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## Chapter 10

### Meeting the Quantitative Requirements of the Regulation

#### 10.1 Introduction

The Part 503 regulation contains operational standards for pathogen and vector attraction reduction. It provides only minimal guidance on the amount of information that must be obtained during a monitoring event to prove that a standard has been met or to demonstrate that process conditions have been maintained. This document provides more detailed information for regulators and facilities on how to adequately satisfy the regulatory requirements. Some frequently asked questions and answers are also included at the end of this chapter.

In general, it has been found that the daily, weekly, and seasonal fluctuations that occur in wastewater treatment works and sludge quality make it difficult to adequately represent sludge quality with minimum sampling. It is therefore recommended that multiple samples be taken for any sampling event and that samples be taken over a minimum 2-week period in order to best represent the performance of a sludge treatment process. Although extensive-sampling is time consuming and facility operators are often under pressure to reduce costs, it is strongly recommended that multiple samples be included in a sampling plan so that the variable quality of sludge can fully be understood.

There are many types of wastewater treatment plants and sludge management practices. This document addresses some of the many operational variables and provides some examples of how to demonstrate compliance with the regulations. The final decision about what to monitor and how frequently to monitor it lies with the permitting authority who may impose permit conditions based on specific parameters including the type of sludge produced, its intended usage, and/or the history of the facility.

#### 10.2 Process Conditions

Sufficient information must be collected about sludge processing conditions and made available to the permitting authority and any other interested parties to enable a qualified reviewer to determine if the Part 503 requirements have been met. How this information is collected and how much information is needed depend on the process. The following example illustrates the type of information and the level of detail that may be included in a permit application. Consider the case of a treatment works that meets

the pathogen reduction requirement for a Class B sludge by using anaerobic digestion conducted at the PSRP conditions of 35°C (95°F) with a 15-day residence time. To meet the pathogen reduction requirement, the monitoring results must demonstrate that the 35°C (95°F) temperature and 15-day residence time are maintained whenever the process is being used. The example below illustrates some of the factors to be considered in assuring compliance with the regulation. In addition, a contingency plan in case the conditions are not met, and product usage should be specified.

#### Example

Facility	Clarksdale Wastewater Treatment Facility Anaerobic Digestion
Size:	300 dry metric tons per year
Class:	B

Sewage sludge is treated in two digesters, operated in parallel, fed by constant displacement progressive cavity pumps. The facility complies with PSRP requirements by maintaining sludge at a temperature at or above 35°C for a minimum of 15 consecutive days.

- **Temperature** — During the first six months of operation under this permit, the permittee shall perform temperature scans throughout the volume of the digester to establish the location of the zone at which temperature is at a minimum. Scans will be conducted under the expected range of operating conditions. Once the location of the zone is established, the permittee will continuously measure digester temperature in the zone of minimum temperature. Temperatures will be recorded continuously or at intervals of eight hours. The temperature measuring device will be calibrated on a monthly basis.
- **Retention Time** — The permittee shall calculate the working volume of the digester to determine residence time. The permittee shall provide evidence that the digester has been cleaned within the last two years, or alternatively, determine the levels of grit and scum accumulation. Residence time must be at least 15 days. Flow rate and residence time will be measured and calculated each year.

- **Vector Attraction Reduction** - The facility will comply with vector attraction reduction via management practices. After digestion, the sludge will be dewatered and transported to farm land where it will be land applied and disked immediately (within six hours) into the soil (see below). Sludge will not be stored at application sites.
- **Reporting**- The data collected throughout the year will be summarized and submitted to the permitting authority annually. Reports will include temperature and residence time records as well as records of all application sites and sludge application rates.
- **Contingency Plan** -If the facility fails to meet the 35° C/15-day requirement, it has several options. The facility can try to meet the Class B time/temperature requirement with lower temperatures and longer residence times as determined by a linear interpolation between 35°C (95°F) and 15 days and 20°C (68°F) and 60 days. If the facility does not have the flexibility to maintain sludge in the digester for longer than 15 days, it can meet Class B requirements by sampling the sludge for fecal coliform and demonstrating that the sludge contains less than 2 million CFU or MPN per gram of sludge on a dry weight basis. Alternatively, the facility can dispose of the sludge by means other than land application. In the case that the facility cannot meet the time/temperature requirements, the permitting authority must be contacted so that a sampling plan which adequately represents sludge quality and demonstrates Class B pathogen reduction can be designed. If the facility decides to divert the sludge from land application, it must notify the regulatory agency of its plans.
- **Product Use** - The sludge will be land applied in accordance with all Part 503 restrictions. The facility will distribute the Class B sludge to local fruit farmers. The facility will notify applicators of sludge quality and relevant site restrictions. Crop harvesting will be restricted in accordance with Part 503 site restrictions. In the case of application to fruit trees, the farmer will wait a minimum of 30 days after application to harvest the fruit. If fruit that has fallen off the trees or otherwise touched the ground will also be harvested, the farmer will wait 14 months after sludge application to harvest the fruit. If there is any question about the waiting period or if the facility wishes to distribute sludge to farmers of crops which touch the ground, the facility should notify the regulator. Site restrictions for crops which touch the soil or which grow below the soil surface are subject to longer waiting periods.

The number and the level of detail of a permit's conditions vary depending on the type of process. Facilities that handle sludge or septage from more than one source should be subject to more frequent testing until they can demonstrate that the product consistently meets quality standards. The permitting authority must determine at what

point the facility has adequately demonstrated consistency and can reduce the level of sampling.

For example, consider a treatment facility that collects liquid sewage sludge and septage from several different sources. Although all of the sludge collected undergoes standard treatment for Class B pathogen reduction, the quality of the sludge generated may vary depending on the particular feedstock received. Initially, the permitting authority may require this facility to monitor every batch of sludge in order to demonstrate that it consistently produces sludge in compliance with regulatory and permit requirements. Eventually, if enough data is available showing that the treated sewage sludge is rarely off specification, the sampling frequency could be reduced.

For other processes, such as static pile composting, a sampling plan might specify that one of several piles constructed in a day could be monitored, probably with several thermocouples at different elevations and locations in the pile, to demonstrate conformance for the whole day's production.

At times, processes do not conform to process conditions. In such cases, the operator should keep records showing that the treated sludge produced was either recycled to be processed again or diverted in some manner for use or disposal consistent with its quality (e.g., disposal in a landfill with daily cover or, if the sludge meets the Class B requirements, application as a Class B [rather than as a Class A] biosolids).

### 10.3 Schedule and Duration of Monitoring Events

For purposes of this discussion:

- A sampling event is defined as the period during which samples are collected. Samples may include several independently analyzed subsamples taken during the sampling event.
- A monitoring event includes the sampling period and the period to analyze the samples and provide the results needed to determine compliance.

Monitoring events are intended to reflect the typical usual performance of the treatment works. Conditions should be as stable as possible before the monitoring event. Day-to-day variations in feed rate and quality are inevitable in sewage sludge treatment, and the processes are designed to perform satisfactorily despite these variations. However, major process changes should be avoided before monitoring events, because long periods of time --as much as 3 months if anaerobic digestion is part of the process train-- are required before steady state operation is reestablished.

#### **Monitoring for Microbiological Quality**

To meet the Part 503 pathogen reduction requirements, sewage sludges may have to be monitored to determine densities of fecal coliforms, *Salmonella* sp., enteric viruses,

and/or viable helminth ova. Monitoring for these microorganisms presents special problems, primarily caused by the length of time it takes to obtain microbiological test results. This is a function of the time it takes to deliver the samples to a laboratory, have the tests conducted, and obtain the results. Microbiological analyses require a substantially longer period than conventional physical and chemical analyses. The approximate time to complete specific microbiological analyses is summarized as follows.

Fecal coliform (MPN), 4 days  
*Salmonella* sp. (MPN) 5 to 7 days  
Enteric viruses, 14 days  
Viable helminth ova, 28 days

Variations in the microbiological quality of the treated sludge and intrinsic variation in the analytical methods are generally large enough that a single measurement of a microbiological parameter is inadequate to determine whether a process meets or fails to meet a requirement. The Pathogen Equivalency Committee recommends that the monitoring event include at least seven samples taken over a period of approximately 2 weeks (see Section 10.7). Based on the reliability of the treatment process and historic test results, there may be times when a reduction in this monitoring recommendation is justified.

Thus, the time required for a monitoring event could range from 3 to 7 weeks. During this time, the quality of the treated sewage sludge generated is unknown. As discussed in Section 4.10, classification of sludge as Class A or B is based on the most recent test results available. Therefore, material can continue to be distributed under its classification as Class A or B until more recent analytical results are available. However, it is recommended that material generated during the monitoring event be retained on site until results from the monitoring event are available. This will prevent misclassified sludge from being erroneously distributed.

For example, consider a facility producing a Class A sludge that is sampled for *Salmonella* sp. analysis every quarter. All historic data has shown the facility to be in compliance with Class A standards including the most recent set of lab analyses from the January monitoring event. Under these results, materials are distributed as Class A products even throughout April when a subsequent monitoring event takes place. This is acceptable because material is still classified under the most recent available lab result. However, suppose the April results show non-compliance with Class A standards. Despite the fact that the preparer complied with regulations, it is possible that some Class B material was inadvertently distributed for Class A use.

In order to avoid this situation, it is recommended that the sludge processed during the monitoring event either be stored until it is demonstrated that the processed sludge meets the quality requirements for use as a Class A or B sludge, or - if the sludge is being monitored for Class A

requirements - used or disposed as a Class B sludge (provided it meets the Class B requirements). This may take up to 3 weeks in the case of fecal coliform or *Salmonella* sp. analysis and much longer if sludge is being analyzed for helminth ova or viruses. Contingencies for this type of situation should be discussed with the regulatory authority and included in permit conditions and operational plans. (For more discussion on the timing of sampling and distribution, see Section 4.10.)

### **Monitoring for Vector Attraction Reduction**

Not all the vector attraction reduction options listed in the regulation (see Chapter 8) require lab testing. Four of the methods (treatment of sewage sludge in an aerobic process for 14 days or longer, injection below the surface of the land, incorporation of sludge into the land, and placement of sludge on a surface disposal site and covering it at the end of each day) are technology descriptions. These technologies have to be maintained throughout the year in the manner described in the regulation. Examples of the kind of information needed to demonstrate adequate performance are provided in Section 10.2.

The remaining vector attraction reduction options are based on laboratory testing for volatile solids reduction, moisture content, or oxygen uptake reduction. Some of the options can only be used with certain sludge processes. For example, the oxygen uptake rate test is only appropriate for a sludge from any aerobic digestion or wastewater treatment process. Other options, such as the 38 percent reduction in volatile solids, can be applied to a variety of biological sludge treatment processes. In any case, the technology aspect of the option, or the process by which vector attraction reduction is being attained, must be documented in the manner described in Section 10.2. Monitoring for vector attraction reduction should be performed at a minimum according to the required monitoring schedule.

Some tests for vector attraction reduction can be conducted within a few hours while others can take more than a month. For the tests that can be conducted within a few hours, the sampling event must be more than a few hours to account for the variability in the material tested and the performance of the vector attraction reduction process as affected by the changes in feedstock.

It is suggested in Section 8.14 that facilities maintain a sampling program that involves sampling at evenly spaced time intervals throughout an established monitoring period. The on-going samples can be used to calculate running averages of volatile solids reduction which are more representative than single samples or an attempt to correlate feed sludge and sludge product. As is the case for the microbiological tests, these vector attraction reduction tests should be conducted over approximately 2 weeks to minimize the expected effect of these variations. The 2-week period can be the same 2-week period during which the microbiological parameters are being determined.

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The longer VAR tests present a similar problem as monitoring for microbiological quality. Some of the tests - such as the additional digestion tests - take more than a month to complete. Unless the treatment works has several sets of duplicate testing equipment, it will be impossible to run these tests on enough samples during a 2-week sampling period to assess the variability in the performance of the treatment process. Storing samples taken during this period until the equipment becomes available is not an option, because samples cannot be stored for more than a limited time period (see Section 9.6.) In such circumstances, the preparer may wish to run the vector attraction reduction tests more frequently than required in order to demonstrate on-going compliance with the requirements. More frequent testing will indicate if the facility is performing consistently and will reduce the need for multiple samples during the sampling period.

The preparer may wish to conduct composite sampling which combines samples taken within a 24-hour period to better represent sludge quality. (See Section 10.6). Since some of the bench scale tests may be affected by long-term storage of samples, compositing should be limited to a 24-hour period. If compositing is done, the composite should be held at 5°C during compositing, and the assay must begin immediately upon completion of the composite.

Preparers should discuss specific facility parameters with the permitting authority to design a sampling program that is appropriate.

## 10.4 Comparison of Feed Sludge and Sludge Product Samples

The enteric virus and viable helminth ova analytical requirements to demonstrate that an existing or new sludge treatment process is equivalent to a PFRP one and some of the vector attraction reduction methods (e.g., percent volatile solids reduction) involve taking input and output samples that correspond (i.e., they are “before processing” and “after processing” samples of the same batch of sludge). The comparison of input and output samples allows for the determination of whether enteric viruses and helminth ova levels are being reduced to adequate levels and/or percent volatile solids reduction.

Obtaining samples that correspond can be difficult for sewage sludge treatment processes, such as anaerobic digestion, that characteristically treat sludge in fully mixed reactors with long residence times. For example, as mentioned in Section 10.3, it can take up to 3 months for an anaerobic digester to achieve steady state operation after some substantive change in feed sludge or process condition is made. Samples taken only after the process has reached steady state operation are considered as corresponding.

Many of the treatment processes that might be considered for demonstrating equivalency to PFRP are either batch or plug flow processes. In theory it is relatively simple

to obtain corresponding samples - it is only necessary to calculate the time for the input material to pass through the system and sample the downstream sludge at that time. Achieving accurate correspondence in practice, however, is seldom easy. Consider, for example, the difficulty of obtaining good correspondence of feed and treated sludge for a composting operation in which the feed sewage sludge is to be compared to composted sludge that has been stored for 3 months.

Taking multiple samples and appropriately compositing the samples of feed and treated sludge averages out the composition of these sewage sludges and reduces the correspondence problem. It is the regulatory authority's task to determine how many samples should be taken and how much data is necessary to demonstrate reduction of microorganisms in corresponding samples. As indicated in Section 10.6, limitations on the periods of time over which microbiological samples can be collected limit the utility of compositing.

## 10.5 The Effect of Sludge Processing Additives on Monitoring

Many sewage sludge dewatering and stabilization processes introduce other substances into the sludge. With the exception of large bulky additives such as wood chips, there is no need to modify sampling and analytical procedures. As discussed below, additives such as wood chips can complicate sample preparation and analysis and are best removed prior to analysis.

Polymers, lime, ferric chloride, paper pulp, and recycled sludge ash are frequently used to aid in dewatering. Disinfection by alkaline treatment requires the addition of lime or other alkaline materials to increase the temperature of the sewage sludge cake to disinfecting temperature. These materials also reduce the microbial densities by dilution and increased solids content. However, the change in microbial density caused by dilution may not be substantial. For example, an increase in mass of 20% would result in a reduction in the log density of a microbiological parameter of only 0.079.

The exposure risk to human health is directly related to the mass of treated sludge. So the achievement of pathogen reduction requirements and safe end-use is dictated by the population of pathogenic organisms in the final product. This is the approach taken by the Part 503 regulation, which requires that the treated sludge, regardless of the mass of other materials added, meet the standards for Class A or Class B sludge.

For some sludges, particularly those treated by composting (these usually will be Class A biosolids), the amount of additive can be considerable. Nevertheless, the regulation requires that the biosolids meet the standard, which means that no correction need be made for dilution.

The issues of sampling and analytical procedures for employment are different when considering wood chips or other materials which are often added to sludge as a bulk-

ing agent for composting. Compost product may be given away or sold as a screened or unscreened product, and although regulations require that the treated sludge, as it is applied, meets 503 standards, in the case of wood chips and other large particle size bulking materials, it is appropriate to remove large pieces before analysis takes place.

Large additives are removed in order to improve the accuracy of the microbial measurements. The wood chips are so big (typically 4 cm x 4 cm x 1 cm) that a very large sample would have to be taken and blended to get a representative subsample. Sample reliability is reduced when the sample consists of a mix of sludge solids and fibrous wood-chip residue from blending. Another reason for removing the wood chips prior to microbial analysis is that the exposure of users to the compost is related to the fine particle content and not to large, physically distinct wood chips. For example, a user who handles the compost gets his or her hands covered with compost particles. Similarly, the user might breathe in a dust of compost particles. In both cases, it is the "fines" of the compost, not the wood chips that the user is exposed to.

In order to ensure that wood chips are not included in the lab's subsample, the facility should remove wood chips after sampling, being careful not to contaminate, with a sterilized sieve. The size of the sieve needed depends on the dimensions of the wood chips, but the same sieve size should be used for each sampling event. Alternatively, the laboratory should be asked to remove wood chips from samples before subsampling or analyses are conducted. Again, the sieve size should be established so that a standard size is used.

## 10.6 Collecting Representative Samples

Sludge quality varies depending on the inputs to the wastewater system. In addition, the process is subject to ambient conditions which vary daily as well as seasonally. The goal of a sampling program is to adequately represent the quality of sludge. Therefore, both the frequency of sampling and the number of samples taken in any one sampling event must be considered carefully. This section discusses the issue of variability and how sampling frequency and composite sampling can improve the quality of data collected. A sampling plan is recommended for all sampling events to assure representative samples.

### **Random Variability**

Virtually all sewage sludge treatment processes will experience a certain amount of short-term random or cyclic variation in the feed sludge and in process performance. Evaluation of average performance over a 2-week time period is suggested as a reasonable approach to account for these variations. Cyclic variation can be minimized by sampling on randomly selected days and time-of-day in a given week. In the case of Class B fecal coliform analysis **ONLY** variability is minimized by taking the geometric mean of analytical results. In the case of Class A, all samples must meet the fecal coliform or *Salmonella* sp. numerical limit.

### **Seasonal Variability**

For some sewage sludge treatment processes, performance is poorer during certain parts of the year due to seasonal variations in such factors as temperature, sunshine, and precipitation. For example, aerobic digestion and some composting operations can be adversely affected by low ambient temperature. In such cases, it is critical that process performance be evaluated during the time of year when poorest performance is expected. If a treatment works is evaluated four or more times a year at intervals of 2 or 3 months, there is no problem, because all seasons of the year will be covered. For small treatment works that are evaluated only once or twice a year, it is important to monitor in the time of year where performance is expected to be poorest, to avoid approving a process that is not performing adequately for much of the year. It may also be beneficial to initially conduct sampling more frequently than the required minimum, perhaps on a quarterly basis, in order to determine the range of sludge quality. Process criteria of PSRPs and PFRPs should be discussed by the facility with the regulatory authority, and specific requirements should be included in permit conditions.

### **Composite Sampling**

Composite sampling, or the combination of several grab samples to better represent a large quantity of sludge, is frequently practiced in wastewater treatment. Composites may consist of grab samples taken over time (typically for continuous flow processes) or from random locations in a vessel or pile (typically for batch processes). Since the purpose of composite sampling is to provide representation of a large quantity of sludge, the number and distribution of grab samples, the locations from where they are taken, and the process of combining grab samples to create a composite sample are important to consider.

The following is an example of a sampling procedure for compositing a continuous flow process. A small stream of wastewater or sludge is drawn off at rate proportional to the flow of the main stream being sampled and collected as a single sample. Typically, times of collection are for one shift (8 hours) or one day (24 hours). In this case, the accumulated sample represents a volume-average sample over the period of time the sample is drawn. The sample is chilled during the period it is being collected to prevent chemical/microbiological change until it can be brought back to the laboratory for analysis.

Composite sampling from stockpiled solid material involves taking multiple grab samples from a range of locations in the stockpile. Samples should be taken from different interior sections of the pile which may represent material produced in different time periods. Grab samples should all be of the same size so that the composite is an equal representation of all of the grab samples. The grab samples should be mixed thoroughly and a subsample pulled from the mixture.

Composite sampling is useful for any type of sampling, but the protocol must be modified when microbial analy-

ses are intended. Samples must be taken over a shorter period of time so that microbial populations do not undergo significant changes during the sampling event. For example, a composite time-average sample can be obtained by combining a series of small samples taken once every 5 minutes for a period of an hour. A composite sample for bacterial and viral testing could be taken over an hour or less under most circumstances without compromising the results. Composite sampling over 24 hours, or even longer if special precautions are taken, is possible for viable helminth ova provided the ova in the sample are not exposed to thermal or chemical stress (e.g., temperatures above 40°C [104°F] or the addition of certain chemicals such as ammonia, hydroxides, and oxidants). In addition to limiting the sampling period, sterile equipment must be used when taking grab samples or compositing the samples for microbiological analysis in order to prevent introducing pathogenic bacteria.

Composite sampling may be possible for samples to be used in some of the procedures to determine whether vector attraction reduction is adequate. It may not be appropriate for those procedures that depend on bacterial respiration (i.e., aerobic or anaerobic digestion). This subject is discussed in Appendix D which presents procedures for three methods to demonstrate reduced vector attraction.

## 10.7 Regulatory Objectives and Number of Samples that Should be Tested

Overall, it is recommended that numerous samples be taken over a period of 2 weeks in order to represent the average characteristics of a sludge stream. Unfortunately, sampling for microbial and vector attraction reduction parameters is more complicated than sampling for heavy metals because of the time limits and contamination issues involved. In addition, the results of microbial testing must be handled differently. The following is a review of the primary sampling and monitoring issues that relate to particular pathogen and vector attraction reduction parameters.

### ***Class B: Monitoring for Fecal Coliform Densities***

Part 503 requires that seven samples be taken to demonstrate compliance with the fecal coliform levels required of Class B biosolids. Under the Class B requirements seven samples also means seven analyses. Seven samples were judged adequate to account for the short-term fluctuations in treated sludge quality and allow determination of average performance. Variance of fecal coliform determinations is known to be high, but analysis (presented below) showed that if seven samples are averaged, the error band about the mean value is sufficiently compressed that treatment works with adequately treated sludge would not have difficulty meeting the standard. If the mean value does not meet the standard, the material is not a Class B biosolids and must be disposed of otherwise until the standard is met.

The regulation requires that the geometric mean fecal coliform density of the seven samples be less than 2 million CFU or MPN per gram of total solids sewage sludge (dry weight basis). If a treatment works were producing a treated sewage sludge with a true mean density of exactly 2 million fecal coliform per gram, measured values of the fecal coliform density would cluster around 2 million per gram, but half would be below and half would be above it. Half the time, the treatment works would appear not to be meeting the requirement. The true mean density must be below 2 million per gram to be confident that the experimentally determined average will be below 2 million per gram. Just how much below depends on the standard error of the average.

Use of at least seven samples is expected to reduce the standard error to a reasonable value. In tests on extended aeration sludges, Farrell et al. (1990) obtained a standard deviation of the logarithm of the fecal coliform density ( $s$ ) of 0.3 using the membrane filter method. This included the variability in the analysis as well as variability over time (approximately a year). Standard error for the average of seven measurements ( $S.E. = s/(n^{1/2})$ ) is 0.11. Using the normal probability distribution, the true mean must be below 1.30 million if the geometric mean of seven measurements is to be below 2 million 95% of the time (see Table 10-1 for details of this calculation). If the standard deviation were higher, the true mean would have to be even lower to be reasonably confident that the geometric mean would be below 2 million per gram. Thus, efforts should be made to reduce variability. Steps that can be taken are:

- Reduce the standard error by increasing the number of measurements used to determine the geometric mean.
- Reduce process variability.
- Improve sampling and analytical techniques.

What action to take to reduce the geometric mean depends on the process. For anaerobic or aerobic digestion, some suggested steps are to increase temperature, increase residence time, use a draw-and-fill feeding procedure rather than fill-and-draw or continuous feeding, and increase the time between withdrawal and feeding. After an attempt at improvement, the evaluation should be repeated. If the process continues to fail, more substantial changes to the process may be appropriate.

### ***Class A: Monitoring for Fecal Coliform or Salmonella sp. Densities***

Part 503 requires that, to qualify as a Class A sludge, sewage sludge must be monitored for fecal coliform or *Salmonella* sp. and have a density of less than 1,000 MPN fecal coliform per gram of total solids sewage sludge (dry weight basis) or *Salmonella* sp. densities below detection limits (3 MPN/4 g). The regulation does not specify the number of samples that have to be taken during a monitoring event. One sample is not enough to properly represent the sewage sludge. It is recommended that multiple

**Table 10-1.** True Geometric Mean Needed If Standard Fecal Coliform Density of 2 Million CFU Per Gram is to be Rarely Exceeded

Assumptions

- The fecal coliform densities of the sewage sludge are log normally distributed. (The arithmetic mean of the logarithms of the fecal coliform densities is the mean of the distribution. The geometric mean is the antilog of the arithmetic mean of the log values.)
- The goal is to ensure that the measured mean value does not exceed the density requirement more than once in 20 monitoring events.
- The standard deviation of the log density is 0.30.

Calculation

To predict the expected frequency of a measurement using the normal probability distribution, the variable  $x$  is converted to the standard measure ( $u$  - see below) and its probability of occurrence is obtained from tabulated values of the probability distribution. In this case, the reverse is carried out. A certain probability of occurrence is desired and the value of the standard measure is read from the tables. From the normal distribution table (single-sided),  $u$  is 1.645 when  $P = 0.05$  (one in 20),

Where:

- $P =$  the proportion of the area under the curve to the right of  $u$  relative to the whole area under the curve.  
and:  $u =$  the standard measure  
 $u = (\bar{x} - \mu)/S\bar{x}$  (Equation 1)  
Where:  $\mu =$  true log mean  
 $\bar{x} =$  log mean of the measurements  
 $S\bar{x} = s/n^{1/2}$   
 $n =$  number of measurements that are averaged  
 $s =$  standard deviation of a single measurement of log mean density

The logarithm of the fecal coliform density requirement (2 million CFU/g) is  $\bar{x}$  ( $\bar{x} = 6.301$ ). This is the number that should not be exceeded more than once in 20 monitoring episodes. Substituting into Equation 1 and calculating  $\mu$ ,

$$1.645 = (6.301 - \mu)/(0.3/7^{1/2})$$
$$\mu = 6.114$$

Antilog 6.114 = 1.3 million CFU/g.

samples ( $\geq 7$ ) be taken over a period of two weeks in order to adequately represent sludge quality. Based on the reliability of the treatment process and historic test results, there may be time when a reduction in this monitoring recommendation is justified. In the case of Class A, analytical results from multiple samples are not averaged together; instead, all results must be in compliance with Class A limits.

The measured fecal coliform density provides an estimate of the likelihood of *Salmonella* sp. detection and, if detected, the expected density. Yanko (1987) obtained a good correlation between fecal coliform density and *Salmonella* sp. detections in his extensive investigation of composts derived from sewage sludge. The fraction detected is less than 10% when fecal coliform density is less than 1,000 MPN/g. Yanko also obtained a good correlation between fecal coliform density and *Salmonella* sp. density for those samples for which *Salmonella* sp. were detected. That correlation predicts that, for fecal coliform densities less than 1,000 MPN/g, *Salmonella* sp. densities will be less than 1.0 MPN/g. Thus, at fecal coliform densities 4,000 MPN/g, *Salmonella* sp. detections will be infrequent and, if detected, densities are expected to be below 1 MPN/g.

The Part 503 allows the monitoring of either fecal coliform or *Salmonella* sp. in order to demonstrate compliance with Class A microbiological requirements. The *Salmonella* sp.

determination is somewhat similar to the fecal coliform test, but it is much more expensive and requires a high experience level. In all likelihood, the *Salmonella* sp. tests would have to be carried out by a contract laboratory.

The standard deviation for Class A sludges will most likely be lower than for Class B. This is due to the fact that we have many more organisms present in Class B sludges which are not equally distributed within the biosolids. Therefore you have greater variability and hence a higher S.D.

What action to take to further reduce pathogens in case the fecal coliform requirement is not met depends on the process. In general, verification of retention times and temperatures as well as elimination of cross-contamination between feed and treated sludge or opportunities for re-introduction of pathogens into treated sludge are recommended. For aerated deep-pile composting, thicker insulating layers on the pile and longer maturing times are suggested.

### **Class A: Monitoring for and Demonstration of Enteric Virus and Viable Helminth Ova Reduction**

The accuracy of monitoring results demonstrating the absence of enteric viruses and helminth ova is influenced by the variability in the influent to the treatment works and the inherent error in the experimental method. Information

on method error for both enteric viruses and helminth ova is available only on standard deviations calculated from duplicate samples. Goyal et al. (1984) report that, in their comparison of methods for determining enteroviruses, the log standard deviation for the virus determination in sewage sludge was 0.26 (47 degrees of freedom). A review of the work of Reimers et al. (1989) indicates that, in the range of 5 to 100 viable *Ascaris* ova per 10 grams sewage sludge solids, standard deviation was about half the number of viable ova. This is equivalent to a log density of 0.3, which is about the same as for fecal coliform. Thus, there is no unusually high variability in the basic test methods that would require an increased number of samples to minimize this effect.

Deciding how many samples to take for enteric viruses and viable helminth ova is more difficult than for fecal coliform and *Salmonella* sp. because enteric viruses and viable helminth ova often may not be present in untreated sludge. For this reason, the interpretation of the density determinations for these organisms in treated sludge depends on the quality of the feed sludge. If no enteric viruses or viable helminth ova are detected in the feed sludge, then the absence of these organisms in corresponding samples of treated sludge does not indicate in any way whether the process is or is not capable of reducing these organisms to below detectable limits. The ability of a process to reduce these organisms to below detectable limits is indicated when analysis shows that these organisms were present in the feed sludge and were not present in corresponding samples of treated sludge. One important question is: What fraction of the total pairs of corresponding samples must show positive in the feed sludge and negative in the treated sludge to provide convincing evidence that the process consistently reduces enteric viruses and viable helminth ova to below detectable levels? This is a difficult question to answer.

Because viable helminth ova are relatively stable microorganisms, compositing is suggested as a way to obtain meaningful representative samples and analytical results. If precautions are taken, such as cooling the sample promptly to close to 0°C (32°F) and destroying or neutralizing any added chemicals such as strong bases that were added as part of the pathogen-reducing process, composites can be collected over a 2-week period. Corresponding composites of feed and treated sludge can be compared, with a much lower likelihood of not finding viable helminth ova in the feed sewage sludge. Because the analytical method itself has a high variance (see above), a minimum of four duplicates of the composite should be tested.

For enteric viruses, the same approach may be used as suggested above for viable helminth ova. Precautions are taken to cool the sample and destroy or neutralize any chemicals added in the pathogen-reducing process. Samples are collected on separate days and are promptly frozen at 0°F (-18°C), or -94°F (-70°C) if samples will be stored for more than 2 weeks. When the samples are to be analyzed, the individual samples are thawed and composited, and viral densities determined.

The density of both viable helminth ova and enteric viruses in processed sludge must be based on the results of several measurements. Most of these measurements are expected to show below detectable densities. If any one sample is above 1 PFU (for viruses) or 1 viable helminth ovum (for helminths) per 4 grams, the process does not meet the Part 503 operational standard.

## **Vector Attraction Reduction Tests**

### **Reduction in Volatile Solids**

One way to demonstrate reduction in volatile solids requires measurement of volatile solids of the sewage sludge before and after sludge treatment. The sampling point for the "after treatment" measurement can be immediately leaving the processing unit or at the point of use or disposal, provided there has been no significant dilution downstream with inert solids.

Farrell et al. (1996) have determined the standard deviation of the percent volatile solids (%VS) determination for separate samples withdrawn from pilot-scale digesters to be 0.65% (total solids content ranged from 2% to 5%). Conventional statistical procedures (see Davies and Goldsmith, 1972) were used to calculate the standard error of the percent volatile solids reduction (%VSR), which is calculated from the %VS of the untreated and treated sludge. The standard error of the %VSR when calculated by the Van Kleeck equation (see Appendix D) is 2.0% in the range of interest (38% VSR). The 95% confidence limits of the %VSR are  $\pm 4\%$ , which is excessive. If the %VSR is the average of seven determinations, the confidence interval is reduced to  $\pm 1.5\%$ , which is a more acceptable value.

The most difficult problem with the %VSR determination, as discussed above in Section 10.4, is getting correspondence of the influent sludge with the effluent sludge. If there has been a significant change in an inlet concentration or flow rate, achieving correspondence can require several months of monitoring inlet and outlet volatile solids concentrations. If conditions have been steady and feed compositions have been fluctuating about an average value for a long period, data taken over a 2-week period would be adequate to establish steady state performance.<sup>1</sup> This implies that data have been collected beforehand that demonstrate that sewage sludge composition has reached steady state for a long period before the 2-week sampling period. It appears that regular collection of data for some months before the sampling period is unavoidable to demonstrate steady state performance before the testing period. Fortunately, the total and volatile solids determinations are not costly, and they provide valuable operating information as well.

Total and volatile solids content of a sample do not change significantly over the course of a day, particularly if

<sup>1</sup>Note that, unlike the plug flow case, there should be no displacement in time between comparisons of input and output for fully mixed reactors. Only when there has been a significant change is it necessary to wait a long time before the comparisons can be made.

the sludge is cooled. Time composites collected over a course of a day can be used for these determinations. Seven or more determinations are recommended to reduce the error band around the mean to minimize the chance that a process that actually has a greater volatile solids reduction than 38% might show an average that is below this value.

### **Additional Digestion Tests**

The essential measurement in the additional digestion tests for aerobic and anaerobic sludges (see Sections 8.3 and 8.4) is the percent volatile solids content (%VS) from which the percent volatile solids reduction is calculated (%VSR). Using the standard deviation of 0.65% determined by Farrell et al. (see above), the standard error of the %VSR when calculated by the Van Kleeck equation (see Appendix D) is 2.5% in the range of interest (15% VSR). The 95% confidence limits of the %VSR are  $\pm 5\%$ . The tests (see Appendix D) require substantial internal replication which shrinks these confidence limits. Samples should also be taken to account for the variability in the process. The 2-week sampling period suggested for the Class A disinfection microbiological tests may be excessively restrictive if several samples are to be evaluated. The equipment needed for the test is not expensive but the units take up substantial bench space. It is unlikely that a treatment works will want to have more than two sets of test equipment. Since the tests take 30 to 40 days, it is not possible to run more than one set of tests (two in a set) within a monitoring event. It is suggested that these tests be routinely carried out during the year and the results be considered applicable to the monitoring period. It is estimated on a best judgment basis that five tests are needed to account for variability in the feed sludge and in the treatment process itself.

### **Specific Oxygen Uptake Rate Test**

The Oxygen uptake measuring part of the specific oxygen uptake rate test (SOUR, see Appendix D) can be completed in the laboratory or field in a few minutes, so there is no difficulty in completing the test during a monitoring event. The test requires the SOUR determination to be made on two subsamples of a given sample. Farrell et al. (1996) found that, in the target SOUR value of 1.5 mg O<sub>2</sub>/hr/g, sludge solids replicates agreed within about  $\pm 0.1$  mg O<sub>2</sub>/hr/g. Since the test is easy to run, it is suggested that seven tests within the 2-week sampling event will adequately define the SOUR. Labs performing this test should demonstrate that they too can achieve this level of precision for replicates ( $\pm 0.1$  mg O<sub>2</sub>/hr/g). Arithmetic average of the tests should be computed and compared against the Part 503 SOUR value.

### **Raising the pH to 12**

There are two options in the regulation that reduce vector attraction by pH adjustment. In the first, sludge is raised in pH by alkali addition so that pH is  $\geq 12$  for 2 hours after alkali addition and, without further alkali addition, remains at pH  $\geq 11.5$  for an additional 22 hours (see Section 8.7).

The second method is for domestic septage. The pH is raised to pH  $\geq 12$  by alkali addition and, without further addition of alkali, remains at  $\geq 12$  for 30 minutes (see Section 8.13). As noted in Section 5.6, the term alkali is used in the broad sense to mean any substance that increases pH.

The pH requirement in the regulation was established using data obtained at room temperature (Counts and Shuckrow, 1975; Ronner and Cliver, 1987), which is presumed to have been 25°C (77°F). Consequently, pH should be measured at 25°C (77°F) or measured at the existing temperature and converted to 25°C (77°F) by use of a temperature-versus-pH conversion table determined experimentally for a treated sludge that meets the pH requirements. The correction is not trivial for alkaline solutions; it is about -0.03 pH units/°C (-0.017 pH units/°F) for aqueous calcium hydroxide with a pH of about 12, and should not be ignored. Note that temperature-compensated pH meters only adjust instrument parameters and do not compensate for the effect of temperature on the pH of the solution.

### **pH Adjustment and Septage**

Each container of domestic septage being treated with alkali addition must be monitored. The pH is monitored just after alkali addition and a half hour or more after alkali addition. Bonner and Cliver (1987) suggest that alkali (they used slaked lime) be added to the septic tank or to the septic tank truck while domestic septage is being pumped from a septic tank into the tank truck. If slaked lime is used, a dose of 0.35 lb per 10 gallons (4.2 g per liter) is sufficient to raise the pH to 12 for a typical domestic septage of about 1% solids content. The agitation from the high velocity incoming stream of septage distributes the lime and mixes it with the domestic septage. The pH is measured when the truck loading is complete. The truck then moves to the use or disposal site. Agitation generated by the motion of the truck may help in mixing and distributing the lime however, supplemental mixing in the tank may be needed. The pH is again measured at the use or disposal site. The second pH measurement should be at least a half hour after the addition of lime. The sample may be obtained through the top entry of the tank truck, using, for example, a stainless steel cup welded to a long handle to collect the sample. The pH is most conveniently measured with alkaline pH paper in the pH range of 11 to 13. The pH paper can age and become contaminated. It is best to use strips from two separate containers. If they do not agree, compare with a third batch and reject the one that disagrees with the others. Accuracy of these measurements is within  $\pm 0.1$  pH unit. If the pH is below 12, either initially or after 30 minutes, more lime should be added and mixed in. After an additional waiting period of at least 30 minutes, the pH must again be measured to ensure that it is greater than 12.

### **pH Adjustment and Sewage Sludges**

For addition of alkali to sewage sludges, the pH requirement is part of both the PSRP process description (see Section 5.3) and the requirement of a vector attraction option (see Section 8.7). Monitoring is required from 1 to 12 times a year (see Table 3-4 in Chapter 3), and the pro-

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cess must meet the prescribed operating conditions throughout the year.

Alkali is sometimes added to liquid sludge and sometimes to dewatered sludge. The pH requirements as stated in the regulation apply in the same way for both liquid and dewatered sludge. For the first measurement of pH in liquid sludge 2 hours after addition of alkali, it is assumed that the alkali and the sludge have been mixed together for a sufficient time to reach equilibrium (not considering the gradual changes that occur over substantial periods of time). Consequently, the pH measurement can be made directly in the liquid sludge. The pH measurement is made preferably with a pH meter equipped with a temperature compensation adjustment and a low-sodium glass electrode for use at pH values over 10. The pH electrode is inserted directly in the sludge for the reading. The second measurement is made 24 hours after addition of alkali. If the sludge is still in the liquid state, the pH measurement is made in the same fashion. However, if the process includes a dewatering step immediately following the alkali addition and the sludge is now a dewatered cake, the cake must be made into a slurry for the pH measurement. Acceptable procedures for preparing the sample and measuring pH are given by EPA (1986). The procedure requires adding 20 mL of distilled water (containing 0.01 M CaCl<sub>2</sub>) to 10 g of sludge cake, mixing occasionally for half an hour, waiting for the sample to clarify if necessary, and then measuring pH. The important step is the mixing step that allows the alkali-treated dewatered sludge to come into equilibrium with the added water.

### **Number of Samples**

The accuracy of pH meters and of pH paper is within  $\pm 0.1$  pH unit. More than one sample is necessary if the domestic septage or sludge is not well mixed. If the lime has been added gradually over the period in which septage is being pumped into a tank truck is considered adequate and a single measurement taken at the top of the tank truck is sufficient. If alkali has been added to liquid sludge in a tank at a treatment plant, tests are easily run to establish how much mixing is required to produce a uniform pH in the sludge. If this adequate mixing time is used, a single sample withdrawn from the tank for pH measurement is sufficient.

If alkali is added to sludge cake, more sampling is suggested. Typically, alkali (usually lime) is added to sludge cake in a continuous process. The sludge from the dewatering process discharges continuously to a mixer, from which it discharges to a pile or to a storage bin. Lime is metered into the mixer in proportion to the sludge flow rate. The flow rate and compositions of the sewage sludge can vary with time. To demonstrate compliance on a given day, several time-composite samples each covering about 5 minutes should be collected, and the pH measured. This procedure should be repeated several times during the course of a 2-week sampling event.

For sludge cake, the composites collected for pH measurement must be reduced in size for the pH

measurement. The alkaline-treated sludge may be discharged from the mixing devices in the form of irregular balls that can be up to 5 to 7.6 cm (2 or 3 inches) in diameter. It is important that the biosolids to which the environment will be exposed have been treated to reduce pathogens and vector attraction to the desired level. If the discharged biosolids are ball shaped and the alkali has not penetrated the entire ball, one or both of these goals is not met for the material inside the ball. The entire ball should be at the proper pH. It is suggested that the composite be thoroughly mixed and that a subsample be taken for analysis from the mixed composite. An even more conservative approach is to sample only the interior of the balls.

### **Percent Solids Greater Than or Equal to 75% and 90%**

The monitoring requirement for these vector attraction options (see Sections 8.8 and 8.9) is simply measurement of total solids. This measurement is described in Standard Methods (APHA [1992], Standard Method 2540 G). Standard Methods states that duplicates should agree within  $\pm 0.5\%$  of their average. For 75% solids, this would be  $\pm 3.8\%$ . For a continuous process, a time-composite sample can be taken over the course of a day, and duplicate analyses carried out on this composite. This is possible because biological activity essentially ceases at high solids content, and decomposition will not occur. Approximately seven such composites over the course of a 2-week sampling period would provide adequate sampling.

Some drying processes such as drying sludge on sand drying beds are batch processes. In such cases, it may be desirable to ascertain that the sludge meets the vector attraction reduction requirements before removing the sludge from the drying area. This can be done by taking two separate space-composites from the dried sludge, analyzing each of them in duplicate, and removing the sludge only if it meets the required solids content.

### **Frequently Asked Questions**

**How many samples should be submitted for each monitoring event for Class A pathogen tests? How many grab samples should be taken for each composite?**

The 503 regulations do not specify a minimum number of samples per sampling event for Class A sludge, but it is strongly recommended that enough samples be taken to adequately represent the mass of material which is to be distributed. A minimum of seven samples, as required for Class B fecal coliform testing is recommended, but the number of samples, and the number of grab samples which each composite should represent, depends on the size of the facility and the volume of sludge product that is distributed. A sampling plan should be developed and submitted to the permitting authority for review.

Are you out of compliance for Class A if you take more than one sample, and one result is over the limit?

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Yes, In order to meet Class A standards, all material must meet pathogen standards. Although Class B pathogen standards are based on a geometric mean of analytical results, geometric (or arithmetic) means are not acceptable for compliance with Class A standards. Therefore, if several samples are submitted for analysis during one monitoring event, and one sample is found to be out of compliance with Class A pathogen standards, the entire batch must be considered Class B (assuming it meets Class B standards).

For batch processes, one way to prevent one 'out of compliance' sample from affecting the classification of a large volume of finished product is to maintain smaller separate storage piles and to sample from segregated areas. For example, finished compost could be separated into piles based on when composting was completed. If one result shows non-compliance with the Class A standards, but other samples are within the Class A limits, it would be relatively simple to separate out the non-compliance material and reprocess it or distribute it as Class B material.

Continuous flow operations can reduce the probability that one outlying result will cause their process to fail by taking multiple samples over a 24-hour period and compositing the samples. The composite sample can then be analyzed in duplicate to provide more data.

Averaging lab results is allowable as a means to eliminate laboratory variability; however, all data must be reported to the permitting authority for review. For example, if a lab runs duplicate fecal coliform analyses on one sample, the results from these analyses can be averaged together for one result. This is not intended to allow facilities to rerun analyses on out-of-compliance samples in the hope of lowering average results.

**Pathogen testing on our Class A sludge product has shown that we consistently reduce *Salmonella* sp. to below detectable limits, but fecal coliform levels are sometimes over 1000 MPN per gram. Should we be concerned about this? Should we be concerned if the fecal coliform level in our Class A material is occasionally as high as 990 MPN/gram?**

According to the regulations, neither situation is a problem. You are required to comply with either the *Salmonella* sp. or the fecal coliform standards, not both. However, the level of fecal coliform in the product may indicate that there is incomplete pathogen destruction or some regrowth in your product, in which case you should examine your pathogen and vector attraction reduction processes to ensure that you are complying fully with the requirements and are not contaminating the product. The high fecal coliform counts may also be due to the presence of other, non-fecal coliforms in the sludge. These coliforms, which share some characteristics with fecal coliforms, may be detected in fecal coliform testing. They are particularly likely to appear in compost samples since they tend to be found in woody materials.

In addition, certain processes have been found to leave a residual population of fecal coliform which can repopu-

late the sludge. It is possible that testing would find fecal coliform over the Class A limits even when the pathogenic bacteria for which fecal coliform are intended to serve as indicators have been reduced below detectable levels. Composting and lime treatment are two of these processes. It is therefore recommended that if properly operated Class A facilities yield high populations of fecal coliform in finished solids that *Salmonella* sp. be used as the indicator organism for these types of facilities.

**Can we distribute finished material before getting pathogen test results back? If yes, what do you do if results later show that material was not Class A?**

This issue is covered extensively in Section 4.10. Sludge classification is based on the most recent available lab data, and therefore, material generated during a sampling period can be distributed before results from that sampling period are available (based on the results of the previous sampling event). However, it is recommended that materials generated during the sampling period be held on site until results are available in order to prevent a situation in which material is erroneously classified and distributed as Class A.

**If composting piles are monitored for temperatures at three different points, do all three points have to meet PFRP at the same time?**

All particles of sludge must undergo the PFRP time and temperature regime. For aerated static pile and in-vessel composting, the entire pile must meet the temperature requirements concurrently. If one point is found to be below the 55°C level during the temperature monitoring period, the entire pile is considered to be out of compliance, and the three consecutive day PFRP period must start over again. However, if temperatures are taken in distinct piles or cells of an in-vessel system, each section can meet the PFRP requirements separately.

**Our facility often stockpiles composted sewage sludge over the winter. In the spring, we may have as much as four months' production of compost on site. How should sampling be conducted?**

After material is stored on site, it must be resampled in order to determine if regrowth of pathogens has taken place. The number of samples should correspond to the time period that the stockpile represents and the mandated frequency of sampling based on the facility's size. For example, if a facility is required to sample sludge every month, and there are four months' worth of compost on site, a minimum of four samples (therefore, 4 times 7 or 28 analysis) from appropriate sections of the stockpile must be submitted. Ideally, material will be stored in segregated piles so that each month's production of compost can be sampled separately.

This applies to other long-term sludge storage such as lagoons. The number of samples taken from lagoons should be based on the time period that the lagoon(s) repre-

sent and the frequency of sampling that a facility is obligated to follow because of the rate of sludge generation.

**What should we do if our process changes or expands?**

Permits are granted based on particular operational parameters. Therefore, any projected changes in the operation or expanded flow should be discussed with the permitting authority before changes are made, even if you do not have a permit.

**Can we be permitted for operation only during certain months?**

If your operation will only meet pathogen or vector attraction reduction standards during part of the year, your permit can contain conditions which allow distribution only during these times. Permits can also be written to take ambient conditions into account; for example, some “low-impact” composting facilities are required to retain material over two summers. It may also be practical to limit storage and utilization of particular types of sludges to some seasons.

**Can we combine two PSRP processes that individually do not meet the specified process requirements to produce a Class B product? Can time in extended aeration be added to digester time?**

The only way to evaluate the effectiveness of pathogen reduction through a combination of two or more PSRP processes is by testing the sludge for fecal coliform density. If sufficient pathogen reduction can be demonstrated consistently, the preparer also may consider applying for a PSRP equivalency for the combined processes in order to eliminate the need for fecal coliform testing.

In general, extended aeration cannot be considered a PSRP or part of a PSRP because raw sewage is continually being added to the aerator and blending with the mixed liquor. Specific cases in which extended aeration is not subject to short-circuiting and is thought to contribute significantly to the pathogen reduction process should be evaluated by testing the resulting sludge for fecal coliform density and by the SOUR test or extended aerobic digestion one for addressing VAR requirements.

**If I produce an “exceptional quality” (EQ) product and mix the product with topsoil before distribution, does the mix have to be tested for 503 compliance?**

Regulations regarding “exceptional quality” material, or material which complies with the highest levels of pathogen and vector attraction reduction as well as heavy metals limits, are based on when the sludge preparer loses control of the material. If the EQ material is still within your control (i.e. on-site or owned by the preparer) when it is mixed, the new product must undergo pathogen and vector attraction reduction processes and be analyzed for Part 503 parameters including pathogens, vector attraction reduction, and heavy metals. This may be problematic for some facilities since a mix of stable compost and soil, for

example, is unlikely to meet/undergo PFRP time and temperature requirements. You may have to test the mix for helminth ova and enteric viruses in order to demonstrate compliance with Class A pathogen reduction. If, however, the EQ material has left your control (i.e. is sold to a soil blender), the material falls out of the jurisdiction of the Part 503, and any subsequent blending of the material with other products is not covered by these regulations. Non-EQ materials are always subject to the Part 503, and storage or mixing of non-EQ materials with soil, yard waste, or other additives must be followed with re-testing and re-classification. The party responsible for the sludge mixing is considered a sludge preparer and is therefore subject to all Part 503 requirements.

**Our sludge product meets vector attraction reduction requirements because the level of total solids in the material is greater than 75 percent. If stored material becomes wet because of rainfall, is the material still in compliance with the requirements?**

The vector attraction reduction requirement stipulates that the material be processed to greater than 75 percent (or 90 percent when unstabilized solids are present) total solids. If dried sewage sludge (biosolids) is stored at your facility and becomes wet, it still meets the vector attraction reduction criteria as long as the facility has testing documentation that the biosolids were processed to  $\geq 75$  or 90 percent solids prior to the time the material became wet. It is a good management practice however to prevent dried biosolids from getting wet while it is being stored at the facility.

In the case of vector attraction reduction Option 6, it is required that the pH of the sludge be raised to  $\geq 12$  for 2 hours and  $\geq 11.5$  for 22 hours. It is not required that the sludge be maintained at the elevated pH once the material has fulfilled the vector attraction reduction requirement. However, it is important to note that the sludge which appears to be stable under the elevated conditions may become odorous and attract vectors if the pH declines. It is recommended that sludge be utilized before the pH drops below 10.5 in order to prevent odors or vector attraction which may result in a public nuisance.

**Can Alternative 1 be used to demonstrate pathogen reduction for composting if the compost piles do not attain 55°C for 3 consecutive days?**

Alternative 1 is based on similar time/temperature relationships as the composting process. Regime A ( $D=131,700,000/10^{0.1400t}$  in which  $t \geq 50^\circ\text{C}$  and  $D \geq 0.0139$  days) can apply to composting. The table below shows some points on the time/temperature curve that would comply with the regime.

Time (Days)	Temperature (°C)
0.02 (30 min)	70
0.04 (1 hour)	68
0.08 (2 hours)	66
1	58
2	56
3	55

As shown, it is theoretically possible that a compost pile could comply with Alternative 1 by reaching very high temperatures for a short period of time. **Alternative 1 is based on the assumption that all particles of sludge are attaining these temperatures uniformly.** This may be difficult in a compost pile unless the compost pile is completely enclosed and well insulated. In addition, excessive temperatures in a composting process may result in anaerobic conditions and subsequent odors.

**Our facility is planning to expand next year, and we would like to implement a new process for pathogen reduction. We will submit our request for equivalency to the PEC this year, but, given the current turn around time for applications, do not expect to have equivalency granted for 2 more years. What should we do in the interim?**

Depending on the class of sludge you are hoping to produce, you have two options. If you are producing a Class B sludge, you should continue to do fecal coliform testing in order to demonstrate compliance with the Class B limit of 2 million CFU or MPN per dry gram of sludge. If you are producing a Class A sludge, you could follow Alternative 4 and test the sludge product for helminth ova and enteric viruses as well as either fecal coliform or *Salmonella* sp. In either case, an application for equivalency will require data demonstrating pathogen reduction, so this data will be useful in that respect.

You may also wish, in the case of Class A sludge, to test the feed sludge for enteric virus and helminth ova. Adequate demonstration that the process reduces these pathogens on a consistent basis may qualify the process as a PFRP equivalent one (Class A, Alternative 6). You should consult with the permitting authority to determine an acceptable sampling protocol. Demonstration of helminth ova and virus reduction is difficult, particularly if the density of these pathogens in the influent is low or sporadic. The sampling program must demonstrate that actual reduction is taking place, not just that the pathogen density in the treated sludge is low. Once pathogen reduction has been sufficiently demonstrated, testing for enteric viruses and helminth ova are no longer necessary as long as the process is conducted in compliance with specified conditions for PFRP equivalency.

**Our facility distributes Class B lime stabilized sludge to farmers who use the sludge on a variety of crops. Is it our responsibility to keep track of how this sludge is used?**

You are required to provide the farmers with all sludge quality data as well as regulatory information which will allow them to comply with the appropriate site restrictions. The applicator, and/or the POTW, is then responsible for following the correct site and harvest restrictions. However, given that any problems with land application will most likely affect the public perception of sludge reuse and this may in turn affect your facility, it is recommended that you work closely with farmers to ensure that the regulations are being followed. In addition, the permitting authority may

choose to include conditions related to site and harvest restrictions in your permit.

**Is there any limit of how long Class B sludge can be stored before it is used?**

Part 503 Rule defines storage as "the placement of sewage sludge: on land on which the sewage sludge remains for two years or less." It does not include placement of sewage sludge on the land for treatment. After two years the storage site is considered a final disposal one. The permitting authority may include storage conditions in your permit which mandates usage of the material while it still retains certain characteristics (moisture content) or within a certain time period. It is recommended that storage of Class B material be limited to 30 days and be conducted under similar site restrictions as usage of Class B material. For example, public contact and access to the storage site should be restricted.

**If the vector attraction reduction requirements have been fulfilled under Option 6, is there any need for the sludge to remain at an elevated pH?**

In the case of vector attraction reduction Option 6, it is required that the pH of the sludge be raised to  $\geq 12$  for 2 hours and  $\geq 11.5$  for 22 hours. It is not required that the sludge be maintained at the elevated pH once the material has fulfilled the vector attraction reduction requirement. However, it is important to note that sludge that appears to be stable under the elevated conditions may become odorous and attract vectors if the pH declines. It is recommended that sludge be utilized before the pH drops below 10.5 in order to prevent odors or vector attraction that may result in a public nuisance.

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