Process (dirty) Water Aeration System Efficiency Test Results
Butler County/Lesourdsville WWTP Sludge Digester Tank

Introduction:

The ratio of process, or dirty water, oxygen transfer relative to clean water oxygen transfer, also known as the Alpha factor, is a critical consideration in the design of activated sludge wastewater treatment plants. The Alpha factor varies depending on the aeration process, tank geometry and water characteristics. Alpha factors ranging from 0.3 for fine bubble diffusion up to 0.85 for low speed surface aerators are commonly reported in literature. In general, mixing energy intensive aeration processes have Alpha factors that are higher in comparison to passive aeration processes, such as fine bubble diffusion. The Mazzei AirJection® process is a high mixing energy intensive aeration process.

The Alpha factor for the Mazzei AirJection® process has been tested and determined to be 0.9 in primary clarifier effluent at a municipal wastewater treatment plant. The high concentrations of contaminants in raw primary clarifier effluent have a depressing affect on the Alpha factor for some aeration processes due to the contaminants tendency to impede the diffusion of oxygen across the air/water interface.

Mixed Liquor Suspended Solids (MLSS) can also have a depressing affect on the Alpha factor for some aeration processes. In order to evaluate the affect of suspended solids on the Alpha factor for the Mazzei process, a series of tests were conducted in a sludge digester outfitted with the Mazzei AirJection® aeration equipment.

The off-gas tests were conducted for the Mazzei Injector/Hydro Mechanics aeration system installed in the sludge digester at the Butler County/Lesourdsville WWTP. The sludge digester typically is operated at an MLSS of approximately 17,000 mg/l (19,900 mg/l MLSS, 79% MLVSS on the test days). The tests allowed an accurate indication of the affect of suspended solids on the Alpha factor for the Mazzei AirJection® process.

Test Procedure:

Testing was done following the procedure outlined in the ASCE “Standard Guidelines for In-Process Oxygen Transfer Testing” section **3.0 Off-Gas Method** (relevant pages are attached). To summarize, the oxygen transfer efficiency of the process was determined from the concentration of oxygen in the off-gas from the aerated tank relative to the concentration of oxygen in the feed air (20.95 % vol).

The off-gas was collected under a “hood” with dimensions of 4’ x 8’ with a peak 1.5’ high. 4” thin wall PVC pipe pontoons were attached along the length of the hood to provide buoyancy. The collected off-gas was conducted to the side to the tank via 1” PVC pipe.

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The percent oxygen saturation in the off-gas was measured using a Teledyne Analytical Instruments Model 320P/D Portable Oxygen Analyzer equipped with a built in air pump for sampling. The meter was calibrated with dry air to 20.9% oxygen. After each off-gas sample the meter was recalibrated vs. air and adjusted as needed. The precision level of the 320P/D Oxygen meter is to one decimal point. Therefore, the calculation of feed gas oxygen concentration was rounded to 20.9% rather than the actual oxygen concentration for dry air of 20.946%.

Carbon dioxide was scrubbed from both the calibration air and off-gas samples by drawing them through a solution of 5% NaOH. Moisture was removed by drawing both the calibration air and off-gas samples through a desiccant column filed with a mixture of Calcium Sulfate and Silica Gel. The off-gas was conducted to the meter with ¼" vinyl tubing attached to a ¼" barb tube connector installed approximately 6' from the end of the 1" PVC pipe to prevent back-flow of air into the test stream.

During the process water tests, the tank DO and temperature were measured using a Royce Model 900 Dissolved Oxygen Analyzer calibrated in air following the manufacturers directions. The Royce DO probe was suspended 7' below the water surface hanging under the off-gas collection hood.

Test Data:

To get a profile of the off-gas oxygen concentration across the tank, the collection hood was moved to ten different locations ranging from near the Mazzei Injector on the south side of the tank, across the middle of the tank, to the far northwest corner of the tank. The relative positions of these off-gas collection sites are represented on the attached field data sheets. Each time the hood was moved, the off-gas was allowed to come into equilibrium for about 30 minutes before oxygen concentration measurements were taken.

The off-gas oxygen concentration varied depending on the location of the collection hood in the tank. Please refer to the attached aeration system picture for details of its layout. When the hood was near the sides over the nozzle manifolds, the oxygen concentration was higher, typically around 18%. When further out in the tank away from the nozzle manifolds, the off-gas oxygen concentrations were as low as 7.5%. The probable reason for the high readings near the manifolds is the presence of "burp" bubbles that occasionally are produced as coalesced air in the manifolds exits.

Variations in off-gas oxygen concentrations are common to most aeration tanks and simple averaging normalizes the data. If practical, it would be preferable to do off-gas testing by covering the entire tank, which of course would provide an exact average of the off-gas oxygen concentration. Normalizing the off-gas data by averaging the measurements taken with the movable hood gives a good estimate of the expected off-gas of the entire tank.

Results:

Off-gas Test Results
Butler County/Lesourdsville WWTP Sludge Digester

Test #	Time/Date	Sample Location	% O2 Feed Air	% O2 Off-Gas	Dissolved Oxygen	Water Temp, C
1	1/19 1130	1	20.9	18.0	1.53	17.3
2	1/19 1215	2	20.9	18.0	0.60	17.3
3	1/19 1300	3	20.9	14.0	0.58	17.4
4	1/19 1410	4	20.9	13.6	0.33	17.4
5	1/19 1448	1	20.9	17.4	0.29	17.5
6	1/20 0945	5	20.9	17.5	0.41	18.3
7	1/20 1025	6	20.9	19.2	0.38	19.1
8	1/20 1050	3	20.9	13.8	0.28	19.2
9	1/20 1120	4	20.9	10.9	0.63	19.3
10	1/20 1430	7	20.9	7.9	0.40	19.5
11	1/20 1500	8	20.9	7.5	0.23	19.6
12	1/20 1530	9	20.9	11.1	0.60	19.6
13	1/20 1545	10	20.9	17.7	0.23	19.6
Averages				14.4	0.50	18.5
Note: Refer to attached drawing for sample location details						

The average off-gas oxygen concentration for the 13 measurements that were conducted was 14.4% oxygen, or an oxygen transfer efficiency of approximately 31%. The average dissolved oxygen (DO) concentration under the hood was 0.5 mg/l, and the average water temperature was 18.5 °C.

The calculated clean water oxygen transfer efficiency of the installed aeration system as it is currently operating (15 PSIG injector inlet pressure and 130 SCFM air feed per Model 12050 12" injector) is approximately 33%. This transfer efficiency was estimated with the Mazzei system design spreadsheet (attached) using the average DO and temperatures of 0.5 and 18.5 °C respectively, and Beta and Alpha factors of 1.0. This spreadsheet uses SOTR calculation tables derived directly from the SOTR testing performed and certified by GSEE Inc. Copies of the GSEE test report are available.

The Alpha factor can be calculated by dividing the calculated clean water oxygen transfer efficiency (as outlined above) into the measured transfer efficiency in dirty water determined from the off-gas testing. **In this case, the test results indicate that the Alpha under the operating conditions on 1/19/2006 and 1/20/2006 in the sludge digester at Butler County is approximately 0.95.**

Conclusion:

This measured Alpha factor of approximately 0.95 in process water with high-suspended solids concentration, ***(19,900 mg/l MLSS, 79% MLVSS on the test days)***, represents one end of the spectrum relative to the affect of contaminants/suspended solids on the Alpha factor for the Mazzei aeration process. The Alpha factor of 0.9 that has been determined using primary clarifier effluent at a municipal WWTP with high contaminant concentrations, represents the other end of the spectrum.

Based on the sludge digester Alpha factor of approximately 0.95 and the primary clarifier effluent Alpha factor of 0.9, it is reasonable and appropriate to use the 0.9 Alpha factor for Mazzei Airjection® aeration system design and sizing.

RMM
5/2/2006

Mazzei Injector Corporation AirJection System

Oxygen Transfer Rate & System Design Calculation

Prepared For:	**Hydromechanics**		
Project:	**Butler County Sludge Digester Off-gas Testing**		
Purpose For Aeration:	**Alpha Estimation**		
Date: 05/2/2006	**Revised to reflect actual injector inlet pressure**		
Aeration Basin Operating Conditions			
Water Depth (min entry is 5 ft)	**ft**	**18**	
Water Temperature	**C**	**19**	Average for all 13 data sets
Operating Dissolved Oxygen	**mg/l**	**0.5**	Average for all 13 data sets
Injector Operating Conditions			
Injector Operating Pressure	**PSI**	**15**	**Measurred by C. Cooley w/ calibrated gauge**
Injector Model & Number Of Injectors	12050	2	
Circulation Rate	GPM	5051	
Air Suction Capacity/Injector	**SCFM**	130	Measured w/ Anemometer
Site Elevation	**ft**	600	
Corrected Suction Capacity	**SCFM**	125	
Aeration System Operating Parameters			
Gas/Liquid Ratio	**Vg/Vl**	**0.37**	**SCFM Air/CFM of Water Circulated**
SOTR @ Operating Pressure/Depth	#'s/hour	**1.80**	#'s O2 Transferred/hour PER 100 GPM Circulated
Standard Aerator Efficiency**, SAE**	#'s/WHPhr	**2.06**	@ 0 mg/l DO, 20 C, 1.0 ATM(A) Press, 100% Pump Efficiency
Beta		1.00	Assumed
Alpha		1.00	Assumed
OTR @ Operating Temp & **DO**	#'s/hour	1.72	#'s O2 Transferred/hour PER 100 GPM Circulated
Aeration System Operating Efficiencies			
Actual Oxygen Transfer Rate	#'s/hour	86.73	
Actual Oxygen Transfer Percent	%	32.76	
Injector Level Above Water	Feet	8	
Water Horsepower Requirement	WHP	54.40	
Pump Efficiency	%	71	Pump & Motor Efficiency
Brake Horsepower Requirement	BHP	76.61	
Aerator Efficiency	#'s/BHPhr	1.13	Based On Maximum Delivery Capability
Nozzle Selection			
MTM Nozzle Model	Model #	60	
Number of MTM Nozzles/Injector	#	8	
Design Back Pressure	PSI	2.9	
Nozzle Submergence Depth	Feet	18	
Estimated Piping Head Loss	PSI	0.5	
Calculated Exit Velocity	ft/s	18.4	Design for 15-20 ft/s
Total Injector Outlet Pressure	PSI	2.9	

References:

Wastewater Engineering, Metcalf & Eddy, Third Edition

Water Pollution Control Federation, Manual Of Practice FD-13

American Society of Civil Engineers (ASCE): Measurement of O2 Transfer In Clean Water, 2d Edition

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ASCE STANDARD

American Society of Civil Engineers

Standard Guidelines for In-Process Oxygen Transfer Testing

ASCE