Example Calculations
Evaluation for Fine Bubble Aeration System

AERATION SYSTEM DESIGN FOR PEAK LOADINGS

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Example Calculations
Evaluation for Fine Bubble Aeration System

Input Data & Design Parameters for Biological / Chemical Process Systems

Design Plant Flowrate	4,000,000	gpd	15,141.60	m3/day
Design COD influent concentration	800.0	mg/l		
Design COD effluent concentration	450.0	mg/l		
Design BOD influent concentration	240.0	mg/l		
Design BOD effluent concentration	20.0	mg/l		
Design NH4 influent concentration	35.0	mg/l		
Design NH4 effluent concentration	5.0	mg/l		
Pre-Determined AOR Value to be Applied	12,000.0	lbs/day	5,443.2	kg/day
Pre-Determined Oxygen Uptake Rate to be Applied	0.000	mg/l/hr		

CLIENT INPUT VALUES

Process Design Values

Lbs of Oxygen required per lb. Of BOD removed	1.10	lbs O2/lb BOD	0.499	kg O2/kg BOD
Lbs of Oxygen Required per lb. Of NH3 removed	3.80	lbs O2/lb BOD	1.724	kg O2/kg BOD
MLSS Concentration at Design	2300	mg/l		
Food to BioMass ratio F/M	0.20			

BIOLOGICAL PROCESS PARAMETERS

Oxygen Transfer Efficiency Values

Diffuser distance from bottom of tank	0.50	ft.	0.2	m
Diffuser Depth (Dp)	15.5	ft.	4.7	m
Site Barometric Pressure (Pa)	29.00	in Hg	14.24	psia
Barometric Pressure at Mean Sea Level (Pmsl)	29.92	in Hg	14.70	psia
Surface Oxygen Saturation at 20 C (Cs)	9.09	mg/l		
Surface Oxygen Saturation at Temp (Cst)	10.10	mg/l		
Submergence Saturation of Diffuser at Depth (Cd)	10.30	mg/l		
Dissolved Oxygen Level (DO)	2.00	mg/l		
Waste Water Temperature (T)	64.4	F	18.0	C
Alpha Factor	0.45			
Beta Factor	0.950			
Theta Factor	1.024			
Corrected Saturation at Temperature (Ccr)	11.4444	mg/l		

SITE CONDITIONS

ENGINEER / PILOT DATA ADJUSTMENT FACTORS

Blower Parameters for Horsepower Sizing

Inlet Blower Air Temperature	100	F	37.7	C
Existing Airflow at design conditions	0	scfm		
Density of Air at Sea Level and 70F	0.075	lbs/ft^3		
Density of Air Correction factor	0.912			
Corrected Density of Air at Site Elevation & Temp	0.0684	lbs/ft^3		

Input Parameters for Post Aeration Systems

Solution Transfer Efficiency Factor		Range (1.10 - 1.40)
Influent Dissolved Oxygen Concentration		mg/l
Required Effluent Dissolved Oxygen Concentration		mg/l

Example Calculations
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RECTANGULAR TANK DIMENSIONS

US Units

US UNITS

Tank	Length feet	Width feet	Water Depth feet	Aeration Surface Area sq. ft.	Conical Bottom Volume cubic feet	Aeration Dimensional Volume cubic feet	Aeration Liquid Volume gallons	AOR Distribution Percentage
1	100.00	40.00	16.00	4,000		64,000	478,720	25%
2	100.00	40.00	16.00	4,000		64,000	478,720	25%
3	100.00	40.00	16.00	4,000		64,000	478,720	25%
4	100.00	40.00	16.00	4,000		64,000	478,720	25%

AOR PROPORTIONING

4 Number of Tanks	16,000 sq.ft.	256,000 cuft	1,914,880 gallons	100%

SI Units

SI UNITS

Tank	Length meters	Width meters	Depth meters	Aeration Surface Area sq. meters	Conical Bottom Volume meter^3	Aeration Dimensional Volume cubic meters	Aeration Liquid Volume liters	AOR Distribution Percentage
1	30.48	12.19	4.88	372	0	1,812	1,811,955	25%
2	30.48	12.19	4.88	372	0	1,812	1,811,955	25%
3	30.48	12.19	4.88	372	0	1,812	1,811,955	25%
4	30.48	12.19	4.88	372	0	1,812	1,811,955	25%

1,486 sq.m.	7,249 cu.m	7,247,821 L	100%

Example Calculations
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Reference Table
Oxygen Requirements for Biological Treatment Processes

REFERENCE TABLE

Carbonaceous BOD5 Removal

BOD / 02 RATIO

Biological Treatment Process Type	Process Parameters			Actual Oxygen Required (AOR) (1)			
	BOD Loading lbs. BOD per 1000 cu.ft. Tank Volume	Food to Biomass Ratio F / M	MLSS Conc. mg/l	Fine Bubble Diffusers lbs. 02 / lb. of BOD	Coarse Bubble Diffusers lbs. 02 / lb. of BOD	Mechanical Aeration lbs. 02 / lb. of BOD	Ten States Standards (2) lbs. 02 / lb. of BOD
Extended Aeration	10 to 25	0.05 to 0.15	1200 to 2500	1.10 to 0.75	1.30 to 0.85	1.50 to 1.00	1.50
Oxidation Ditch	5 to 30	0.05 to 0.30	800 to 2500	1.10 to 0.75	1.30 to 0.85	1.50 to 1.00	1.50
Single Stage Nitrification	5 to 20	0.10 to 0.25	800 to 2500	1.10 to 0.75	1.30 to 0.85	1.50 to 1.00	1.10
Sequencing Batch Reactor	5 to 50	0.05 to 0.45	800 to 5500	1.10 to 0.75	1.30 to 0.85	1.50 to 1.00	1.10
Plug Flow / Complete Mix	20 to 120	0.30 to 1.00	2500 to 5500	0.75 to 0.30	0.85 to 0.40	1.00 to 0.50	1.10
High Rate Aeration	100 to 1000	0.40 to 1.5	4500 to 10,000	0.75 to 0.30	0.85 to 0.40	1.00 to 0.50	1.10

Nitrification of Ammonia

NH3 / 02 RATIO

Biological Treatment Process Type	Process Parameters			Actual Oxygen Required (AOR) (1)			
	BOD Loading lbs. BOD per 1000 cu.ft. Tank Volume	Food to Biomass Ratio F / M	MLSS Conc. mg/l	Fine Bubble Diffusers lbs. 02 / lb. of TKN	Coarse Bubble Diffusers lbs. 02 / lb. of TKN	Mechanical Aeration lbs. 02 / lb. of TKN	Ten States Standards (2) lbs. 02 / lb. of TKN
Extended Aeration	10 to 25	0.05 to 0.15	1200 to 2500	3.80 to 4.00	4.20 to 4.40	4.50 to 4.60	4.60
Oxidation Ditch	5 to 30	0.05 to 0.30	800 to 2500	3.80 to 4.00	4.20 to 4.40	4.50 to 4.60	4.60
Single Stage Nitrification	5 to 20	0.10 to 0.25	800 to 2500	3.80 to 4.00	4.20 to 4.40	4.50 to 4.60	4.60
Sequencing Batch Reactor	5 to 50	0.05 to 0.45	800 to 5500	3.80 to 4.00	4.20 to 4.40	4.50 to 4.60	4.60
Plug Flow / Complete Mix	20 to 120	0.30 to 1.00	2500 to 5500	3.40 to 3.60	4.00 to 4.20	4.50 to 4.60	4.60
High Rate Aeration	100 to 1000	0.40 to 1.5	4500 to 10,000	3.40 to 3.60	4.00 to 4.20	4.50 to 4.60	4.60

1. AOR Ratio Values listed are typical operating values, a safety factor of 1.20 should be applied for blower capacity design.
2. Recommended value if treatibility design data is unavailable for the application.

Example Calculations
Evaluation for Fine Bubble Aeration System

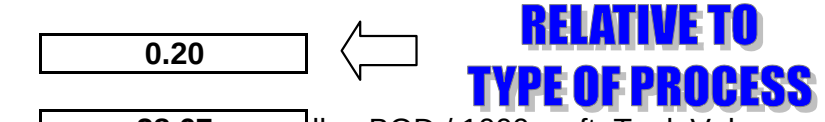
Check Aeration Tank Volume Required Based on Food to (Bio)Mass Ratio

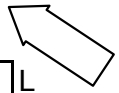
BIOLOGICAL TREATMENT PROCESS

Design BOD to be removed =	**7,339**	lbs/day	**3,329.1**	kg/day
Applied Food to (Bio)Mass Ratio F/M =	**0.20**			
BOD Loading =	**28.67**	lbs. BOD / 1000 cu.ft. Tank Volume		
MLSS Mass =BOD / (F/M) =	**36696.0**	lbs	**16,645.31**	kg
Required MLSS Concentration =	**2300**	mg/l		

Tank Volume Required = (MLSS Mass) / [(MLSS Conc.) x 8.34)]

Tank Liquid Volume Required =	**1,913,043**	GAL	**7,241,658**	L
Existing Tank Volume or Tank Volume Specified by Client =	**1,914,880**	GAL	**7,248,610**	L





TANK VOLUME REQUIRED

TANK VOLUME AVAILABLE

Example Calculations
Evaluation for Fine Bubble Aeration System

Actual Oxygen Required (AOR)
Based on BOD, COD and NH3 Loading

BOD Influent Conc.	BOD Effluent Conc.	Plant Flow Capacity
240 mg/l	20 mg/l	4,000,000 GPD

Total Influent BOD Mass	Total Effluent BOD Mass
8,006 lbs./day	667 lbs./day

BOD / O2 RATIO

Total BOD mass to be removed	7,339	lbs./day	3,329	kg/day
Lbs. of Oxygen required per lb. of BOD removed	1.10	lbs.O2/lb BOD	0.499	kg.O2/lb BOD
Oxygen required for BOD removal	8,073	lbs./day	3,662	kg/day

MUNICIPAL / FOOD PROCESSING WASTEWATER

NH3 Influent Conc.	NH3 Effluent Conc.
35 mg/l	5 mg/l

Total Influent NH3 Mass	Total Effluent NH3 Mass
1,168 lbs./day	166.8 lbs./day

NH3 / O2 RATIO

Total NH3 mass to be removed	1,001	lbs./day	454	kg/day
Lbs. of Oxygen required per lb. of NH3 removed	3.80	lbs.O2/lb NH3	1.724	kgO2/lb NH3
Oxygen required for NH3 removal	3,803	lbs./day	1,725	kg/day

COD Influent Conc.	COD Effluent Conc.
800 mg/l	450 mg/l

Total Influent COD Mass	Total Effluent COD Mass
26,688 lbs./day	15,012 lbs./day

INDUSTRIAL CHEMICAL WASTEWATER

Oxygen Demand = (Alpha x COD x R) + (Beta x (COD / FM))

Alpha =	0.40	Alpha = Oxygen Utilization Coefficient for Synthesis, lb/lb
Beta =	0.10	Beta = Oxygen Utilization Coefficient for Endogenous Respiration, lb/lb
COD =	11,676	COD = COD loading to Aeration Tank, lbs/day
R =	1	R = % Reduction of COD
FM =	0.20	FM = Food to Biomass Ratio

COD / O2 RATIO

Total COD mass to be removed	11,676	lbs./day	5,296	kg/day
Oxygen Required for COD Removal	10,508	lbs/day	4,767	kg/day

Example Calculations
Evaluation for Fine Bubble Aeration System

Selected - Actual Oxygen Required (AOR)
Based on COD, BOD, NH3 and Uptake Rates

	Oxygen Uptake Rate	**0**	mg/l/hr		
AOR1	AOR per Uptake Rate	**0**	lbs./day	**0**	kg/day
AOR2	AOR for BOD & NH3 removal	**11,876**	lbs./day	**5,387**	kg/day
AOR3	AOR for COD	**10,508**	lbs./day	**4,767**	kg/day
AOR4	AOR as Specified by Owner	**12,000**	lbs./day	**5,443**	kg./day
AOR5	AOR as Required by Digestor	**4,416**	lbs./day	**2,003**	kg./day
	Selected AOR (maximum of AOR1, AOR2, AOR3,AOR4 & AOR5)	**12,000**	lbs./day	**5,443**	kg/day
	AOR conversion	**500.00**	lbs/hr (24 hr. day)	**226.80**	kg/hr (24 hr. day)

AOR: ACTUAL DISSOLVED OXYGEN REQUIRED FOR BIOLOGICAL ORGANISMS TO REDUCE THE MASS OF WASTE LOADING

Example Calculations
Evaluation for Fine Bubble Aeration System

FINE BUBBLE DIFFUSER SYSTEM
Number of Fine Bubble Diffusers and Total Airflow Required

AOR = Actual Oxygen Transferred into wastewater solution
SOTR = Oxygen transfer rate based on clean water

CLEAN WATER EQUIVALENT O2

Tank No.	AOR kg/hr	AOR lbs/hr		SOTR kg/hr	SOTR lbs/hr	Airflow scmm	Airflow scfm	Fine Bubble Diffusers Required
1	56.70	125.00		140.66	310.11	26.73	943.85	472
2	56.70	125.00		140.66	310.11	26.73	943.85	472
3	56.70	125.00		140.66	310.11	26.73	943.85	472
4	56.70	125.00		140.66	310.11	26.73	943.85	472
	226.80 kg/hr	**500.00 lbs/hr**		**562.65 kg/hr**	**1,240.42 lbs/hr**	**106.92 scmm**	**3,775.40 scfm**	**1,888 units**

FINE BUBBLE DIFFUSER UNIT AIRFLOW AND EFFICIENCY

Headloss per diffuser	12.5	in.H20	
Air flowrate per Diffuser	2.00	scfm	0.0566 scmm
Diffuser Efficiency per foot depth	2.05%		
Total Diffuser efficiency (De)	31.78%		
Wastewater transfer efficiency	40%		

GENERATED FROM OXYGEN TRANSFER CURVE & DEPTH

MODEL TFX-26

1 CUFT. OF AIR = 0.0174 LBS. O2

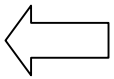
GENERATED FROM ALPHA, BETA, THETA PROCESS FACTORS

Example Calculations
Evaluation for Fine Bubble Aeration System

FINE BUBBLE DIFFUSER SYSTEM
Design Check - Airflow Required for Complete Mixing based on Surface Area of Tank

Applied Design Unit Airflow Rate	0.200	scfm/sq.ft.	Airflow Rate per Diffuser	2.000	scfm/diffuser
	0.061	scmm/sq.m		0.0566	scmm/diffuser

Recommended Minimum Design Values
0.200 scfm/sq.ft. for MLSS up to 2500 mg/l
0.240 scfm/sq.ft. for MLSS up to 3500 mg/l
0.280 scfm/sq.ft. for MLSS up to 4500 mg/l



UNIT DESIGN VALUES TO OBTAIN SUFFICIENT MIXING OF VOLUME

Tank	Surface Area sq.ft.	Surface Area sq. meters	Airflow Rate Required scfm	Airflow Rate Required scmm	Quantity of Fine Bubble Diffusers Required
1	4,000	372	800.00	22.65	400
2	4,000	372	800.00	22.65	400
3	4,000	372	800.00	22.65	400
4	4,000	372	800.00	22.65	400

CHECK FOR MIXING REQUIRED

16,000.00	**1486.4**	**3,200.00**	**90.6**	**1,600**
sq.ft	sq.m.	scfm	scmm	units

Note: If the Total Airflow Rate calculated on this sheet exceeds the Airflow Rate calculated to provide sufficient oxygen, then these values should be applied to ensure sufficient mixing is provided for the system.

Example Calculations
Evaluation for Fine Bubble Aeration System

DESIGN BY TANK CAPACITY

DESIGN BY CURRENT LOAD

Oxygen Required for Volatile Solids Reduction

Waste Sludge Volume Determination

Method 1			Method 2		
Volume of Tank	**64,000**	cu.ft.	**Waste Sludge Flowrate**	**90,000**	gallons / day
Volatile Solids Loading (0.1 - 0.3)	**0.100**	lbs./ cu.ft. - day	**Percent Solids in WAS**	**1.00%**	
Total Mass of Sludge in Influent	**8,000**	lbs./day Sludge	**Total Mass of Sludge in Influent**	**7499.7**	lbs/day Sludge

Total Mass of Sludge in Influent (Maximum from Method 1 & Method 2)	**8,000**	lbs./day Sludge	
% Volatiles in Total Mass	**80%**		% VOLATILES INFLUENT
Total Mass of Volatile Solids	**6,400**	lbs./day	
% Reduction of Volatiles through Digestion	**30.00%**	(30-40 % Standard)	% VOLATILES REDUCED
Total Volatiles Reduced	**1,920**	lbs./day	
Unit Rate for Oxygen Requirement	**2.30**	lbs.O2/ lbs. Volatile solids	
Mass of Oxygen Required	**4,416**	lbs.O2/day	
Actual Oxygen Transfer Rate (AOR)	**184.00**	lbs/hr	**Aeration Design Value**

AOR FOR DIGESTER DESIGN

Check Hydraulic Retention Time	**5.3195026**	days	(10-15 Waste activated sludge only) (12-18 Activated sludge without settling (15-20 Primary + Secondary sludge)

Example Calculations
Evaluation for Fine Bubble Aeration System

FINE BUBBLE DIFFUSER SYSTEM
APPLIED AIRFLOW BASED ON OXYGEN DEMAND REQUIREMENTS

Water Depth at Diffusers (DWD) =	15.50	ft.	4.72	m
Total System Operating Airflow (SCFM) =	3,775.4	scfm	107	scmm
Number of Operating Blowers =	2.0			

SCFM

Airflow per Blower =	1,887.7	scfm	53	scmm
Airflow per Diffuser =	2.00	scfm	0.057	scmm
Inlet Blower Temperature (T) =	100	F	37.74	C
Site Barometric Pressure (BP) =	14.24	psia	0.982	Bar
Blower Efficiency Estimate =	70%			
Headloss - Hydrostatic =	186	in.	4.724	m
Headloss - Piping =	12	in.	0.305	m
Headloss - Diffusers =	12.5	in.	0.318	m
Total Headloss =	210.5	in.	5.3467	m
Blower Gauge Pressure =	7.58	psig	0.523	Bar
Blower Discharge Atm Press =	21.82	psia	1.505	
R =	1.6041			
Mass Rate =	283.98	lbs/min		
Effective Blower Airflow (ICFM) =	4,132.6	icfm	117	icmm

ADJUSTED AIRFLOW REQUIRED DUE TO SITE CONDITIONS

ICFM

Individual Blower Output HP =	68.0	HP	51	kW
Individual Blower Brake HP =	97.1	HP	72	kW
Total Combined Output HP =	136.0	HP	101	kW
Total Combined Brake HP =	194.3	HP	145	kW

BLOWER EFFICIENCY ADJUSTMENT