JACOBS

Memorandum

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Subject	**Tipping Building Ventilation Mechanical Options, Response to Comments**
Attention	Alfredo Arroyo/PSCAA
From	Stacia Dugan/Jacobs
Date	November 9, 2018
Copies to	Cedar Grove Composting, Inc.

Puget Sound Clean Air Agency (PSCAA) reviewed the mechanical options Cedar Grove has investigated to assist the current building control/ventilation system as provided in the document, "Cedar Grove Composting, Inc. Tipping Building Ventilation Review," dated December 18, 2017. Based on the review, PSCAA has developed the following list of questions/comments, which are presented in **Bold** below. Below each question, Cedar Grove and Jacobs have provided responses.

1) **Where did the concept/calculation of four air exchanges for odor control come from? Please provide a peer reviewed source of the concept and Cedar Grove's calculation showing the volume of the entire tipping/sorting building complex to formulate the flow rate into the biofilter(s).**

The room air change (RAC) rate for tipping buildings is based on fire prevention codes and Occupational Safety and Health Administration (OSHA) guidelines. The tipping building at Cedar Grove's Maple Valley facility was constructed in 1998 and the tipping building extension was added in 2008. At that time, there were no specific National Fire Protection Association (NFPA) Room Air Change (RAC) guidelines for buildings containing compost. The general requirement was a minimum of 4 room air changes per hour (RAC/hr). This RAC rate agreed with the Occupational Safety and Health Administration (OSHA) requirement of a minimum of 4 RAC/hr for industrial settings.

On June 20, 2011 NFPA include RAC guidelines for buildings used for composting sludge in their *Standard for Fire Protection in Wastewater Treatment and Collection Facilities.* In that document, the required RAC rate for a building containing composting aerobic sludge is 6 RACs per hour for an unclassified area and D; no ventilation or ventilation less than 6 RACs for a Division 2 area. The tipping building at Cedar Grove does not contain sewage sludge and would be considered a Division 2 area. However, for new tipping Buildings, 6 RACs is usually used in the design specification to be conservative. See Attachment 1, Table 6.2, Row 24a from the NFPA document as well as the definitions of the different divisions and groups. Cedar Grove's tipping building is an existing building, so 4 RACs is still applicable. During the permit application process, airflows to the new sorting biofilter were discussed with the agency. The airflow selected was based on desired number of RACs, required minimum residence time through the biofilter, and size of the biofilter. The recommended minimum design residence time through a biofilter is 45 seconds. The recommended minimum residence time though a biofilter once it is operating is 30 seconds. The difference allows for the fact that biofilters will settle over time and the height of the biofilter will decrease. The size of the biofilter was also limited by the maximum space available at the site near the tipping building.

Also included in Attachment 1 is an excel workbook. The workbook includes building dimensions, design RAC rates, calculated airflow rates to meet design criteria, and airflow rates included in the permit. The biofilter residence times based on the airflow rates in the permit are also provided. Both the tipping and sorting biofilters typically operate above the airflow rates stated in the permit.

The RAC rate from NFPA has been applied to tipping buildings throughout the country. There is no indication that any air quality agency has implemented a different requirement for ventilation rates on non-co-composting facilities. Jacobs and Cedar Grove request that PSCAA please provide any information they may have where an agency as implemented a specific RAC rate.

2) The first sentence of Paragraph 3 in Page 2 of the review states that "In 2012, the tipping building had a continuous exhaust ventilation system with the exhaust point located near the peak of the interior south wall." Is the current exhaust point location and size the same as in 2012? Please provide a diagram of the south wall verifying the information.

The tipping building biofilter has one intake which is in the tipping building. The sorting biofilter has two intakes, one located in the tipping building extension and the other in the sorting building. The location of the intakes is indicated by an X in Figure 1.

Figure 1. Biofilter Intakes

The tipping building intake that sends air to the tipping biofilter was not moved and is in the same position it was in before 2012. The fan is also the same fan as was in place before 2012. However, as stated in the document, the tipping biofilter was redesigned to allow for increasing the size of the biofilter by about 23 percent, therefor increasing the residence time in the biofilter. The 23 percent increase was the most Cedar Grove could do because of restrictions created by truck traffic and storm water drainage flow. Figure 2 is a picture of the tipping biofilter intake.

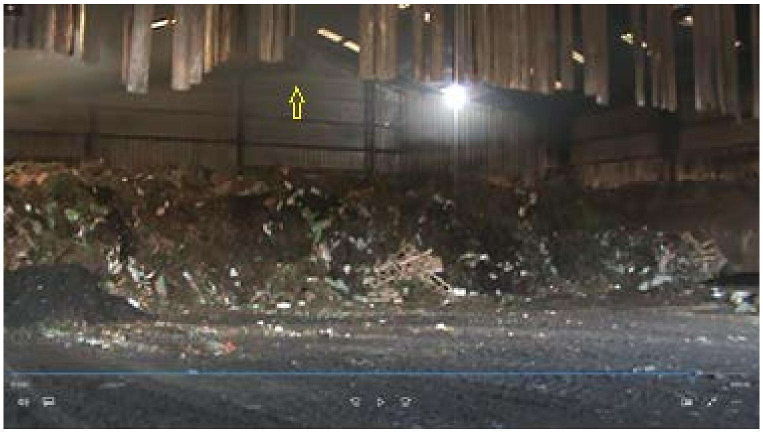

Figure 2. Tipping Building Biofilter Intake

A second intake was added to the tipping building in 2015 and is in the tipping building extension, near the grinding operation (see Figure 3). The intake sends building air to the sorting biofilter. The location of this intake was specified by PSCAA.

Figure 3. Tipping Building Extension Intake

3) The first two sentences of Paragraph 4 in Page 4 of the review states that "It is important to understand that the intake behaves like a vacuum. If you put your hand right in front of the vacuum, the pull is strong, but as you move your hand farther away the pull diminishes." The tipping building's set of bay doors are located on the wall opposite the south wall where the only exhaust point (of tipping building) and intake into the biofilter is located. The statements documented by Jacobs hypothesize that the pull or vacuum per minute at any open tipping building bay door is less than that at or near the exhaust point. When designing the tipping building's ventilation system, did Cedar Grove verify that the design pull or vacuum per minute "at or near" any open tipping building bay door would exceed the natural ventilation rate to the outdoors? Please provide the engineering analysis confirming the design. By "at or near" I mean the area that the natural ventilation rate can potentially exceed the pull or vacuum of the biofilter's ventilation system. During smoke tests, smoke has been observed to escape (the amount is irrelevant from a permitting standpoint), therefore, showing that the pull

or vacuum per minute at or near an open tipping building bay door is not enough to overcome the natural ventilation rate of the building.

The tipping building did **not** have a design requirement that the ventilation system's pull or vacuum per minute "at or near" any open tipping building bay door would exceed the natural ventilation rate to the outdoors. The memo provided to PSCAA on April 13, 2017, Cedar Grove Composting, Inc. Building Ventilation Test Procedures, discusses the changes to the smoke test procedure during the permit application process and how those changes resulted in a requirement of 100 percent capture. Jacobs and Cedar Grove have found no evidence that this level of capture has been applied to any other tipping building and would like the agency to provide an example of where this design requirement has been applied and has been shown to be technically feasible.

EPA's Performance Evaluation Guide for Large Flow Ventilation systems, EPA–340/1-84-012, Figures 4 and 5 indicate how airflow velocity diminish as you move away from the ventilation intake.

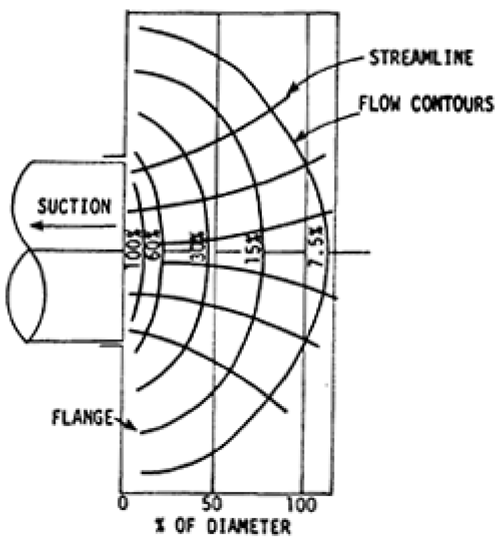

Figure 9. Velocity contours and streamlines for flanged hood.

Courtesy: Silverman, L. Centerline Velocity Characteristics of Round Openings Under Suction. Journal of Industrial Hygiene and Toxicology, 24, 259. November 1942.

Figure 4. Velocity Contours and Streamlines for Flanged Hood

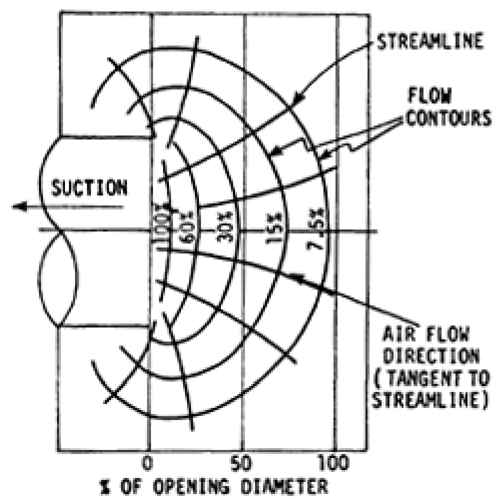

Figure 8. Velocity contours (expressed in percentage of opening velocity) and streamlines for circular openings.

Courtesy: Silverman, L. Velocity Characteristics of Narrow Exhaust Slots. Journal of Industrial Hygiene and Toxicology, 24, 267. November 1942.

Figure 5. Velocity Contours (expressed in percentage of opening velocity) and Streamlines for Circular Openings

The figure demonstrates that the air velocity decreases as you move away from the face of the intake, but the volume of air being moved increases. This is the reason the smoke does not appear to go directly into the intake and the reason why the smoke moves in a swirling pattern though the building as air moves to replace the air going into the intake. However, we can still use the airflow at the intake to estimate the airflow at the open doorway. The total volume of air being sent to the biofilter is being replace by the air coming in through the doorway. This volumetric airflow can be used to estimate the average air flow velocity through the doorway.

A typical kitchen hood has a face velocity between 30 and 50 fpm. A typical laboratory ventilation hood has a face velocity between 75 and 125 fpm, which is equivalent to about 1 mph wind speed. This face velocity is sufficient because a lab hood is inside a build and only needs to work against minor air currents created by building ventilation and the movements of workers.

The face velocity at the doorway to the tipping building is about 41 fpm or 0.5 mph based on the design airflow. This is the range of airflows for hoods used to control odors in kitchens. Attachment 2 includes the door velocity calculations for the design airflow.

To counteract the vacuum created at the doorway by winds outside of the building, the airflow through the doorway would need to meet or exceed the wind speeds outside. Assuming a 5 mile per hour (mph)wind speed and only one door open, the air velocity at the door way would need to be 440 feet per minute (fpm). Because a biofilter should be designed with a minimum residence time of 45 seconds, the biofilter would need to have an area of 71,500 square feet, about 10.2 times larger than the current biofilter. The tipping building is an existing building on an existing site. There is no space available at the site for a biofilter of that size, which makes it technically infeasible. Figure 6 is a picture of the site and the yellow lines indicate the location and size of the current tipping and sorting biofilters. Attachment 3 provides the door velocity calculations needed to match a 5 mph windspeed.

Figure 6. Site Layout

The purpose of EPA's Performance Evaluation Guide for Large Flow Ventilation systems, EPA–340/1-84-012, was to review design principles and O&M considerations for large-scale (i.e., generally 50,000 cfm) ventilation systems commonly found in the metallurgical industry. When the ventilation system for an entire building is used to capture and control metal dust and fume emissions, EPA recommends 20 RACs or more. The number of RACs is based on the toxicity of the metals present in the process. A section of the report is provided in Attachment 4.

The document is an older document, but it demonstrates why the metallurgical industry typically controls emissions right at the source of each emission point instead of using the whole building. Even at 20 RACs per hour, EPA does not expect full containment of the building emissions. A RAC rate of 20 on the tipping building would equate to a face velocity at the door of only 1.8 mph, and the biofilter would need to be about 3.4 times larger than its current size, see Attachment 5. Again, there is no room for a biofilter that large on the site and we are capturing odorous emissions, not toxic metals.

EPA's Air Pollution Control Fact Sheet for Permanent Total Enclosures (PTEs) provides the following criteria to achieve 100 percent control of emissions.

> *In order to qualify as a PTE, an enclosure must meet EPA Method 204 Criteria for and Verification of a Permanent or Temporary Total Enclosure. If the criteria are met, the capture efficiency is assumed to be 100 percent. Overall control efficiency will be equal to the control device reduction efficiency. A capture efficiency test is not required for a PTE. The five point control criteria in Method 204 are given below.*
>
> 1. *All natural draft openings (NDOs) are at least four equivalent opening diameters from each VOC emitting point.*
> 2. *The total area of the NDOs shall not exceed 5 % of the surface area of the enclosure's walls, floor, and ceiling.*
> 3. *The average facial velocity (FV) of air through all NDOs shall be at least 3,600 m/hr (200 fpm), or the static pressure in the enclosure must be -0.007 in. of H2O. The direction of air flow through all NDOs must be into the enclosure.*
> 4. *All access doors and windows shall be closed during routine process operation.*
> 5. *All VOC emissions must be captured and contained for discharge through a control device.*
>
> *PTEs usually accommodate production personnel within its structure during operation; therefore, PTEs are regulated by OSHA. PTEs must provide fresh air to the space and safe and comfortable working conditions. There may be additional design requirements to meet fire and insurance regulations.*

PTE are typically for processes with high VOC emissions like printing presses. They are much smaller than the tipping building and the doors are closed during operation. There is no room for a building with four equivalent opening diameters from the door to the location of the compost and there are other issues with this type of building layout, which was discussed in the Tipping Building Ventilation Review document under Additional Structures. A face velocity of 200 fpm is equal to approximately 2.3 mph which would not be enough to overcome wind conditions above that speed and as stated before, there is no room on the site for a biofilter that big.

Based on all the information above, Jacobs and Cedar Grove believe that 100 percent capture efficiency on the tipping building is technically infeasible. We have seen no evidence from other agencies that indicated that it could be technically feasible. As stated above, Jacobs and Cedar Grove have found no evidence that this level of capture has been applied to any other tipping building and would like the agency to provide an example of where this design requirement has been applied and has been shown to be technically feasible. In addition, what equipment or controls are being used at other permitted facilities in their region that Cedar Grove has not evaluated or put into place. Are the other facilities implementing all the equipment and controls that Cedar Grove is using?

4) In Pages 7 and 8, Cedar Grove proposed adding a new intake over the entire bay door that would remain open. However, Cedar Grove determined this to be technically infeasible. The review stated: "It would require more air flow than is available and might actually draw air from further in the building to the door." Please define what "available" means. What is stopping Cedar Grove from getting a bigger fan? And if this requires expanding the biofilter, what is stopping Cedar Grove from expanding the filter? These are not technologically infeasible. The review also states: "The extra ducting would add back pressure to the system and reduce the amount of air the fan could pull from the building." Adding ducting does increase friction and would require more force to pull the air, but what is stopping Cedar Grove from getting a bigger fan? Again, this is not technologically infeasible. The review further states that: "The building was not designed to support a ventilation system over the

doorway and does not have enough available space for the equipment." Please provide the engineering analysis showing the building's structural load capacity in case of adding a new ventilation system. Please also provide the engineering analysis showing the building's space capacity in case of adding a new ventilation system.

As discussed above the airflow that would be required to insure 100 percent capture would require a biofilter that would be larger than the space available on site, so it is not technically feasible. The current sorting biofilter cost $274,000 to build. If there was room to build a bigger biofilter, the cost to build a biofilter large enough to handle the airflow needed to generate a 5 mph face velocity at the doorway would be approximately $2.8 million dollars. The current tipping building appears to be collecting greater than 90 percent of the air based on smoke tests, which may or may not represent the actual movement of the odors in the building. The cost to improve the collection of smoke or odors by 10 percent would be over $2.5 million dollars not including operating cost. Jacobs and Cedar Grove do not believe that the cost of control per percent reduction in odor emissions is economically feasible. Jacobs and Cedar Grove request PSCAA provide information on what other facilities are using to control odors in their tipping building, and the economic analysis of their use.

5) **In Page 10, Cedar Grove proposed moving the location of the ventilation intake. It is stated: "With a door as large as the opening on the tipping building extension at the Cedar Grove facility, the ventilation design tends to add collection points for the exhaust ventilation system well within the building to maximize the exhaust capture effectiveness. The statement documented by Jacobs conjects that the current design of the tipping building's ventilation system needs more intake points within the building to maximize the capture efficiency. What is stopping Cedar Grove from maximizing its current tipping building's ventilation system? The last sentence of the last paragraph of Page 10 states: "If the ventilation intake were moved from the tipping building extension to the other side of the roofline curtain on the northwest corner of the main tipping building, it might reduce the amount of smoke that is pulled into the tipping extension." The statement documented by Jacobs hypothesizes that moving the ventilation intake of the building extension to the NW corner of the main tipping building can increase the capture efficiency within the tipping building. What is stopping Cedar Grove from maximizing its current tipping building's ventilation system?**

The location of the intake to the sorting biofilter was specified by PSCAA during the permitting process. Cedar Grove needs agreement from PSCAA to move the intake. Moving the intake may slightly improve the tipping building's performance during a smoke test, but it will not lead to 100 percent capture of the smoke as required by the agency.

Attachment 1
Room Air Change Rates

Table 6.2(a) *Continued*

Row	Line	Location and Function	Fire and Explosion Hazard	Ventilation[1, 3]	Extent of Classified Area	*NEC* Area Electrical Classification (All Class I, Group D)[3]	Material of Construction for Buildings or Structures	Fire Protection Measures
23		UNDERGROUND (PIPING) TUNNELS NOT CONTAINING NATURAL GAS PIPING OR SLUDGE GAS PIPING Transmission of sludge, water, air, and steam piping; also might contain power cable and conduit	NA	NR	NA	Unclassified	NC, LC, or LFS	FDS and FE
24	a	COMPOSTING PILES Aerobic sludge reduction	Liberation of ammonia and toxic gas (composting materials can self-ignite)	D	Enclosed area	Division 2	NC, LC, or LFS	H and FDS
	b			C		Unclassified		

Notes:

(1) The NR designation in the ventilation column indicates that no ventilation requirements are established for the space, and, therefore, Table 9.1.1.4 also has no requirements.

(2) Row and Line columns are used to refer to the specific figures in A.6.2 and for specific requirements for each location and function.

(3) The following codes are used in this table:

A: No ventilation or ventilated at less than 12 air changes per hour.

B: Continuously ventilated at 12 air changes per hour or in accordance with Chapter 9.

C: Continuously ventilated at six air changes per hour or in accordance with Chapter 9.

CGD: Combustible gas detection system.

D: No ventilation or ventilated at less than six air changes per hour.

Division	Probability of Hazardous Material
Division 1	The substance referred to by class has a **high probability** of producing an explosive or ignitable mixture due to it being present continuously, intermittently, or periodically or from the equipment itself under normal operating conditions.
Division 2	The substance referred to by class has a **low probability** of producing an explosive or ignitable mixture and is present only during abnormal conditions for a short period of time - such as a container failure or system breakdown

Group	Type of Hazardous Material
Group A	Atmosphere containing **acetylene**.
Group B	Atmosphere containing a flammable gas, a flammable liquid produced vapor, or a combustible liquid produced vapor mixed with air that may burn or explode, having either a MESG (Maximum Experimental Safe Gap)[1)] value less than or equal to 0.45 mm or a MIC (Minimum Igniting Current)[2)] ratio less than or equal to 0.40 - such as **hydrogen** or fuel and combustible process gases containing more than 30% hydrogen by volume - or gases of equivalent hazard such as **butadiene**, **ethylene oxide**, **propylene oxide** and **acrolein**.
Group C	Atmosphere containing a flammable gas, a flammable liquid produced vapor or a combustible liquid-produced vapor whose MESG is greater than 0.75 mm or MIC ratio is greater than 0.40 and less than 0.80 - such as **carbon monoxide, ether**, **hydrogen sulfide**, **morphline**, **cyclopropane**, **ethyl, isoprene, acetaldehyde** and **ethylene** or gases of equivalent hazard.
Group D	Atmosphere containing flammable gas, flammable liquid produced vapor, or combustible liquid produced vapor mixed with air that may burn or explode, having either a MESG value greater than 0.75 mm or a MIC ratio greater than 0.80 - such as **gasoline**, **acetone**, **ammonia**, **benzene**, **butane**, **ethanol**, **hexane**, **methanol**, **methane**, **vinyl chloride**, **natural gas**, **naphtha**, **propane** or gases of equivalent hazard.
Group E	Atmosphere containing combustible metal dusts, including **aluminum**, **magnesium, bronze, chromium, titanium, zinc** and their commercial alloys or other combustible dusts whose particle size, abrasiveness and conductivity present similar hazards in connection with electrical equipment.
Group F	Atmosphere containing carbonaceous dusts, **carbon black**, **coal black**, **charcoal**, **coal** or **coke** dusts that have more than 8% total entrapped volatiles or dusts that have been sensitized by other materials, so they present an explosion hazard.
Group G	Atmosphere containing combustible dust not included in Group E & F - such as **flour**, **grain**, **starch**, **sugar**, **wood**, **plastics** and **chemicals**.

Attachment 1. Calculation of Air Exchange Rate

Cedar Grove Composting - Maple Valley

Tipping Building Dimensions

Length:	100	ft
Width:	100	ft
Height:	26	ft
Peak Height:	16.7	ft
Volume:	343500	cu ft
Number of Air Exchanges:	4	
Air Volume per hour:	1374000	cu ft/hr

Tipping Building Extension Dimensions

Length:	50	ft
Width:	100	ft
Height:	26	ft
Peak Height:	16.7	ft
Volume:	171750	cu ft
Number of Air Exchanges:	4	
Air Volume per hour:	687000	cu ft

Sorting Building Dimensions

Length:	130	ft
Width:	70	ft
Height:	22	ft
Peak Height:	4.7	ft
Volume:	221585	cu ft
Number of Air Exchanges:	4	
Air Volume per hour:	886340	cu ft

Total Building Volume:	736,835	cu ft
Air Volume per hour:	2,947,340	cu ft/hour
Air Flow Rate for Air Exchanges:	49,122	cf/min
Design Airflow Rate:	53,300	cf/min

Minimum Biofilter Residence Time (Design):	45	sec
Minimum Biofilter Residence Time (Operation):	30	sec

Current Biofilter Dimensions:

Tipping Biofilter:

Height:	6	ft
Length:	103	ft
Width:	20	ft
Area:	2001	sq ft
Volume:	12004.2	cu ft
Airflow:	18,000	cu ft/min
Residence Time:	40	sec

Sorting Biofilter:

Height:	6	ft
Length:	93	ft
Width:	47	ft
Area:	4371	sq ft
Volume:	26226	cu ft
Airflow:	35,300	cu ft/min
Residence Time:	45	sec

Total Biofilter Volume:	38230.2
Total Biofilter Area:	6372

Attachment 2
Door Velocity at Design Airflow

Attachment 2. Door Velocity at Design Airflow
Cedar Grove Composting - Maple Valley

Door Dimensions		
Width:	50	ft
Height:	26	ft
Area:	1300	ft2
Assumed Wind Speed Outside:	0.47	mph
Matching Door Velocity:	0.47	mph
	41	fpm *
Design Airflow Rate:	53,300	cfm
Biofilter Dimensions:		
Height:	6	ft
Area:	6,372	ft2
Volume:	38230.2	cu ft
Area of Existing Biofilters:	6,372	ft2

*Kitchen hoods for capturing smoke and odors have face velocities between 30 and 50 fpm. Laboratory Fume hood face velocities between 75 and 125 fpm are generally considered acceptable to meet required capture.

Attachment 3
Door Velocity to Counter 5 mph Winds

Attachment 3. Required Door Velocity to Counter 5 mph Winds
Cedar Grove Composting - Maple Valley

Door Dimensions		
Width:	50	ft
Height:	26	ft
Area:	1300	ft2
Assumed Wind Speed Outside:	5	mph
Matching Door Velocity:	5	mph
	440	fpm *
	572,000	cfm
Minimum Biofilter Residence Time (Design):	45	sec
Required Biofilter Dimensions:		
Height:	6	ft
Area:	71500	ft2
Length:	267	ft
Width:	267	ft
Volume:	429000	cu ft
	0.75	min
Area of Existing Biofilters:	6,372	
Increase in size required:	1022%	

*Fume hood face velocities between 75 and 125 fpm are generally considered acceptable to meet required capture.

Attachment 4
EPA's Performance Evaluation Guide for Large Flow Ventilation systems – Building Evacuation

The National Fire Protection Association (NFPA) Standard for Fire Protection in Wastewater Treatment and Collection Facilities, June 20, 2011, Section 8.5.

8.5 BUILDING EVACUATION

The use of total building evacuation to control air pollution contamination or to improve the work area environment is normally a difficult and costly approach.

The problem areas are:

1. Achieving the necessary number of air changes per hour (20 or more, depending on the contaminants).

2. The ability to reach the specific work areas to supply these air changes. (Some areas have dead air pockets, and either ducting or forced ventilation has to be provided.)

3. The volume of air required. (A building 800 ft long, 80 ft wide, and 40 ft high has a volume of 2,560,000 ft^3. With 20 air changes per hour, ≈850,000 scfm of air is required. If contaminants, open doorways, heat emissions, and air currents caused by thermal processes or vehicle movement are added, the actual requirement for effective ventilation of such a building would be 3 to 4 x 10^6 scfm.)

4. The existing building structure not being designed for total enclosure. (The weight of siding, ducting, and wind loads may require strengthening of the building columns and roof trusses and the addition of more purlins, struts, and bracing.)

5. The location of process equipment and the flow patterns of materials not being conducive to the proper collection of emissions. (Lighting may also be a problem.)

6. Need for redundancy of the fans. (Clean-out mechanisms should be built into the ducting that are readily accessible and repairable. Ducting is long and huge.)

A newly designed building in which process equipment is located specifically for total building evacuation can greatly reduce these problems.

Attachment 5
Airflow at 20 Room Air Changes

Attachment 5. Airflow at 20 Room Air Changes
Cedar Grove Composting - Maple Valley

Tipping Building Dimensions

Length:	100	ft
Width:	100	ft
Height:	26	ft
Peak Height:	16.7	ft
Volume:	343500	cu ft
Number of Air Exchanges:	20	
Air Volume per hour:	6870000	cu ft/hr

Tipping Building Extension Dimensions

Length:	50	ft
Width:	100	ft
Height:	26	ft
Peak Height:	16.7	ft
Volume:	171750	cu ft
Number of Air Exchanges:	20	
Air Volume per hour:	3435000	cu ft

Sorting Building Dimensions

Length:	130	ft
Width:	70	ft
Height:	22	ft
Peak Height:	4.7	ft
Volume:	221585	cu ft
Number of Air Exchanges:	20	
Air Volume per hour:	4431700	cu ft

Total Building Volume:	736,835	cu ft
Air Volume per hour:	14,736,700	cu ft/hour
Air Flow Rate for Air Exchanges:	245,612	cf/min
Design Airflow Rate:	53,300	cf/min

Minimum Biofilter Residence Time (Design):	45	sec
Minimum Biofilter Residence Time (Operation):	30	sec

Current Biofilter Dimensions:

Tipping Biofilter:

Height:	6	ft
Length:	103	ft
Width:	20	ft
Area:	2001	sq ft
Volume:	12004.2	cu ft
Airflow:	18,000	cu ft/min
Residence Time:	40	sec

Sorting Biofilter:

Height:	6	ft
Length:	169	ft
Width:	169	ft
Area:	28451	sq ft
Volume:	170709	cu ft
Airflow:	227,612	cu ft/min
Residence Time:	45	sec

Total Biofilter Volume:	182713
Total Biofilter Area Required:	30452
Area of Existing Biofilters:	6,372
Increase in size required:	378%