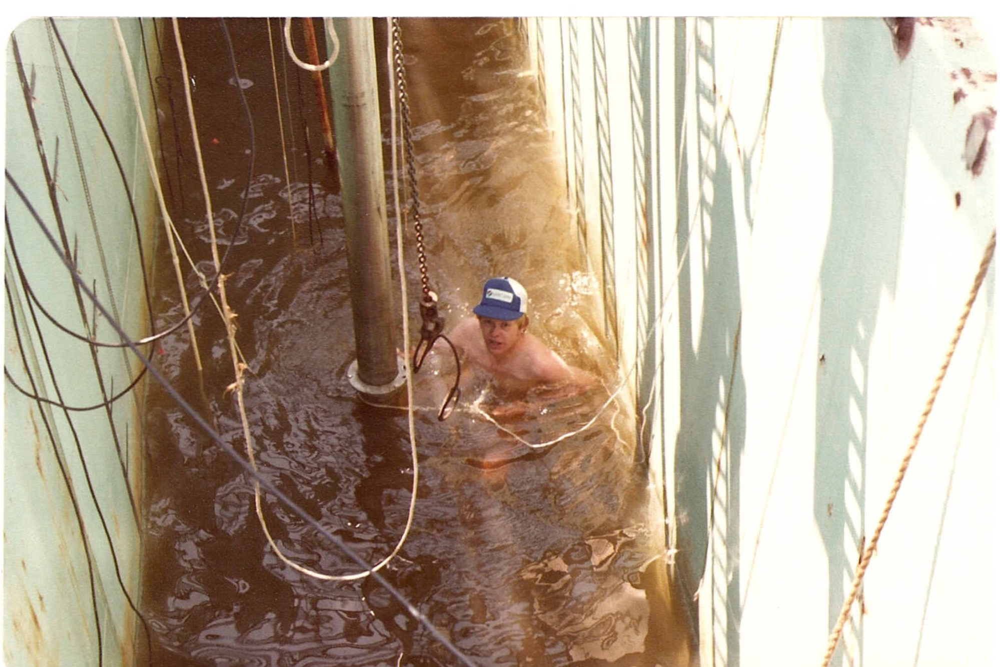


Figure 3

The Sanitaire Test Tank

The Witnesses



The Tank Interior
With No Aeration