

target compounds are suspended. The owner or operator shall prepare a sampling plan. Wastewater samples shall be collected using sampling procedures which minimize loss of organic compounds during sample collection and analysis and maintain sample integrity. The sample plan shall include procedures for determining recovery efficiency of the relevant compounds regulated in the applicable subpart. An example of an acceptable sampling plan would be one that incorporates similar sampling and sample handling requirements to those of Method 25D of 40 CFR part 60, appendix A.

2.1. Sampling and Analysis

2.1.1. For each waste matrix, collect twice the number of samples required by the applicable regulation. Designate and label half the sample vials the "spiked" sample set, and the other half the "unspiked" sample set. Immediately before or immediately after sampling (immediately after in the context of this procedure means after placing the sample into the sample vial, but before the sample is capped, cooled, and shipped to the laboratory for analysis), inject, either individually or as a solution, all the target compounds into each spiked sample.

2.1.2. The mass of each spiked compound shall be 40 to 60 percent of the mass expected to be present in the waste matrix. If the concentration of the target compounds in the waste are not known, the mass of each spiked compound shall be 40 to 60 percent of the limit allowed in the applicable regula-

tion. Analyze both sets of samples (spiked and unspiked) with the chosen method.

3. Calculations

For each pair of spiked and unspiked samples, determine the fraction of spiked compound recovered (R) using the following equations.

where:

m_r = mass spiked compound measured (μ g).

m_s = total mass of compound measured in spiked sample (μ g).

m_u = total mass of compound measured in unspiked sample (μ g).

where:

S = theoretical mass of compound spiked into spiked sample (μ g).

3.1. Method Evaluation

In order for the chosen method to be acceptable for a compound, $0.70 \leq R \leq 1.30$ (R in this case is an average value of all the spiked and unspiked sample set R values). If the average R value does not meet this criterion for a target compound, the chosen method is not acceptable for that compound, and therefore another method shall be evaluated for acceptance (by repeating the procedures outlined above with another method).

3.2. Records and Reports

Report the average R value in the test report and correct all reported measurements made with the method with the calculated R value for that compound by using the following equation:

$$\text{Reported Result} = \frac{\text{Measured Mass of Compound}}{R \text{ for that compound}}$$

3.3. Optional Correction Step

If the applicable regulation allows for correction of the mass of the compound in the waste by a published f_m value, multiply the reported result calculated above with the appropriate f_m value for that compound.

[61 FR 34200, July 1, 1996, as amended at 74 FR 30230, June 25, 2009]

APPENDIX E TO PART 63—MONITORING PROCEDURE FOR NONTHOROUGHLY MIXED OPEN BIOLOGICAL TREATMENT SYSTEMS AT KRAFT PULP MILLS UNDER UNSAFE SAMPLING CONDITIONS

1. Purpose

This procedure is required to be performed in subpart S of this part, entitled National Emission Standards for Hazardous Air Pollutants from the Pulp and Paper Industry.

Subpart S requires this procedure in §63.453(p)(3) to be followed during unsafe sampling conditions when it is not practicable to obtain representative samples of hazardous air pollutants (HAP) concentrations from an open biological treatment unit. It is assumed that inlet and outlet HAP concentrations from the open biological treatment unit may be obtained during the unsafe sampling conditions. The purpose of this procedure is to estimate the concentration of HAP within the open biological treatment unit based on information obtained at inlet and outlet sampling locations in units that are not thoroughly mixed and, therefore, have different concentrations of HAP at different locations within the unit.

II. Definitions

Biological treatment unit = wastewater treatment unit designed and operated to promote the growth of bacteria to destroy organic materials in wastewater.

f_{bio} = The fraction of organic compounds in the wastewater biodegraded in a biological treatment unit.

Fe = The fraction of applicable organic compounds emitted from the wastewater to the atmosphere.

K1 = First-order biodegradation rate constant, L/g mixed liquor volatile suspended solids (MLVSS)-hr

KL = Liquid-phase mass transfer coefficient, m/s

Ks = Monod biorate constant at half the maximum rate, g/m³

III. Test Procedure for Determination of f_{bio} for Nonthoroughly Mixed Open Biological Treatment Units Under Unsafe Sampling Conditions

This test procedure is used under unsafe sampling conditions that do not permit practicable sampling of open biological treatment units within the unit itself, but rather relies on sampling at the inlet and outlet locations of the unit. This procedure may be used only under unsafe sampling conditions to estimate f_{bio} . Once the unsafe conditions have passed, then the formal compliance demonstration procedures of f_{bio} , based upon measurements within the open biological treatment unit must be completed.

A. Overview of Estimation Procedure

The steps in the estimation procedure include data collection, the estimation of concentrations within the unit, and the use of Form 1 to estimate f_{bio} . The data collection procedure consists of two separate components. The first data collection component demonstrates that the open biological treatment unit can be represented by Monod kinetics and characterizes the effectiveness of the open biological treatment unit as part of the initial performance test, and the second data collection component is used when there are unsafe sampling conditions. These two data collection components are used together in a data calculation procedure based on a Monod kinetic model to estimate the concentrations in each zone of the open biological treatment unit. After the first two components of data collection are completed, the calculation procedures are used to back estimate the zone concentrations, starting with the last zone in the series and ending with the first zone.

B. Data Collection Requirements

This method is based upon modeling the nonthoroughly mixed open biological treatment unit as a series of well-mixed zones

with internal recycling between the units and assuming that two Monod biological kinetic parameters can be used to characterize the biological removal rates in each unit. The data collection procedure consists of two separate components. The first data collection component is part of the initial performance test, and the second data collection component is used during unsafe sampling conditions.

1. Initial Performance Test

The objective of the first data collection component is to demonstrate that the open biological treatment unit can be represented by Monod kinetics and to characterize the performance of the open biological treatment unit. An appropriate value of the biorate constant, Ks, is determined using actual sampling data from the open biological treatment unit. This is done during the initial performance test when the open biological treatment unit is operating under normal conditions. This specific Ks value obtained during the initial performance test is used in the calculation procedure to characterize the open biological treatment unit during unsafe sampling conditions. The following open biological treatment unit characterization information is obtained from the first component of the data collection procedure:

- (1) The value of the biorate constant, Ks;
- (2) The number and characteristics of each zone in the open biological treatment unit (depth, area, characterization parameters for surface aeration, submerged aeration rates, biomass concentration, concentrations of organic compounds, dissolved oxygen (DO), dissolved solids, temperature, and other relevant variables); and
- (3) The recycle ratio of internal recirculation between the zones. The number of zones and the above characterization of the zones are also used to determine the performance of the unit under the unsafe sampling conditions of concern.

2. Data Collected Under Unsafe Sampling Conditions

In the second data collection component obtained under unsafe sampling conditions, the measured inlet and outlet HAP concentrations and the biomass concentration are obtained for the open biological treatment unit. After the site specific data collection is completed on the day a parameter excursion occurs, the inlet and outlet concentrations are used with the prior open biological treatment unit characterization to estimate the concentrations of HAP in each zone. The following information on the open biological treatment unit must be available in the second data collection component:

- (1) Basic unit variables such as inlet and recycle wastewater flow rates, type of agitation, and operating conditions;

(2) The value of the inlet and outlet HAP concentrations; and

(3) The biomass concentration in the open biological treatment unit.

C. One Time Determination of a Single Value of K_s (Initial Performance Test)

A single value of K_s is calculated using Form 3 for each data set that is collected during the initial performance test. A single composite value of K_s , deemed to be representative of the biological unit, is subsequently selected so that the f_{bio} values calculated by the procedures in this appendix (using this single value of K_s) for the data sets collected during the initial performance test are within 10 percent of the f_{bio} value determined by using Form 1 with these same data sets. The value of K_s meeting these criteria is obtained by the following steps:

(1) Determine the median of the K_s values calculated for each data set;

(2) Estimate f_{bio} for each data set using the selected K_s value (Form 1 and Form 2);

(3) Calculate f_{bio} for each data set using Form 1; and

(4) Compare the f_{bio} values obtained in steps (2) and (3); if the f_{bio} value calculated using step (2) differs from that calculated using step (3) by more than 10 percent, adjust K_s (decrease K_s if the f_{bio} value is lower than that calculated by Form 1 and vice versa) and repeat this procedure starting at step (2). If a negative value is obtained for the values of K_s , then this negative kinetic constant may not be used with the Monod model. If a negative value of K_s is obtained, this test procedure cannot be used for evaluating the performance of the open biological treatment unit.

D. Confirmation of Monod Kinetics (Initial Performance Test)

(1) Confirmation that the unit can be represented by Monod kinetics is made by identifying the following two items:

(i) The zone methanol concentrations measured during the initial performance test; and

(ii) The zone methanol concentrations estimated by the Multiple Zone Concentrations Calculations Procedure based on inlet and outlet concentrations (Column A of Form 2). For each zone, the concentration in item 1 is compared to the concentration in item 2.

(2) For each zone, the estimated value of item 2 must be:

(i) Within 25 percent of item 1 when item 1 exceeds 8 mg/L; or

(ii) Within 2 mg/L of item 1 when item 1 is 8 mg/L or less.

(3) Successful demonstration that the calculated zone concentrations meet these criteria must be achieved for 80 percent of the performance test data sets.

(4) If negative values are obtained for the values of K_L and K_s , then these negative kinetic constants may not be used with the Monod model, even if the criteria are met. If negative values are obtained, this test procedure cannot be used for evaluating the performance of the open biological treatment unit.

E. Determination of K_L for Each Zone (Unsafe Sampling Conditions)

(1) A site-specific liquid-phase mass transfer coefficient (K_L) must be obtained for each zone during the unsafe sampling conditions. Do not use a default value for K_L . The K_L value for each zone must be based on the site-specific parameters of the specific unit. The first step in using this procedure is to calculate K_L for each zone in the unit using Form 4. Form 4 outlines the procedure to follow for using mass transfer equations to determine K_L . Form 4 identifies the appropriate form to use for providing the detailed calculations to support the estimate of the value of K_L . Forms 5 and 6 are used to provide individual compound estimates of K_L for quiescent and aerated impoundments, respectively. A computer model may be used to perform the calculations. If the WATER8 model or the most recent update to this model is used, then report the computer model input parameters that you used as an attachment to Form 4. In addition, the Bay Area Sewage Toxics Emission (BASTE) model, version 3.0, or equivalent upgrade and the TOXCHEM (Environment Canada's Wastewater Technology Centre and Environmega, Ltd.) model, version 1.10, or equivalent upgrade may also be used to determine K_L for the open biological treatment unit with the following stipulations:

(i) The programs must be altered to output a K_L value that is based on the site-specific parameters of the unit modeled; and

(ii) The Henry's law value listed in Form 4 must be substituted for the existing Henry's law values in the models.

(2) The Henry's law value listed in Form 4 may be obtained from the following sources:

(i) Values listed by EPA with temperature adjustment if needed;

(ii) Measured values for the system of concern with temperature adjustment; or

(iii) Literature values of Henry's law values for methanol, adjusted for temperature if needed.

(3) Input values used in the model and corresponding output values shall become part of the documentation of the f_{bio} determination. The owner or operator should be aware that these models may not provide equivalent K_L values for some types of units. To obtain an equivalent K_L value in this situation, the owner or operator shall either use the appropriate procedure on Form 4 or adjust the K_L value from the model to the equivalent K_L value as described on Form 4.

(4) Report the input parameters that you used in the computer model on Forms 5, 6, and 7 as an attachment to Form 4. If you have submerged air flow in your unit, you must add the value of KL estimated on Form 7 to the value of KL obtained with Forms 5 and 6 before using the value of KL with Form 2.

**F. Estimation of Zone Concentrations
(Unsafe Sampling Conditions)**

Form 2 is used to estimate the zone concentrations of HAP based on the inlet and outlet data. The value of Ks entered on the form is that single composite value of Ks discussed in section III.C of this appendix. This value of Ks is calculated during the Initial Performance Test (and subsequently updated, if necessary). A unique value of the biorate K1 is entered on line 5 of Form 2, and the inlet concentration is estimated in Column A of Form 2. The inlet concentration is located in the row of Form 2 corresponding to zone 0. If there are three zones in the system, n-3 equals 0 for the inlet concentration row. These estimated zone concentrations are then used in Form 1 to estimate f_{bio} for the treatment unit.

**G. Quality Control/Quality Assurance (QA/
QC)**

A QA/QC plan outlining the procedures used to determine the measured inlet and outlet concentrations during unsafe conditions and how the zone characterization data were obtained during the initial performance test shall be prepared and submitted with the initial performance test report. The plan should include, but may not be limited to:

(1) A description of each of the sampling methods that were used (method, procedures, time, method to avoid losses during sampling and holding, and sampling procedures) including simplified schematic drawings;

(2) A description of how that biomass was sampled from the biotreatment unit, including methods, locations, and times;

(3) A description of what conditions (DO, temperature, etc.) are important, what the target values are in the zones, how the factors were controlled, and how they were monitored. These conditions are primarily used to establish that the conditions of the

initial performance test correspond to the conditions of the day in question:

(4) A description of how each analytical measurement was conducted, including preparation of solutions, dilution procedures, sampling procedures, monitoring of conditions, etc;

(5) A description of the analytical instrumentation used, how the instruments were calibrated, and a summary of the accuracy and precision for each instrument;

(6) A description of the test methods used to determine HAP concentrations and other measurements. Section 63.457(c)(3) specifies the test methods that must be used to determine HAP concentrations. During unsafe sampling conditions, you do not have to sample over an extended period of time or obtain more than one sample at each sample point,

(7) A description of how data are captured, recorded, and stored; and

(8) A description of the equations used and their solutions for sampling and analysis, including a reference to any software used for calculations and/or curve-fitting.

**IV. Calculation of Individual f_{bio} (Unsafe
Sampling Conditions)**

Use Form 1 with your zone concentration information to estimate the value of f_{bio} under unsafe sampling conditions. Form 1 uses measured concentrations of HAP in the unit inlet and outlet, and Form 1 also uses the estimated concentrations in each zone of the unit obtained from Form 2. This procedure may be used on an open biological treatment unit that has defined zones within the unit. Use Form 1 to determine f_{bio} for each open biological treatment unit as it exists under subpart S of part 63. The first step in using Form 1 is to calculate KL for each zone in the unit using Form 4. Form 7 must also be used if submerged aeration is used. After KL is determined using field data, obtain the concentrations of the HAP in each zone. In this alternative procedure for unsafe sampling conditions, the actual measured concentrations of the HAP in each zone are replaced with the zone concentrations that are estimated with Form 2. After KL and the zone concentrations are determined, Form 1 is used to estimate the overall unit F_e and f_{bio} for methanol.

Form 1

DATA FORM FOR THE ESTIMATION OF MULTIPLE ZONE BIODEGRADATION FROM UNIT CONCENTRATIONS

NAME OF THE FACILITY for site specific biorate determination	
COMPOUND for site specific biorate determination	Methanol
Number of zones in the biological treatment unit	1
VOLUME of full-scale system (cubic meters)	2
Average DEPTH of the full-scale system (meters)	3
FLOW RATE of wastewater treated in the unit (m ³ /s)	4
Recycle flow of wastewater added to the unit, if any (m ³ /s)	5
Concentration in the wastewater treated in the unit (mg/L)	6
Concentration in the recycle flow, if any (mg/L)	7
Concentration in the effluent (mg/L).	8

TOTAL INLET FLOW (m ³ /s) line 4 plus the number on line 5	9
TOTAL RESIDENCE TIME (s) line 2 divided by line 9.	10
TOTAL AREA OF IMPOUNDMENT (m ²) line 2 divided by line 3	11

Zone number	Concentration for zone, C _i (mg/L)	Area of the zone, A (m ²)	Estimate of K _L in the zone (m/s) from Form 4	AIR STRIPPING K _L A C _i (g/s)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
TOTALS sum for each zone.	12		13	

Removal by air stripping (g/s). Line 13.	14
Loading in effluent (g/s). Line 8 times line 9.	15
Total loading (g/s). (Line 5 * line 7) + (line 4 * line 6).	16
Removal by biodegradation (g/s) Line 16 minus (line 14 + line 15).	17
Fraction biodegraded: Divide line 17 by line 16.	18
Fraction air emissions: Divide line 14 by line 16.	19
Fraction remaining in unit effluent: Divide line 15 by line 16.	20

Form 2

DATA FORM FOR THE DETERMINATION OF ZONE CONCENTRATIONS FROM KS AND INLET/OUTLET DATA								
COMPOUND for site specific biotates determination						Methanol		
Influent Flow (m ³ /s)						1		
Inlet Concentration (g/m ³)						2		
Outlet Concentration (g/m ³) - Use value from line 3 as Ci value in column A for final Zone (zone n) in table below						3		
Saturation Coefficient, Ks (g/m ³) From Form 3						4		
Biorate K1 (1/s) - Estimate						5		
Number of Zones						6		
<p>Adjust K1 value (line 5) until Column A, Row (n - line 6) is within +/- 5% of line 2.</p> <p>Instructions for completion of table: (1) Transfer value from line 3 into row n, column A. (2) Enter data for all zones into columns B, D, E, G, H, & K. (3) Beginning with row n, perform calculations for columns F, I, J, L, M, N, & O for that zone only. (4) Calculate row n-1, column A using results from previous row (i.e., J_{n-1}, M_{n-1}, N_{n-1}). (5) Repeat steps (3) and (4) until a row of calculations has been completed for each zone. (6) row n - line 6, column A is the calculated inlet concentration.</p>								
	A	B	C	D	E	F	G	H
Zone Number	Ci (J _{n-1} + N _{n-1})/O _{n-1} g/m ³	Temp C	(1.045) ^(B-25)	biomass g/m ³	Volume m ³	line 5 * A * C * D *E/(line 4 * A) g/s	KL m/s	Area m ²
n								
n-1								
n-2								
n-3								
n-4								
	I	J	K	L	M	N	O	
Zone Number	A * G * H g/s	Reaction F + I g/s	Backmix BM	(1 + BM _i + BM _{i+1}) * C _i line 1 g/s	BM _{i+1} * C _{i-1} * line 1 g/s	Flux L - M g/s	(1 + BM _i) * line 1 g/s	
n								
n-1								
n-2								
n-3								
n-4								
<p>The backmix ratio, BM_i, is the ratio of (the return flow from the zone back to the upstream zone) to (the total inlet flow into the unit). This approach assumes that the flow is sequential through the different zones.</p>								

Form 3

DATA FORM FOR THE DETERMINATION OF MONOD CONSTANTS FROM ZONE CONCENTRATIONS WITH BACKMIXING								
COMPOUND for site specific biorates determination						Methanol		
Total Inlet Flow (m ³ /s)						1		
Inlet Concentration (g/m ³) - Use value from line 2 as C _{i-1} value in column D for Zone 1 in table below						2		
	A	B	C	D	E	F	G	H
Zone Number	C _i g/m ³	Backmix (BM) _i	(1+BM _i +BM _{i+1}) ² C _i g/m ³	(1+BM _i) ² C _{i-1}	BM _{i-1} ² C _{i-1} g/m ³	KL m/s	Area m ²	A ² F ² G g/s
1								
2								
3								
4								
5								
	I	J	K	L	M	N	O	
Zone Number	Volume m ³	Temp C	(1.045) ^(J-25)	biomass g/m ³	I ² K ² L g/m	M/(line 1*(D+E-C)-H) s	1/A m ³ /g	
1								
2								
3								
4								
5								
Plot values in column N on y axis, and values in column O on x axis, up to, and including first row where C _i is equal to MDL or to last zone.								
						Y intercept from plot (g-s/m ³)	3	
						K1 (1/s). 1/line 3	4	
						Slope of line	5	
						Ks (g/m ³). Line 5 times line 4	6	
<i>The backmix ratio, BM_i, is the ratio of (the return flow from the zone back to the upstream zone) to (the total inlet flow into the unit). This approach assumes that the flow is sequential through the different zones.</i>								

Form 4

PROCEDURES FORM FOR THE ESTIMATION OF THE KL FROM UNIT SPECIFICATIONS	
NAME OF THE FACILITY for site specific biorate determination	
NAME OF UNIT for site specific biorate determination	
NAME OF COMPOUND	Methanol
HENRY'S LAW constant for the compound (mole fraction in gas per mole fraction in water at 25 degrees Celsius)	
IDENTIFY THE TYPE OF UNIT (check one box below)	
Quiescent impoundment	1
Surface agitated impoundment	2
Surface agitated impoundment with submerged air present	3
Unit with submerged aeration gas	4
PROCEDURES BASED UPON THE TYPE OF UNIT	
1. Use Form 5 to determine KL for the surface of the quiescent impoundment. 2. Use Form 5 to determine KL for the surface of the quiescent part of the impoundment. Use Form 6 to determine KL for the part of the surface that is agitated, then complete Form 6 with Kq as determined from Form 5. 3. Use Form 5 to determine KL for the surface of the quiescent part of the impoundment. Use Form 6 to determine KL for the part of the surface that is agitated, then complete Form 6 with Kq as determined from Form 5. The total system KL is the sum of the KL from the completed Form 6 and the equivalent KL from Form 7. 4. Evaluate the fraction of the surface that is agitated and the extent of the aeration. Use Form 5 to determine KL for the quiescent part of the surface of the impoundment. Use Form 6 to determine KL for the part of the surface that is agitated, then complete Form 6 with Kq as determined from Form 5. The total system KL is the sum of the KL from the completed Form 6 and the equivalent KL from Form 7. See section 5.6.1 in the document Air Emission Models for Waste and Wastewater.	
Estimate of surface KL obtained from above procedures (m/s)	5
If the submerged aeration is present, the equivalent KL from Form 7	6
The total KL is the sum of line 5 and line 6.	7

Form 5

$k_L = 2.78 \times 10^{-6} (D_w/D_{ether})^{2/3}$

Where U_{10} is > 3.25 and $14 < F/D < 51.2$, Calculate k_L as follows:

$k_L = [2.605 \times 10^{-9} (F/D) + 1.277 \times 10^{-7}] U_{10}^2 (D_w/D_{ether})^{2/3}$

Where $U_{10} > 3.25$ m/s and $F/D > 51.2$, calculate k_L as follows:

$k_L = (2.611 \times 10^{-7}) U_{10}^2 (D_w/D_{ether})^{2/3}$

B. Calculate the gas phase mass transfer coefficient, k_G , using the following procedure from MacKay and Matsasugu, (m/s):

Calculate the Schmidt number on the gas side, Sc_G , as follows: $Sc_G = \mu_G / GDa$

Calculate the effective diameter of the impoundment, d_e , as follows, (m):

$d_e = (4A/3.14)^{0.5}$

Calculate k_G as follows, (m/s): $k_G = 4.82 \times 10^{-3} U_{10}^{0.78} Sc_G^{-0.67} d_e^{-0.11}$

C. Calculate the partition coefficient, K_{eq} , as follows: $K_{eq} = H/[R(T+273)]$

D. Calculate the overall mass transfer coefficient, K_q , as follows, (m/s):

$1/K_q = 1/k_L + 1/(K_{eq} \cdot k_G)$

Where the total impoundment surface is quiescent:

$K_L = K_q$

Where a portion of the impoundment surface is turbulent, continue with Form 6.

Form 6

DATA FORM FOR CALCULATING THE MASS TRANSFER COEFFICIENT FOR AN AERATED SURFACE IMPOUNDMENT

Facility Name:
 Waste Stream Compound:

Enter the following:

- J - Oxygen transfer rating of surface aerator, (lb O₂/hr-hp)
- POWR - Total power to aerators, (hp)
- T - Water temperature, (C)
- Ot - Oxygen transfer correction factor
- MWL - Molecular weight of liquid
- At - Turbulent surface area of impoundment, (ft²)
(If unknown, use values from Table 1)
- A - Total surface area of impoundment, (ft²)
- rhoL - Density of liquid, (lb/ft³)
- Dw - Diffusivity of constituent in water, (cm²/s)
- Do - Diffusivity of oxygen in water, (cm²/s)
- d - Impeller diameter, (cm)
- w - Rotational speed of impeller, (rad/s)
- a - Density of air, (gm/cm³)
- N - Number of aerators
- gc - Gravitation constant, (ftm-ft/s²/lbf)
- d* - Impeller diameter, (ft)
- Da - Diffusivity of constituent in air, (cm²/s)
- MWa - Molecular weight of air
- R - Universal gas constant, (atm-m³/g mol. C)
- H = Henry's law constant, (atm-m³/g mol)

Calculate the following:

- A. Calculate the liquid phase mass transfer coefficient, k_L, using the following Equation from Thibodeaux:

$$k_L = [8.22 \times 10^{-9} J (POWR)(1.024)^{(T-20)} Ot 10^6 MWL / (At \times \rho_L / 62.37)] (Dw/Do)^{0.5}, (m/s)$$

- B. Calculate the gas phase mass transfer coefficient, k_G, using the following procedure from Reinhardt:

Calculate the viscosity of air, μ_a, as follows, (g/cm.s):
 $\mu_a = 4.568 \times 10^{-7} T + 1.7209 \times 10^{-4}$

Calculate the Reynold's number as follows:
 $Re = d^2 w a / \mu_a$

Calculate power to impeller, PI, as follows, (ft.lbf/s):
 $PI = 0.85 (POWR) 550/N$

