San Joaquin Valley
Air Pollution
Control District

PRELIMINARY DRAFT

Best Available Control Technology (BACT)

Dairy Operations

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I. BACKGROUND[1]

As of January 1, 2004, state law requires that permits be obtained for all agricultural operations whose air pollution emissions exceed one-half of the major source threshold of any criteria pollutant. Such operations, including all existing dairies with emissions of volatile organic compounds (VOC) over 12.5 tons per year (approximately 1954 total head[2]), are required to apply for permits from the Air Pollution Control District on or before July 1, 2004.

New dairies, and existing dairies that propose to increase their capacity, whose emissions are over these thresholds, must also obtain a pre-construction permit from the District, called an Authority to Construct permit, before commencing construction. Such proposals are subject to the District's New and Modified Stationary Source Review (NSR) Rule, Rule 2201, which implements NSR requirements from both state and federal law. One of the requirements of NSR is that new equipment and equipment that will be modified must control their air pollution emissions with Best Available Control Technology (BACT).

This evaluation will establish BACT for such new and modifying dairies, after a series of public workshops in which industry and other interested parties are invited to comment on our proposal. All written comments received will be addressed prior to the District finalizing this BACT determination.

II. SOURCE CATEGORIES AND POLLUTANTS

A dairy consists of many sources of emissions, including the milking center, lagoons, cow housing, feeding areas, manure storage piles, and on-field manure-handling activities. The purpose of this analysis is to specifically and proactively identify the Best Available Control Technology for the following categories: a) Cow Housing and Feeding; b) Dairy Waste Treatment Lagoon; c) Milking Center; d) Dairy Manure Storage; and e) Dairy Manure Land Application.

Dairy cows generate anywhere from 80 to 120 pounds of manure per day. How the manure is collected, stored and treated depends directly on the manure management techniques of a dairy.

Dairy manure is collected and managed as a liquid, a semi-solid or slurry, and a solid. Manure with a total solids or dry matter content of 20% or higher usually can be

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[1] The Background section has been revised on 4-29-2004.

[2] Dairies with less than 1954 total head are generally accepted by the District as producing VOC emissions less than 12.5 tons per year, and are therefore exempt from permitting and BACT requirements. However, the number 1954 total head is based on a set of worst-case assumptions, and it may be that some dairies with more than 1954 cows have emissions less the 12.5 tons of VOC per year, and would therefore be exempt from these requirements, also. To help dairy owners and operators to be aware of emissions from their operations and to determine whether permits and BACT are required, the District is developing some web-based emissions calculators, available soon at www.valleyair.org.

handled as a solid while manure with a total solids content of 10% or less can be handled as a liquid. Most dairies have both wet and dry manure management systems (USDA, 1997). Manure is scraped (dry system) or flushed (liquid system) from alleys or pits and is separated into solid and liquid components. Solid manure is stored in piles, while liquid manure is stored in a lagoon.

Manure accumulates in confinement areas such as barns, drylots, and milking center, and is primarily deposited in areas where the herd is fed and watered. Drylots are used to house calves, and heifers. Either drylots or freestall barns are used to house the lactating herd when they are not milked. The milking center houses the lactating cows when they are being milked.

A. Definitions

1. Active Composting:

Compostable material that has undergone the time/temperature Process to Further Reduce Pathogen (PFRP), and is undergoing or capable of undergoing rapid decomposition but isn't sufficiently stabilized as a soil amendment; not horticulturally or agronomically beneficial in its present condition.

2. Aerated Static Pile:

Composting system that uses a series of perforated pipes (or equivalent) air distribution system running underneath a compost pile and connected to a blower that either draws or blows air through piles. Little or no agitation or turning is performed.

3. Aeration in Compost:

The process by which oxygen-deficient air in compost is replaced by air from the atmosphere to allow microbial aerobic metabolism (biooxidation).

4. Aerobic Digestion:

Decomposition of organic matter carried out by microbiological organisms (microbes) in the presence of O_2. During this oxidation process, pollutants are broken down into CO_2, H_2O, nitrates, sulphates and biomass (sludge). The figure below simplifies the comparison between aerobic and anaerobic digestion:

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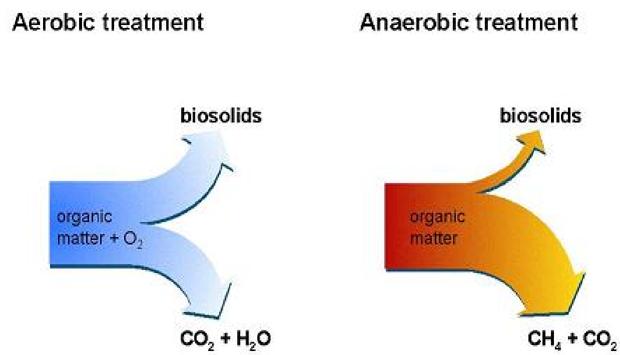

Source: http://www.biotank.co.uk/anaerobic_digestion.htm

5. Agriculture:

The science, art and business of cultivating the soil, producing crops and raising livestock; farming

6. Ammonia:

A gaseous inorganic compound comprised of nitrogen and hydrogen; ammonia, which has a pungent odor, is commonly formed from organic nitrogen compounds during composting.

7. Anaerobic:

Occurring in the absence of free or dissolved oxygen; capable of living and growing in the absence of oxygen, such as anaerobic bacteria.

8. Anaerobic digester:

An enclosed basin or tank for anaerobically digesting wastewater. In it, anaerobic bacteria produce biogas, which is typically exhausted continuously and collected for use as a fuel or for a reagent for some industrial chemical reactions. Some types of digesters that can be used for dairy manure are covered lagoons, complete mix, plug flow, thermophilic (operate between 110-160 ^oF), mesophilic (operate between 68-105 ^oF) and fixed film.

9. Anaerobic Digestion:

Decompostion of organic matter by microbes in the absence of oxygen (O_2). During the digestion process, a gas *primarily* composed of methane (CH_4) and carbon dioxide (CO_2), known as biogas, waste gas or digester gas is produced. However, biogas also consists of relatively small amounts Nitrogen (N_2), Oxygen (O_2), Hydrogen Sulfide (H_2S), Ammonia (NH_3) and various Volatile Organic Compounds (VOCs), when compared to the amount of CH_4 and CO_2 produced. Small amounts of sludge are also produced as a result of anaerobic digestion. The following figure summarizes the main stages of biogas production process due to anaerobic digestion:

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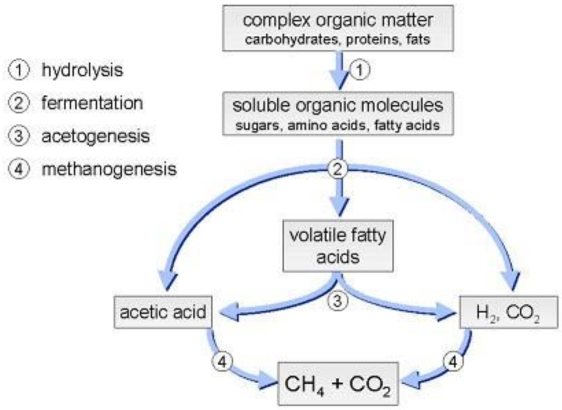

Source: http://www.biotank.co.uk/anaerobic_digestion.htm

10. Anaerobic Lagoon:

A waste treatment lagoon in which livestock or poultry manure is stabilized using anaerobic microorganisms to reduce organic compounds to methane and carbon dioxide.

Anaerobic lagoons should be built as deep as possible, with a small surface area, consistent with construction limitations and groundwater conditions. Anaerobic lagoons have depths from 6 to 30 feet. The depth of the lagoon is not restricted by light penetration as for naturally aerobic lagoons.

11. Animal feeding Operation:

A lot or facility (other than an aquatic animal production facility) where animals have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period, and the animal confinement areas do not sustain crops, vegetation, forage growth, or post harvest residues in the normal growing season.

12. Biodegradable:

A material that is capable of undergoing decomposition into simple compounds such as carbon dioxide, methane, water, inorganic compounds, and biomass in which the predominant mechanism is the enzymatic action of micro-organisms, such as bacteria, fungi, and algae that can be measured by standardized tests, in a specified period of time, reflecting available conditions for composting (aerobic) or fermentation (anaerobic).

13. Biofiltration:

A device for removing contaminants from a gas in which the gas is passed through a media that supports the microbial activity by which the pollutant is degraded.

An established type of biofilter involves a porous medium (typically soil, compost or wood chips - green waste), that contain large populations of microbes. This type of system can be used as an after control assuming captured biogas, like with a digester.

Other types of after control biofilters may be referred to as biotrickling or bioscrubbers. These types of filters and bioscrubber types function with the microbes suspended or mobilized in liquid phase.

In the case of lagoon applications however, a biocover (made of straw, grass, peat, chopped cornstalks, etc.) may serve the same purpose as the above mentioned after controls.

14. Biogas (also known as wastegas and digester gas):

A gaseous product of anaerobic digestion.

15. Biomass:

Material or mass produced by a biological system.

16. Bulking Agent:

Material, usually carbonaceous such as wood chips, or shredded yard trimmings, added to a compost system to maintain airflow by reducing settling and compaction.

17. Co-composting:

Composting where biosolids and/or manure are mixed with bulking agents to produce compost. Co-composting includes the active and curing phases of the composting process.[3]

18. Composting:

The controlled biological degradation of organic solid waste yielding a product for uses as a soil conditioner; a managed process that controls biological decomposition and transformation of biodegradable material into a humus like substance called compost.

19. Curing phase:

Phase of the composting process that follows the completion of the active composting phase. The mixed material is moved to the curing ASP for an additional 20-40 days for further maturation prior to screening and distribution.

[3] Definition taken from SCAQMD Rule 1133.2 (*Emissions Reductions from Co-Composting Operations*) -

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20. Denitrification:

The process by which nitrates and nitrites are converted into free dinitrogen (N_2) gas or nitrous oxide (N_2O) gas. Denitrification requires microbes, nitrates and nitrites, carbon and anaerobic conditions.

21. Holding Pond (Waste Storage Pond):

A small basin designed for *temporary* collection and storage of organic waste such an animal manure. A holding pond is not a waste treatment lagoon since little bacterial degradation of organic matter takes place since treatment is not considered in the design of a holding pond. Holding ponds are completely emptied when pumped, and the design storage periods are about 90 to 180 days.

22. Hydraulic Retention Time (HRT):

Volume of the lagoon divided by the daily influent flow as measured in days.

23. Impermeable:

Not permitting water or another fluid to pass through

24. In-vessel:

A diverse group of composting technologies in which composting materials are contained in a reactor or vessel.

25. Mechanically Aerated Lagoon:

A waste treatment lagoon in which the organic material is treated due to mechanical promotion of aerobic decomposition. Complete aerobic digestion is the best way to reduce malodorous air emissions. Aeration can be achieved with floating, submerged or fixed aerators. Aeration can be performed with injection of tiny air bubbles into the lagoon water, mixing of the lagoon water or spraying of the water into the air. For each type of aerator, the O_2 from the air supports natural aerobic bacteria.

26. Mesophilic Microorganisms:

Microorganisms that live under lower temperatures (50-104 degree F). The curing stage of composting is where the mesophilic microorganism population is the highest, the need for oxygen and the evaporation rate both decrease.

27. Modified:

As defined in District Rule 2201.

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28. Naturally Aerobic Lagoon:

A waste treatment lagoon in which the organic material is treated due to naturally occurring aerobic decomposition. Because oxygen must be absorbed from the air, and sunlight is necessary for the growth of oxygen-producing algae, design aerobic lagoons on the basis of surface area. The depth of a naturally aerated lagoon should be from 3 to 5 feet. Shallow depths are required to allow adequate penetration of sunlight for algae photosynthesis. Aerobic lagoons are normally not practical for animal manure treatment because they would need such a large surface area. A major advantage is that the naturally aerobic lagoon is odor free (as holds true for mechanically aerated lagoons), as long as sufficient oxygen is provided to insure the activity of the aerobic bacteria.

29. Nitrification:

The process by which ammonia-N is oxidized to nitrate-N. Nitrification requires microbes, ammonium nitrogen, free oxygen (aerobic conditions), sufficient reaction time and the carbon in organic matter. The process takes places in the following two steps:

Step 1: Oxidation of Ammonia to Nitrite

NH_3 + O_2 + Nitrosomonas bacteria $\rightarrow$ NO_2 (Nitrite)

Step 2: Oxidation of Nitrite to Nitrate

NO_2 + O_2 + Nitrobacter bacteria $\rightarrow$ NO_3 (Nitrate)

30. Pathogen:

Any disease-producing agent, especially a microorganism such as a virus, bacterium or fungus.

Measures to control pathogens include effective industrial hygiene and worker hygiene practices, effective design, and operation of biodegradation of pathogen nutrients and for adequate and uniform aeration and temperature/time to assure pathogen destruction and process and product monitoring for quality control.

31. Pile porosity:

The area (pore space) around individual compost particles.

32. Separated Solids:

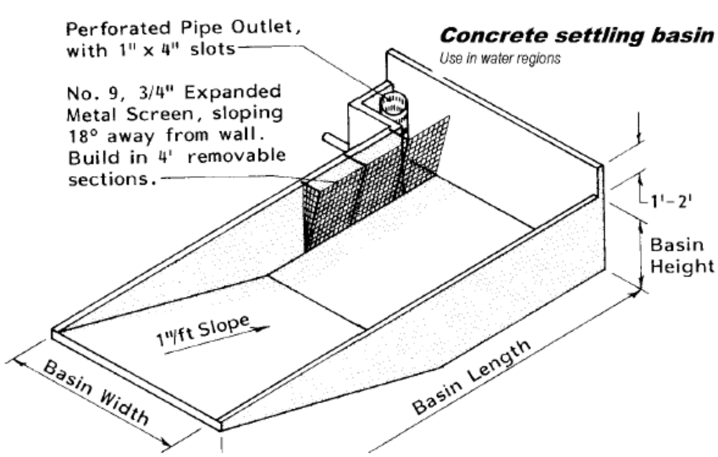
Separated solids are organic and inorganic solids that have been separated from the liquid manure prior to the treatment lagoon or storage pond. Removal of fresh solids from manure slurries reduces the nutrient content of manure, prolongs the life of storage structures, improves the effectiveness of biological treatment, and minimizes odors. Beneficial uses of the recovered solids include bedding materials, animal feed supplements, composts, and soil amendments.

33. Solids Separation:

Solids separation is the partial removal of organic and inorganic solids from liquid manure. Solids separation is primarily performed by sedimentation (solids settle by gravity) and/or by mechanical separation.

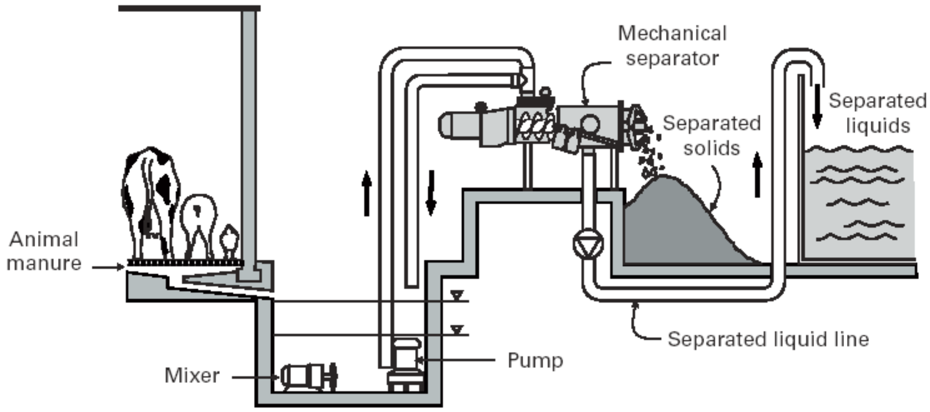
Settling basins are structures designed to separate solids from liquid manure by sedimentation. The inflow of manure is restricted to allow some of the solids to settle out. The liquids gradually drain to a holding pond, treatment lagoon or to some other storage structure. Solids remaining in the basin are left to dry and then are removed. Below is a photo and a diagram of a concrete settling basin:

Source: http://www.biomagic.com/e13.pdf



Source: http://www.bae.ncsu.edu/programs/extension/manure/technologies/solids.pdf

Mechanical separators include screen separators, centrifuges, hydroclones and presses (screw or belt type). Below is a basic arrangement for a mechanical solids separation system:



Source: http://www.lpes.org/Lessons/Lesson43/43_3_Solid_Liquid_Separation.pdf

34. Thermophilic Microorganisms:

Microorganisms that can sustain life under high temperatures (104-149 degree F). The active phase of composting is where the thermophilic microorganisms' population is usually the highest. High temperatures, high level of oxygen demand, and high evaporation rates due to temperature, characterize this stage.

35. VOC (Volatile Organic Compounds):

Any compound containing at least one (1) atom of carbon except for exempt compounds specified Section 3.53 of District Rule 1020.

36. Waste Treatment Lagoon:

A basin used to store and biologically treat organic waste such as animal manure. Treatment lagoons handle a frequent stream of animal waste and may be classified as anaerobic, mechanically aerobic or naturally aerobic (see above definitions for each type of lagoon). A waste treatment lagoon will always have a permanent pool or residual volume that provides a bacterial seedbed to help assure continued digestion after pumping.

III. BACT APPLICABILITY

District Rule 2201, New and Modified Stationary Source Review (NSR), applies to new and modified sources of air pollution that are subject to the District's permitting requirements. BACT is a key NSR requirement that applies to new or modified sources of air pollution that result in increase in emissions greater than 2 pounds per day. BACT does not apply retroactively to existing, unmodified sources.

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BACT requirements are triggered on a pollutant-by-pollutant basis and on an emissions unit-by-emissions unit basis. BACT is required for the following actions: (1) Any new emissions unit with a potential to emit exceeding two pounds in any one day, (2) The relocation of an existing emissions unit from one stationary source to another with a potential to emit exceeding two pounds in any one day, (3) Modifications to an existing emissions unit with a valid Permit to Operate resulting in an Adjusted Increase in Permitted Emissions (AIPE) exceeding two pounds in any one day, and (4) Title I/Major Modifications. Pursuant to Section 4.2 of APR 1305 (Appendix A), BACT is not triggered for CO emissions if the facility's post project Stationary Source Potential to Emit (SSPE2) is less than 200,000 lb of CO per year.

IV. BACT DEFINITION

In conformance with state and federal laws, District Rule 2201 defines BACT as the most stringent emission limitation or control technique from the following options:

- An emission limitation or control technique that has been achieved in practice for such emissions unit and class of source.

- An emission limitation or control technique contained in any State Implementation Plan approved by the Environmental Protection Agency for such emissions unit category and class of source. A specific limitation or control technique shall not apply if the owner or operator of the proposed emissions unit demonstrates to the satisfaction of the APCO that such limitation or control technique is not presently achievable.

- Any other emission limitation or control technique, including process and equipment changes of basic or control equipment, found by the APCO to be technologically feasible for such class or category of sources or for a specific source, and cost effective as determined by the APCO.

V. BACT DETERMINATION PROCESS

BACT determination is an integral part of the permit review process. On a case-by-case basis, for each application, the District must determine the control technology that satisfies the above BACT definition for the particular emissions unit and class of source being proposed. Towards that end, the District performs a five-step top-down analysis that accomplishes the following:

A. Step 1:

Identify all possible control technologies for the emission unit in question.

B. Step 2:

Eliminate controls that are not technologically feasible for the class of source or the particular emission unit being reviewed. To exclude a control option, a demonstration of technological unfeasibility must be clearly documented and should show, based on physical, chemical, and engineering principles, the technical difficulties which would preclude the successful use of the control option for the emissions unit under review.

C. Step 3:

All remaining controls are ranked by their control effectiveness.

D. Step 4:

A cost effectiveness analysis is performed in which economic impacts are considered, to arrive at the final level of control. The cost effectiveness of each alternative is determined by calculating the annual cost in dollars per ton of emissions reduced. Control options that are not cost effective, except for controls that have been achieved in practice or are required by an EPA approved SIP, are eliminated from consideration.

E. Step 5:

The most effective control not eliminated under step 4 is selected as BACT.

A detailed description of the District's BACT determination policies and procedures is contained in District Policy APR 1305.

VI. POLLUTANTS FORMED AT DAIRIES

A. Ammonia Formations and Emission from Manure

Ammonia is produced as a by-product of the microbial decomposition of the organic nitrogen compounds in manure. Nitrogen occurs as both unabsorbed nutrients in manure and as either urea (mammals) or uric acid (poultry) in urine. Urea and uric acid will hydrolyze rapidly to form ammonia and will be emitted soon after excretion. The formation of ammonia will continue with the microbial breakdown of manure under both aerobic and anaerobic conditions. Because ammonia is highly soluble in water, ammonia will accumulate in manures handled as liquids and semi-solids or slurries, but will volatize rapidly with drying from manures handled as solids. Therefore, the potential for ammonia volatilization exists wherever manure is present, and ammonia will be emitted from confinement buildings, open lots, stockpiles, anaerobic lagoons, and land application from both wet and dry handling systems.

The volatilization of ammonia from any AFO operation can be highly variable depending on total ammonia concentration, temperature, pH, and storage time. Emissions will depend on how much of the ammonia-nitrogen in solution reacts to form ammonia versus ionized ammonium (NH_4+), which is nonvolatile. In solution, the partitioning of ammonia between the ionized (NH_4+) and un-ionized (NH_3) species is controlled by pH and temperature. Under acidic conditions (pH values of less than 7.0) ammonium is the predominate species, and ammonia volatilization occurs at a lower rate than at higher pH values. However, some ammonia volatilization occurs even under moderately acidic conditions. Under acidic conditions, ammonia that is volatized will be replenished due to the continual reestablishment of the equilibrium between the concentrations of the ionized and un-ionized species of ammonia in solution following volatilization. As pH increases above 7.0, the concentration of ammonia increases as does the rate of ammonia volatilization. The pH of manures handled as solids can be in the range of 7.5 to 8.5, which results in fairly rapid ammonia volatilization. Manure handled as liquids or semi-solids tend to have lower pH.

Because of its high solubility in water, the loss of ammonia to the atmosphere will be more rapid when drying of manure occurs. However, there may be little difference in total ammonia emissions between solid and liquid manure handling systems if liquid manure is stored over extended periods of time prior to land application.[4]

B. VOC Formation and Emissions from Manure

Volatile organic compounds are formed as intermediate metabolites in the degradation of organic matter in manure. Under aerobic conditions, any VOCs formed are rapidly oxidized to carbon dioxide and water. Under anaerobic conditions, complex organic compounds are degraded microbially to volatile organic acids and other volatile organic compounds, which in turn are converted to methane and carbon dioxide by methanogenic bacteria. When the activity of the methanogenic bacteria is not inhibited, virtually all of the VOC are metabolized to simpler compounds, and the potential for VOC emissions is nominal. However, the inhibition of methane formation results in a buildup of VOC in the manure and ultimate volatilization to the air. Inhibition of methane formation typically is caused by low temperatures or excessive loading rates of volatile solids in a liquid storage facility. Both of these conditions create an imbalance between populations of the microorganisms responsible for the formation of VOC and methanogenic bacteria. Therefore, VOC emissions will be minimal from properly designed and operated stabilization processes (such as anaerobic lagoons) and the associated manure application site. In contrast, VOC emissions will be higher from storage tanks, ponds, overloaded anaerobic lagoons, and associated land application sites. The specific VOC emitted will vary depending on the solubility of individual compounds and other factors (including temperature) that affect solubility.[5]

C. PM_{10} Formation and Emissions from Manure

Sources of particulate matter emissions include feed, bedding materials, dry manure, unpaved soil surfaces, animal dander, and poultry feathers. Therefore, confinement facilities, dry manure storage sites, and land application sites are potential PM emission sources. The relative significance of each source depends on three interrelated factors:

[4] Emissions From Animal Feeding Operations – Draft, US EPA – Emissions Standards Division, August 15, 2001, pgs. 2-6 and 2-7
[5] Emissions From Animal Feeding Operations – Draft, pg. 2-10

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1) The type of animal being raised,
2) The design of the confinement facility being utilized, and
3) The method of manure handling.

The National Ambient Air Quality Standards currently regulate concentrations of particulate matter with a mass median diameter of 10 micrometers or less (PM_{10}). Studies have shown that particles in the smaller size fractions contribute most to human health effects. The current PM_{10} standard may be replaced by a standard for $PM_{2.5}$. A $PM_{2.5}$ standard was published in 1997, but has not been implemented pending the results of ongoing litigation.

The particle size distribution of particulate matter emitted from AFOs has not been well characterized. Virtually all of the emission studies to date have measured total suspended particulate or did not report the test method used. Particle size distribution data was found only for beef feedlots. In one study, ambient measurements of PM_{10} and $PM_{2.5}$ (using five hour sample collection periods) were taken downwind (15 to 61 meters) of three cattle feedlots in the Southern Great Plains (Sweeten, et al., 1998). In this study, PM_{10} was measured as 20 percent to 40 percent of TSP (depending on the measurement method used), and $PM_{2.5}$ was 5% of TSP. No studies were found of particle size distribution from confinement buildings. Based on the emission mechanisms at AFOs, one would expect to find that

1) PM from AFOs would have varying particle size distributions depending on the animal sector, method of confinement, and type of building ventilation used, and
2) The PM emitted would include PM_{10} and a lesser fraction of $PM_{2.5}$. In addition to direct emission, $PM_{2.5}$ can be secondarily formed in the atmosphere from emissions of ammonia. If sulfur oxides or nitrogen oxides are present in the air, ammonia will be converted to ammonium sulfate or ammonium nitrate, respectively. No information is available at this time to quantify the emissions of secondarily formed $PM_{2.5}$. In this evaluation, PM means total suspended particulate, except where noted specifically as PM_{10}.

All confinement facilities are sources of particulate matter emissions. However, the composition of these emissions will vary. The only constant constituent is animal dander and feather particles from poultry. For poultry and swine, feed particles will constitute a significant fraction of particulate matter emissions because the dry, ground feed grains and other ingredients used to formulate these feeds are inherently dusty. Pelleting of feeds reduces, but does not eliminate, dust and PM emissions. Dried forages also generate particulate matter, but most likely to a lesser degree. Silages, which have relatively high moisture contents tend to generate less PM than for other types of feed. Because veal calves are fed a liquid diet, feed does not contribute to particle emissions from veal operations.

The mass of particulate matter emitted from totally or partially enclosed confinement facilities, as well as the particle size distribution, depend on type of ventilation and ventilation rate. Particulate matter emissions from naturally ventilated buildings will be lower than those from mechanically ventilated buildings. Mechanically ventilated buildings will emit more PM at higher ventilation rates. Therefore, confinement facilities located in warmer climates will tend to emit more PM because of the higher ventilation rates needed for cooling.

Open feedlots and storage facilities for dry manure from dairy drylots also are potential sources of particulate matter emissions. The rate of emission depends on whether or not the manure is covered. Open sites are intermittent sources of particulate matter emissions, because of the variable nature of wind direction and speed and precipitation. Thus, the moisture content of the manure and the resulting emissions will be highly variable. The PM emissions from covered manure storage facilities depend on the degree of exposure to wind.[6]

D. H_2S Formation and Emissions from Manure

Hydrogen sulfide and other reduced sulfur compounds are produced as manure decomposes anaerobically. There are two primary sources of sulfur in animal manures. One is the sulfur amino acids contained in the feed. The other is inorganic sulfur compounds, such as copper sulfate and zinc sulfate, which are used as feed additives to supply trace minerals and serve as growth stimulants. Although sulfates are used as trace mineral carriers in all sectors of animal agriculture, their use is more extensive in the poultry and swine industries. A possible third source of sulfur in some locations is trace minerals in drinking water.

Hydrogen sulfide is the predominant reduced sulfur compound emitted from AFOs. Other compounds that are emitted are methyl mercaptan, dimethyl sulfide, dimethyl disulfide, and carbonyl sulfide. Small quantities of other reduced sulfur compounds are likely to be emitted as well.

Under anaerobic conditions, any excreted sulfur that is not in the form of hydrogen sulfide will be reduced microbially to hydrogen sulfide. Therefore, manure managed as liquids or slurries are potential sources of hydrogen sulfide emissions. The magnitude of hydrogen sulfide emissions is a function of liquid phase concentration, temperature, and pH. Temperature and pH affect the solubility of hydrogen sulfide in water. The solubility of hydrogen sulfide in water increases at pH values above 7. Therefore, as pH shifts from alkaline to acidic (pH <7), the potential for hydrogen sulfide emissions increases (Snoeyink, 1980). Under anaerobic conditions, manure will be acidic, with pH values ranging from 5.5 to 6.5.

Under aerobic conditions, any reduced sulfur compounds in manure will be oxidized microbially to nonvolatile sulfate, and emissions of hydrogen sulfide will be minimal. Therefore, emissions from confinement facilities with dry manure handling systems and dry manure stockpiles should be negligible, if there is adequate exposure to atmospheric oxygen to maintain aerobic conditions. Any hydrogen sulfide that is

[6] Emissions From Animal Feeding Operations – Draft, pgs. 2-11 to 2-13

generated in dry manure generally will be oxidized as diffusion through aerobic areas occurs.

In summary, manure storage tanks, ponds, anaerobic lagoons, and land application sites are primary sources of hydrogen sulfide emissions whenever sulfur is present in manure. Confinement facilities with manure flushing systems that use supernatant (the clear fluid above a sediment or precipitate) from anaerobic lagoons also are sources of hydrogen sulfide emissions.[7]

VII. DECRIPTION OF DAIRY OPERATIONS

A. Milking Center

Lactating cows require milking at least twice per day and are milked in a milking center. Milking centers (also called parlors) are separate buildings, apart from the lactating cow confinement. The center is designed to facilitate changing the groups of cows milked and to allow workers access to the cows during milking. A holding area confines cows that are ready for milking. Usually, the holding area is covered and is part of the milking center, which in turn, may be connected to the barn or located in the immediate vicinity of the cow housing. Cows that are kept in tie stalls may be milked from their stalls. The housing is equipped with a pipeline system that flows through the barn and contains ports in each stall for collecting milk. Emissions from the milking center are caused when the cows defecate and urinate. After each milking, the operator sprays or flushes out the manure and urine from the milking center, usually towards the lagoon.

The following methods are used at other dairy operations to collect accumulated manure for disposal.

B. Drylots

Manure produced in drylots used for confining dairy cows, including lactating and dry cows, heifers, and calves being raised as replacements, generally is removed by scraping using a tractor-mounted blade. The rate of manure accumulation in drylots for dairy cows is highest along feed bunks and this area will be scraped more frequently than other areas of the lot. This area is usually paved with concrete. Due to loss of moisture through evaporation and drainage, drylot manure is either spread directly after collection or stored in stockpiles for subsequent disposal by land application. Manure scraped from areas along feed bunks usually is stock piled and spread when the lot is completely scraped. Factors that affect emissions from drylots include the number of animals on the lot, the moisture of the manure, and the length of time the manure remains on the lots. The number of animals will influence the amount of manure generated and the amount of dust generated. In wet drylots, decomposition will be anaerobic and will have emissions of ammonia, hydrogen sulfide, and other odor causing compounds. Additionally, the drylot is a potential air release point of particulate matter/dust from feed and movement of

[7] Emissions From Animal Feeding Operations – Draft, pgs. 2-10 and 2-11

cattle. The manure deposited on the open corrals will collect for some period, approximately 1 to 6 months of time until a front-end loader scrapes the corrals and stockpiles the manure.

C. Freestall Barns

Dairy cattle manure accumulations in freestall barns are typically collected and removed by mechanized scraping systems or by using a flush system. The two types of methods are described below:

1. Mechanical/Tractor Scraper

Manure and bedding from barns and shade structures are collected normally by tractor or mechanical chain pulled scrapers. Dairies using scrapers to remove manure from freestall barns are often referred to as scrape dairies. Tractor scraping is more common since the same equipment can be used to clean outside lots as well as freestalls and loose housing. A mechanical alley scraper consists of one or more blades that are wide enough to scrape the entire alley in one pass. A timer can be set so that the scraper runs two to four times a day, or continuously in colder conditions to prevent the blade from freezing to the floor. Scrapers reduce daily labor requirements, but have a higher maintenance cost due to corrosion and deterioration.

2. Vacuum Systems

Vacuum systems collect “as excreted” manure with a vacuum truck. Generally, the trucks collect approximately 4000 gallons per load. The manure can be hauled to a disposal site rather than to an intermediate sump. Vacuum collection is a slow and tedious process. The advantage is that the collected manure is undiluted and approximately equal to the “as excreted” concentration.

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Vacuum Truck Collecting Manure Solids

a) Flush Systems

Manure can be collected from areas with concrete flooring by using a flushing system. A large volume of water is introduced at the head of a paved area, and the cascading water removes the manure. Flush water can be introduced from storage tanks or high-volume pumps. The required volume of flush water varies with the size of the area to be flushed and slope of the area. The total amount of flush water introduced can be minimized by recycling from the supernatant of a storage pond or anaerobic lagoon; however, only fresh water can be used to clean the milking parlor area. In a flush dairy, the manure generated by the cows by the freestalls (near the feed lanes) are flushed by large amounts of water a few times a day to the lagoon. The lagoon serves as the basis of holding and decomposing the manure.

Most dairies can be grouped into one of three categories depending on the method of removing manure from the freestall barn: a) Flush Dairy, b) Scrape Dairy, or c) Flushed Alley Dairy. Flushing systems are the only method of manure removal from the milking center. Dairies using flush systems to remove manure from freestall barns are referred to as flush dairies. Some dairy operations use flush water in freestall barns but only in areas where animals are fed (i.e., the feed alleys). Mechanical scrapers are used in the rest of the barn. Dairies using this type of manure removal method are referred to as flushed alley dairies. A feedlot dairy, confines animals in a drylot, similar to beef cattle and does not use a freestall barn.

The method used to transport manure from confinement depends largely on the consistency of the manure. Liquids and slurries from milking centers, freestall barns that are flushed, and run-off from drylots can be transferred through open channels, pipes, and in liquid tank wagons. Pumps can be used to transfer liquid and slurry manure as needed; however, the higher the solids content of the manure, the more difficult it is to pump. Solid and semisolid manure from drylots can be transferred by mechanical conveyance or in solid manure spreaders. Slurries can be transferred in large pipes by using gravity, piston pumps, or air pressure. Gravity systems are preferred due to their low operating cost and reliability. Emissions from freestall barns and milking centers are influenced by the frequency of manure removal (i.e., flush frequency or scrape frequency). The longer the manure is present, the more emissions will occur from the confinement area. Due to the wet nature of manure in these areas, decomposition will be anaerobic and emissions of ammonia, hydrogen sulfide, and other odor causing compounds will occur. These areas may also be a source of particulate matter emissions from feeding systems.

Manure collected from the confinement facilities may be transferred directly to storage or undergo solids separation or stabilization prior to storage and land application.

b) Storage

Solid manure (from the feedlot and from scraped freestall barns) is typically stored in uncovered storage stockpiles. Because open piles are subjected to rain, they exhibit emission profiles of both aerobic and anaerobic conditions over time.

Manure handled as a slurry or liquid is stored in either earthen storage ponds or anaerobic lagoons. Above ground tanks is another option for storage of liquid or slurry manure but are not commonly used. Storage tanks and ponds are designed to hold the volume of manure and process wastewater generated during the storage period, the depth of normal precipitation minus evaporation, and the depth of the 25-year, 24-hour storm event with a minimum of two feet of freeboard remaining at all times.

c) Stabilization

Stabilization is the treatment of manure to reduce odor and volatile solids prior to land application. Run-off from drylots and liquid manure from flush alleys are often stabilized in anaerobic lagoons. Anaerobic lagoons use bacterial digestion to decompose organic carbon into methane, carbon dioxide, water, and residual solids.

If manure is allowed to remain on drylots for extended time periods, a significant degree of decomposition due to microbial activity occurs. When stacked for storage, a significant increase in temperature may occur depending on moisture content due to microbial heat production. Manure accumulations on drylots and stored in stacks can be sources of ammonia, hydrogen sulfide, VOC, and methane if moisture content is sufficient to promote microbial decomposition.

VIII. DAIRY COW HOUSING, CALVING AND MATERNITY HOUSING AND FEEDING

A. Process Description

Volatile compound, ammonia, H_2S and particulate matter emissions are associated with the housing (confinement) of animals in a dairy operation. All dairies have mature animal maternity housing (lactating and dry) and may also have housing for calves.

A District permit and BACT will be required for a new dairy with 12.5 tons/yr or more of VOC emissions, which is roughly equivalent to a dairy with 2,000 animals. New dairies of this size built in the valley air basin will typically have freestall barns and/or dry lots for confining the animals and separate facilities for milking and birthing.

The freestall barn, typically in combination with drylot or corral, is the predominate type of housing system used on large (2,000 head) dairy farms for lactating cows. In a freestall barn, cows are grouped in large pens with free access to feed bunks, waterers, and stalls for resting. Standard freestall barn design has a feed alley in the center of the barn separating two feed bunks on each side. Freestall barns are typically constructed with concrete alleys between the each row of freestalls and between the first row of freestalls and the center feed bunk.

In the mild climate of the San Joaquin Valley, the typical freestall barn is an open structure (roof but no sides) with access to an outside drylot, corral, or pasture typical. The drylot or corral is simply a fenced-off area with ready access to the freestall.

Emissions result from the activities undertaken in cow housing and confinement. There are direct gaseous animal emissions (belching and flatulent), for which there are no practical means of control through collection and destruction. (However, diet manipulation, which is discussed below, may result in lower gaseous emissions.)

Controllable emissions form cow housing and confinement emissions are primarily particulate matter and ammonia with lesser amounts of H_2S and VOC. Emissions are primarily associated with the manure and the soil on which it rests. Particulate matter is emitted as the manure and soil are trampled as the animals move about in the confined space of the drylot and/or freestall barn. The manure generated is both liquid and solid, and dries quickly in the low humidity and high temperatures of the valley. In those areas of a freestall barns that are flushed to keep clean, such as walkways and feed alleys, particulate matter emissions are much less of a concern.

Particulate matter emissions from cow housing are expected to be very low for freestall confinement depending on the feeding and bedding practices employed and 2.46 lb/yr - head for drylot confinement (California Air Resources Board).

Particulate matter emissions are also generated by the action of wind on manure and on any disturbed soil surface in outdoor confinement facilities. Additional particulate may be generated by bedding (indoor freestall barns) and feed distribution.

Ammonia emissions from cow housing are expected to be 28 lb/yr-au for a freestall with manure removed by flushing and 16 lbyr-au for a freestall barn with manure removed by scraping. VOC and H_2S emissions from cow housing are expected to be negligible. (US EPA, Emissions From Animal Feeding Operations, Draft, August 2001,Table 8-15).

B. Overview of Control Technologies and Strategies for Cow Housing and Feeding

1. Particulate Matter Emissions:

The controls that may be instituted to reduce the particulate matter emissions from animal confinement depend on the type of confinement employed. In this analysis we have limited the types of confinement to drylot and freestall barns.

In a drylot or corral, particulate matter can be controlled by paving and flushing with water the areas of high utilization (feed lanes and walkways), installing windbreaks, removing manure frequently to prevent pulverization, using water sprays after a manure removal to hold down dust and by limiting animal movement to less windy times of the day.

In a freestall barn, the most effective method of control is the frequent flushing of the high travel areas. The type of bedding used in the freestalls can also be expected to have an impact on dust emissions produced in the barn. The types of bedding typically used include: dry manure, mechanically separated solids, straw, sawdust, woodchips, synthetic mats, and sand. Due to the lack of information regarding the expected emissions from various bedding types, the District, at this time, is not requiring the use of specific bedding types. The District is requiring that best management practices available to the industry be used in selecting the appropriate bedding. The District will continue to investigate this emissions source category and will revise the BACT requirement as new and supportable information becomes available.

Diet manipulation is an area of much interest in the agricultural sciences, even more so now that large animal feeding operations are becoming subject to air and water regulations. Efforts are focusing on diets that maximum efficiency of milk production, while minimizing the loss of nutrients, primarily nitrogen and phosphorous, in the urine and feces.

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The primary effect of diet manipulation on particulate matter emissions is to increase the efficiency of milk production, i.e., reduce the number of animals needed to produce a given quantity of milk. Fewer animals mean fewer overall particulate matter emissions from dairies. The effectiveness of diet manipulation on controlling particulate matter has not been quantified for the individual dairy.

As discussed below, diet manipulation has a much more important effect on ammonia emissions.

2. Gaseous Emissions (Ammonia, VOC and H_2S):

The gaseous emissions associated with cow housing are primarily ammonia emissions and odors. Gaseous emissions of VOC and H_2S are considered to be negligible from cow housing.

Ammonia is emitted directly from the manure and from the conversion of organic nitrogen. Of the total nitrogen excreted in the manure, 40-50% is from urea and organic nitrogen in the urine. The ammonia and the urea, which is readily converted to ammonia in the presence of urease, are emitted as a gas. Ammonia has an objectionable odor, is considered a hazardous air pollutant, and may cause a nuisance. Ammonia reacts in the atmosphere to form ammonia nitrate, ammonia sulfate, and ammonia chloride, which are considered secondary particulate matter.

Nutritional management of dairy feed is routinely practiced to improve milk production and herd health. Diet is formulated to feed the proper amounts of ruminantly degradable protein, which results in improved nitrogen utilization by the animal and corresponding reduction in manure ammonia, urea and organic nitrogen content. The level of microbial action in the manure corresponds to the level of organic nitrogen content in the manure; the lower the level of nitrogen the lower the level of microbial action and the lower the production of ammonia, VOC and H_2S. The guidelines for the selection of an optimal diet published in the National Research Council (NRC) document, *Nutrient Requirements of Dairy Cattle: Seventh Revised Edition, 2001, National Academy of Sciences,* should be followed to the maximum extent possible. The diet recommendations made in this publication seek to achieve the maximum uptake of protein by the animal and the minimum carryover of nitrogen into the manure.

Based on very limited data (Klaunser, 1998, *J Prod Agric),* diet manipulation decreased nitrogen excretion by 34% while improving milk production. Up to 70% of excess nitrogen is lost off of the farm through volatilization, denitrification and leaching. Assuming that one-half the loss through these processes is ammonia, then diet manipulation could result in a reduction in ammonia emissions of 11% (0.34 x0.70 x 0.5).

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Additional information on diet manipulation was referenced from the following report: *Animal Diet Modification to Decrease the Potential for Nitrogen and Phosphorous Pollution, Issue Paper, July 2002, Council for Agricultural Science and Technology.*

Emissions from manure produced in cow housing result over time. The longer the time the manure has to volatilize, decompose or to be otherwise be acted on, the greater the overall emissions. Daily manure removals from the freestall barn and weekly from the drylot, with separation and further processing in covered piles, lagoons, and/or digesters, will reduce overall ammonia emissions.

C. Top-Down BACT Analysis

1. Particulate Matter Emissions

a) Step 1 - Identify All Possible Control Technologies

(1) Option 1:

Building ventilation and control using particulate filters (freestall barns), water sprays, windbreaks, limiting movement during daylight hours for the drylot, concrete feed lanes, twice daily flushing (freestall barn) and weekly scraping (dry lot), and selection of bedding using best management practices.

(2) Option 2:

Water sprays, windbreaks, limiting movement during daylight hours for the drylot, concrete feed lanes, twice daily flushing (freestall barn) and weekly scraping (drylot), and selection of bedding using best management practices.

b) Step 2 - Eliminate Technologically Infeasible Options

In Option 1 above, a ventilation system using particulate matter filters is not considered a technologically feasible option for controlling emissions in drylots or freestall dairy barns.

Drylots are open and never ventilated. Freestall barns constructed in mild climates, such as we have in the valley air basin typically do not have ventilation systems or have ventilation systems that are not conducive to controlling emissions. Freestall barns are typically constructed with large open areas, as it is not necessary to fully enclose the barn to allow for heating during the winter months. Easy egress to the milking center, the corral and drylot are more important than enclosed space. Therefore, installing an air handling system capable of capturing particulate matter emissions in a typical freestall barn is not feasible.

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c) Step 3 - Rank Remaining Control Technologies

After eliminating the technologically infeasible options, the remaining options are ranked according to either their control efficiency or their emission factor. Any option which ranks below an achieved in practice option is not listed because, at a minimum, the achieved in practice option will be BACT.

(1) Option 2:

Water sprays, windbreaks and limiting animal movement during daylight hours for the drylot, concrete feed lanes, twice daily flushing (freestall barn) and weekly scraping (dry lot), and selection of bedding using best management practices.

The overall control for an animal housing facility incorporating the option listed above is sum of the emissions controlled at each sub operation. Each sub-operation has the control efficiency listed below:

The listed control efficiencies of the sub-options are not taken from specific evaluations made on dairy farms, as none have been identified, but are referenced from similar operations controlled in the same manner or from general engineering knowledge. Thus, the estimates have been given a wide range typifying the degree of uncertainty that exists.

Sub Operation of Control Option 2	Method of Control	Control Efficiency of Sub operation	Achieved in Practice
Drylot confinement	Water spray / windbreak/ limit animal movement /Concrete walkways/ Weekly Scraping	40 –90% (AP-42, Section 11.19.1, Sand and Gravel Processing	Yes
Freestall confinement	Twice daily flushing/concrete walkways	10-20% (AP-42, Section 13.2.2, Fugitive Dust Sources)	Yes
Bedding	Selection using best management practices	50-90% (AP-42, Section 13.2.2, Fugitive Dust Sources)	Yes

The control technologies and methods listed in Option 2 above have been achieved in practice for commercial dairy operations[1].

1. Harmony Farms, Hilarides Dairy, Borba Dairy

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d) Step 4 - Cost Effectiveness Analysis

Control technologies that have been deemed to be technologically feasible but have not been achieved in practice can only be required as BACT if shown to be cost effective. The controls listed above in Option 2 have been achieved in practice and are required as BACT. As there have not been any controls identified as technologically feasible, a cost effectiveness analysis is not required.

Should technological feasible controls be later identified for this source category, the District will update the BACT guideline to add these control options.

For technologically feasible measures that are more effective than achieved-in-practice controls, a detailed, site-specific cost effectiveness analysis is required. Such analysis will consider all costs that are attributable to the control technology beyond those for a standard device that is typically used by the industry. Examples of the types of costs that would be included in such an analysis are capital cost, utility cost, fuel cost, labor, and other operational and maintenance costs. For PM_{10}, any control with an annual cost of more than $5,700 per ton of emission reduced is not considered to be cost effective.

e) Step 5 - Select BACT

The controls listed in Option 2 have been identified as achieved in practice for cow, calf and maternity housing at a dairy with12.5 tons/yr or more of VOC emissions. BACT will be the controls listed in option 2.

2. Volatile Organic Compounds (VOC)

a) Step 1 - Identify All Possible Control Technologies

(1) Option 1:

Building ventilation and control using biofilters (freestall barns). Animals fed in accordance with NRC guidelines utilizing routine nutritional analysis for rations. Freestall and drylot walkways and feed lanes constructed of concrete. Drylots sloped to facilitate runoff and prevent anaerobic decomposition. Feed lanes and walkways cleared of manure twice daily and drylots and corrals to be cleared weekly.

(2) Option 2:

Animals fed in accordance with NRC guidelines utilizing routine nutritional analysis for rations. Freestall and drylot walkways and feed lanes constructed of concrete. Drylots sloped to facilitate runoff and prevent anaerobic decomposition. Feed lanes and walkways cleared of manure twice daily and drylots and corrals to be cleared weekly.

b) Step 2 - Eliminate Technologically Infeasible Options

In option 1 above, a ventilation system using biofilters is not considered technologically feasible for controlling emissions VOC emissions in drylots or freestall dairy barns.

Drylots are open and never ventilated. Freestall barns constructed in mild climates, such as we have in the valley air basin typically do not have ventilation systems or have ventilation systems that are not conducive to controlling emissions. Freestall barns are typically constructed with large open areas, as it is not necessary to fully enclose the barn to allow for heating during the winter months. Easy egress to the milking center and the corral or drylot is more important than enclosed space. Therefore, installing an air handling system capable of capturing VOC emissions in a typical freestall barn is not feasible.

c) Step 3 - Rank Remaining Control Technologies

After eliminating the technologically infeasible options, the remaining options are ranked according to either their control efficiency or their emission factor. Any option which ranks below an achieved in practice option is not listed, because such control cannot be approved as BACT.

(1) Option 2

Animals fed in accordance with NRC guidelines utilizing routine nutritional analysis for rations. Freestall and drylot walkways and feed lanes constructed of concrete. Drylots sloped to facilitate runoff and prevent anaerobic decomposition. Feed lanes and walkways cleared of manure twice daily and drylots and corrals to be cleared weekly.

The overall control for an animal housing facility incorporating the option listed above is the sum of the emissions controlled at each sub operation. If available, the control efficiency of each sub operation is listed below

Specific control efficiencies for VOC emissions control for dairy housing have not been identified in the literature. The controls listed are based on the control of similar processes and engineering judgment.

Sub Operations of Option 2	Method of Control	Control Efficiency of Sub operation	Achieved in Practice
Feeding	Diet manipulation to reduce nitrogen and other nutrients in the manure	10% (Klaunser, J Prod Agric, NRC feeding guidelines)	Yes
Drylot confinement	Drylots sloped for drainage, concrete walkways and feed lanes, twice daily feed lane manure removal and weekly scraping of pens	25-50% Removal allows for control at lagoon/storage pile. Control efficiency based on twice rather than once per day	Yes
Freestall confinement	Concrete feed lanes and freestalls and twice daily flushing	25-50% Removal allows for control at lagoon/storage pile. Control efficiency based on twice rather than once per day	Yes

The amount of VOC directly emitted in cow housing is expected to be small but not zero. The control achieved through diet manipulation affects not only direct VOC emissions but also the VOC emitted in the lagoons and storage piles.

The control technologies and methods listed in Option 2 above have achieved in practice for commercial dairy operations[8].

d) Step 4 - Cost Effectiveness Analysis

The control technologies listed above in option 2 are achieved in practice and are required as BACT for cow, calf and maternity housing at a dairy with12.5 tons/yr or more of VOC emissions. A cost effectiveness analysis is not required.

e) Step 5 - Select BACT

Animals fed in accordance with NRC guidelines utilizing routine nutritional analysis for rations. Freestall and drylot walkways and feed lanes constructed of concrete. Drylots sloped to facilitate runoff and prevent

[8] Harmony Farms, Hilarides Dairy, Borba Dairy

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anaerobic decomposition. Feed lanes and walkways cleared of manure twice daily and drylots and corrals to be cleared weekly.

3. Ammonia Emissions

a) Step 1 - Identify All Possible Control Technologies

(1) Option 1:

Building ventilation and control using biofilters. Animals fed in accordance with NRC guidelines utilizing routine nutritional analysis for rations. Freestall and drylot walkways and feed lanes constructed of concrete. Drylots sloped to facilitate runoff and prevent anaerobic decomposition. Feed lanes and walkways cleared of manure twice daily and drylots and corrals to be cleared weekly.

(2) Option 2:

Animals fed in accordance with NRC guidelines utilizing routine nutritional analysis for rations. Freestall and drylot walkways and feed lanes constructed of concrete. Drylots sloped to facilitate runoff and prevent anaerobic decomposition. Feed lanes and walkways cleared of manure twice daily and drylots and corrals to be cleared weekly.

b) Step 2 - Eliminate Technologically Infeasible Options

In option 1 above, a ventilation system using biofilters is not considered a technologically feasible for controlling ammonia emissions in drylots or freestall dairy barns.

Drylots are open and never ventilated. Freestall barns constructed in mild climates, such as we have in the valley air basin typically do not have ventilation systems or have ventilation systems that are not conducive to controlling emissions. Freestall barns are typically constructed with large open areas, as it is not necessary to fully enclose the barn to allow for heating during the winter months. Easy egress to the milking center and the corral or drylot is more important than enclosed space. Therefore, installing an air handling system capable of capturing ammonia emissions in a typical freestall barn is not feasible.

c) Step 3 - Rank Remaining Control Technologies

After eliminating the technologically infeasible options, the remaining options are ranked according to either their control efficiency or their emission factor. Any option which ranks below an achieved in practice option is not listed because that level of control is below the minimum level of control required to satisfy District's BACT policy.

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(1) Option 2:

Animals fed in accordance with NRC guidelines utilizing routine nutritional analysis for rations. Freestall and drylot walkways and feed lanes constructed of concrete. Drylots sloped to facilitate runoff and prevent anaerobic decomposition. Feed lanes and walkways cleared of manure twice daily and drylots and corrals to be cleared weekly.

The overall control for an animal housing facility incorporating the option listed above is the sum of the emissions controlled at each sub operation. If available, the control efficiency of each sub operation is listed below.

Specific control efficiencies for ammonia emissions for dairy housing have not been identified in the literature. The controls listed are based on the control of similar processes and engineering judgment.

Sub Operations of Option 2	Method of Control	Control Efficiency of Sub operation	Achieved in Practice
Feeding	Diet manipulation to reduce nitrogen and other nutrients in the manure	10% (Klaunser, J Prod Agric, NRC feeding guidelines)	Yes
Drylot confinement	Drylots sloped to facilitate drainage, concrete walkways and feed lanes, twice daily feed lane manure removal and weekly scraping of pens	25-50% Removal allows for control at lagoon/storage pile. Control efficiency based on twice rather than once per day	Yes
Freestall confinement	Concrete feed lanes and freestalls and twice daily flushing	25-50% Removal allows for control at lagoon/storage pile. Control efficiency based on twice rather than once per day	Yes

The amount of ammonia emitted directly and ammonia converted from urea on the cow house floor is expected to be a significant portion of total ammonia emitted. Therefore, the frequency of removal of the manure to the areas where it can be controlled (lagoons and storage piles) is though to be an effective control strategy. The control achieved through diet manipulation affects not only direct ammonia emissions but also the ammonia emitted in the lagoons and storage piles.

The control technologies and methods listed in Option 2 above have achieved in practice for commercial dairy operation[9].

d) Step 4 - Cost Effectiveness Analysis

The control technologies listed above in option 2 are achieved in practice and are required as BACT for cow, calf and maternity housing at a dairy with12.5 tons/yr or more of VOC emissions. A cost effectiveness analysis is not required.

e) Step 5 - Select BACT

Animals fed in accordance with NRC guidelines utilizing routine nutritional analysis for rations. Freestall and drylot walkways and feed lanes constructed of concrete. Drylots sloped to facilitate runoff and prevent anaerobic decomposition. Feed lanes and walkways cleared of manure twice daily and drylots and corrals to be cleared weekly.

4. Hydrogen Sulfide (H_2S)

a) Step 1 - Identify All Possible Control Technologies

(1) Option 1:

Building ventilation and control using biofilters. Animals fed in accordance with NRC guidelines utilizing routine nutritional analysis for rations. Freestall and drylot walkways and feed lanes constructed of concrete. Drylots sloped to facilitate runoff and prevent anaerobic decomposition. Feed lanes and walkways cleared of manure twice daily and drylots and corrals to be cleared weekly.

(2) Option 2:

Animals fed in accordance with NRC guidelines utilizing routine nutritional analysis for rations. Freestall and drylot walkways and feed lanes constructed of concrete. Drylots sloped to facilitate runoff and prevent anaerobic decomposition. Feed lanes and walkways cleared of manure twice daily and drylots and corrals to be cleared weekly.

b) Step 2 - Eliminate Technologically Infeasible Options

In option 1 above, a ventilation system using biofilters is not considered a technologically feasible for controlling H_2S emissions in drylots or freestall dairy barns.

Drylots are open and never ventilated. Freestall barns constructed in mild climates, such as we have in the valley air basin typically do not have

[9] Harmony Farms, Hilarides Dairy, Borba Dairy

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ventilation systems or have ventilation systems that are not conducive to controlling emissions. Freestall barns are typically constructed with large open areas as it is not necessary to fully enclose the barn to allow for heating during the winter months. Easy egress to the milking center and the corral or drylot is more important than enclosed space. Therefore, installing an air handling system capable of capturing H2S emissions in a typical freestall barn is not feasible.

c) Step 3 - Rank Remaining Control Technologies

After eliminating the technologically infeasible options, the remaining options are ranked according to either their control efficiency or their emission factor. Any option which ranks below an achieved in practice option is not listed because that level of control is below the minimum level of control required to satisfy the District's policy.

(1) Option 2:

Animals fed in accordance with NRC guidelines utilizing routine nutritional analysis for rations. Freestall and drylot walkways and feed lanes constructed of concrete. Drylots sloped to facilitate runoff and prevent anaerobic decomposition. Feed lanes and walkways cleared of manure twice daily and drylots and corrals to be cleared weekly.

The overall control for an animal housing facility incorporating the option listed above is the sum of the emissions controlled at each sub operation. If available, the control efficiency of each sub operation is listed below:

Specific control efficiencies for H2S emissions for dairy housing have not been identified in the literature. The controls listed are based on the control of similar processes and engineering judgment.

Sub Operations of Option 2	Method of Control	Control Efficiency of Sub operation	Achieved in Practice
Feeding	Diet manipulation to reduce nitrogen and other nutrients in the manure	10% (Klaunser, J Prod Agric, NRC feeding guidelines)	Yes
Drylot confinement	Drylots sloped to facilitate drainage, concrete walkways and feed lanes, twice daily feed lane manure removal and weekly scraping of pens	25-50% Removal allows for control at lagoon/storage pile. Control efficiency based on twice rather than once per day	Yes
Freestall confinement	Concrete feed lanes and freestalls and twice daily flushing	25-50% Removal allows for control at lagoon/storage pile. Control efficiency based on twice rather than once per day	Yes

H_2S, like VOC, is emitted in small quantities from manure on the cow house floor, and the number of removal per day will effect direct H_2S emissions. The control achieved through diet manipulation affects not only direct H_2S emissions but also the H_2S emitted in the lagoons and storage piles.

The control technologies and methods listed in Option 2 above have achieved in practice for commercial dairy operation[10].

d) Step 4 - Cost Effectiveness Analysis

The control technologies listed above in option 2 are achieved in practice and are required as BACT for cow, calf and maternity housing at a dairy with12.5 tons/yr or more of VOC emissions. A cost effectiveness analysis is not required.

e) Step 5 - Select BACT

Animals fed in accordance with NRC guidelines utilizing routine nutritional analysis for rations. Freestall and drylot walkways and feed lanes constructed of concrete. Drylots sloped to facilitate runoff and prevent

[10] Harmony Farms, Hilarides Dairy, Borba Dairy

anaerobic decomposition. Feed lanes and walkways cleared of manure twice daily and drylots and corrals to be cleared weekly.

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Best Available Control Technology (BACT) Guideline 5.7.X*			
Last Update:			
Emission Unit:	**Dairy Confined Animal Feeding Operation (> 12.5 tons/yr of VOC Emissions) – Cow, Calf and Maternity Housing**		
Pollutant	**Achieved in Practice or contained in SIP**	**Technologically Feasible**	**Alt. Basic Equip**
VOC	Animals fed in accordance with NRC guidelines utilizing routine nutritional analysis for rations. Concrete freestall and drylot feed lanes and walkways. Feed lanes and walkways to be cleared twice daily and drylots/corrals cleared weekly. Drylots sloped to facilitate runoff and drying.		
PM_{10}	Drylots controlled by windbreaks, limiting animal movements and water sprays, concrete feed lanes, twice daily flushing (freestall barn) and weekly scraping (drylot) and selection of bedding using best management practices.		
Ammonia	Animals fed in accordance with NRC guidelines utilizing routine nutritional analysis for rations. Concrete freestall and drylot feed lanes and walkways. Feed lanes and walkways to be cleared twice daily and drylots/corrals cleared weekly. Drylots sloped to facilitate runoff and drying.		
H2S	Animals fed in accordance with NRC guidelines utilizing routine nutritional analysis for rations. Concrete freestall and drylot feed lanes and walkways. Feed lanes and walkways to be cleared twice daily and drylots/corrals cleared weekly. Drylots sloped to facilitate runoff and drying.		

*This is a Summary Page for this Class of Source - Permit Specific BACT Determinations on Next Page(s)

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IX. DAIRY LIQUID WASTE TREATMENT

A. Process Description

As mentioned earlier, there are three types of manure that a dairy may have to manage, solid (moisture content > 20%), slurry (moisture content between 10 & 20%), and liquid (moisture content less than 10%). This part of the evaluation will cover the controls associated with liquid and slurry type manure. Scrape or vacuum dairies mainly deal with slurry type manure, while flush dairies handle liquid manure. Refer to Section VII of this document for the process description.

Most flush dairies flush their manure from the feed lanes to an anaerobic treatment lagoon or storage pond. Lagoons typically operate with a solids content less than 2%. Anaerobic lagoons have the smallest surface area, can decompose more organic matter per unit lagoon volume than aerobic bacteria and are the cheapest to construct. For these reasons, anaerobic lagoons are the most common type of lagoon in practice at dairies. However, this type of lagoon has the greatest potential for odor. Odor problems can be minimized though, when the lagoon is designed and operated correctly. An anaerobic lagoon is an area source for biogas, which is the product of anaerobic digestion (see definition of anaerobic digestion).

During anaerobic digestion, acid-forming bacteria (acetogens) convert soluble organic matter into odorous volatile organic acids. In the next stage, methane-forming bacteria (methanogens) convert the volatile acids into biogas composed of about 60% methane and 40% carbon dioxide, with trace amounts of water vapor, H2S, and NH3. However, it is typical of liquid manure storages to have more acid-forming bacteria than methane forming bacteria;[11] therefore, VOC's are also a by-product of anaerobic digestion. In an optimum environment though, methanogens exist and convert the odor-producing volatile acids into methane. Therefore, an efficient anaerobic digestion system reduces VOC emissions.

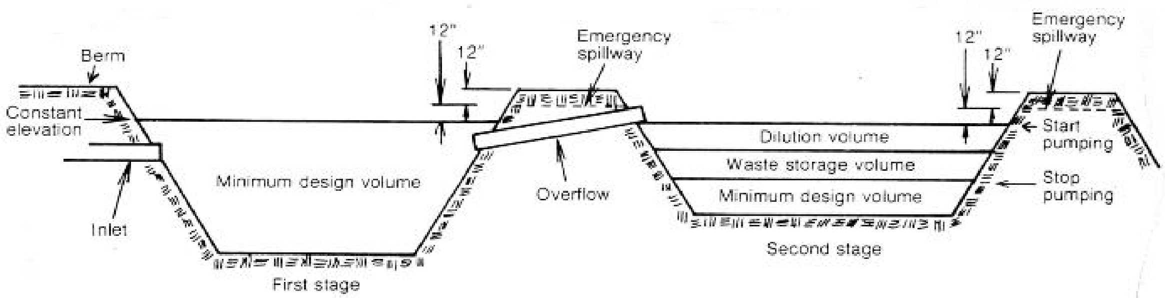
<u>Storage Ponds</u>
A single lagoon (also called a holding pond or storage pond) is not designed for manure treatment. Storage ponds are completely emptied two or more times a year, which interrupts the anaerobic digestion process. For this reason, storage ponds result in more odor than a treatment lagoon system.

<u>Anaerobic Treatment Lagoons</u>
Many dairies operate with more than one open (uncovered) lagoon to handle the liquid waste (see figure above). The first stage of the lagoon system is the biological treatment stage. The first stage is designed with a constant liquid level to stabilize the anaerobic digestion. The effluent from the first stage overflows into a second

[11] Penn State, "Anaerobic Digestion: Biogas Production and Odor Reduction from Manure".

lagoon designed for liquid storage capacity. Effluent from the second lagoon is used in the flush lanes and for crop irrigation.
A properly designed two-stage lagoon system has an air pollution benefit over single lagoon systems. Odorous emissions are reduced with a two-stage system since the primary lagoon has a constant treatment volume, which promotes more efficient anaerobic digestion when compared to a storage pond. As mentioned above, an increase in anaerobic digestion efficiency results in less VOC and other odorous emissions.

The secondary (overflow) lagoon acts as the storage pond, which can be emptied when necessary. The figure below identifies some parameters that should be considered in the design of a proper treatment lagoon system[12]:



The National Resource Conservation Service (NRCS) outlines design specifications for waste treatment lagoons (both open and covered). The following design criteria shall be considered prior to construction of an anaerobic waste treatment lagoon system (from NRCS Interim Practice Standards No. 359 - Waste Treatment Lagoon, and No. 360 - Methane Production and Recovery - Covered Anaerobic Lagoon):

- Required volume: The minimum design volume should account for all potential sludge, treatment, precipitation, and runoff volumes:

- Treatment period: retention time of the material in the lagoon shall be the time required to provide environmentally safe utilization of waste. The minimum hydraulic retention time for a covered lagoon in the San Joaquin Valley is about 38 days.

- Waste loading: shall be based on the maximum daily loading considering all waste sources that will be treated by the lagoon. The loading rate is typically based on volatile solids (VS) loading per unit of volume. The suggested loading rate for the San Joaquin Valley is 10-11 lb-VS/1000 ft_3/day.

- The operating depth of the lagoon shall be 12 feet or greater. Maximizing the depth of the lagoon minimizes the surface area, which in turn minimizes the cover size and cost. Increasing the lagoon depth has the following advantages:

[12] "Design and Operation of Livestock Waste Lagoons", Don Jones, Alan Sutton, Purdue University, 1999.

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  - Minimizes air pollution
  - Smaller surface areas provide a more favorable and stable environment for methane bacteria
  - Better mixing of lagoon due to rising gas bubbles
  - Requires less land
  - More efficient for mechanical aeration

- The lagoon design shall also consider location, soils and foundation, and erosion.

Crucial to a dairy lagoon system is a solids separator, which removes material from the waste stream that would prematurely fill a lagoon. A settling basin may achieve a solids remove rate of between 40-70%, and a mechanical separator may achieve between 20-50%. A separator is crucial to the treatment of the lagoon water. The efficiency of the treatment would suffer without separation, which would result in more odors from the lagoon. Most of the separated solids are fibrous material that leads to excessive sludge buildup or the formation of crusts on the lagoon surface, both of which interfere with pumping operations. Also, lagoon cleanout costs are reduced since the cleanout frequency is reduced if the excess material is prevented from entering the lagoon. Separation will also allow existing lagoons to accommodate more animals, or will reduce the land area required when designing a lagoon since the volume to be treated is less. As a final benefit, the separated solids may be recycled and used for composting, soil amendments, refeeding, bedding, etc.

Operating a two-stage lagoon system with power generation and/or heat recovery is an excellent scenario for the environment. The optimal system will operate with the primary lagoon as the enclosed anaerobic digester, where the biogas is captured (via covered lagoon, plug flow or complete mix digester) and sent to a combustion device for power generation or facility water heating. So not only is a system like this a renewable energy source, the capture and combustion of the biogas provides additional odor and nuisance control. The payback for an anaerobic digestion system has been reported to be between 3 and 7 years.

Potential benefits to farmer of an anaerobic digester system:

1. Renewable energy source
2. Minimizes odor/nuisance issues
3. Reduces mosquitoes
4. Reduces weed seeds (herbicide reduction)
5. Reduces pathogens (pesticide reduction)
6. Nutrient management (N import reduction)

Below is a schematic of a dairy utilizing a biogas capture and collection system with power generation and heat recovery:

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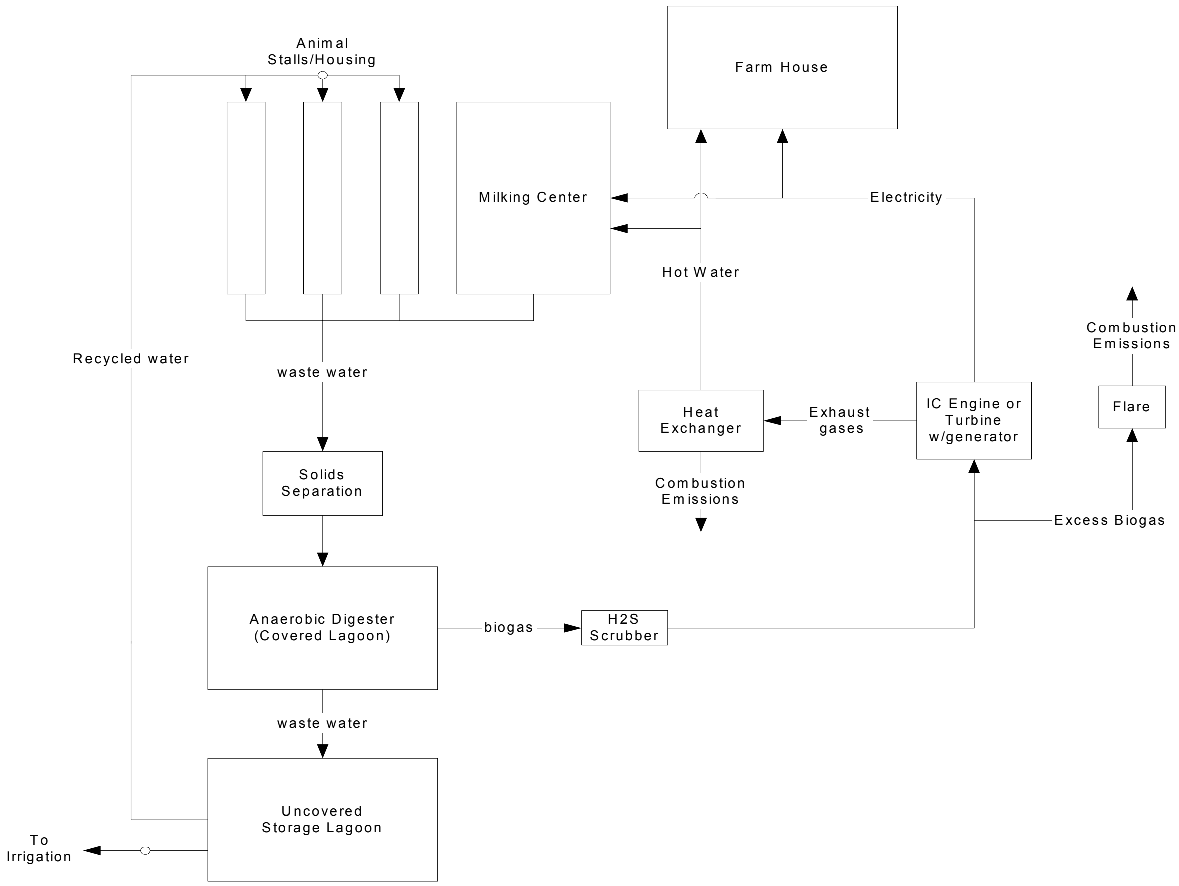

The captured biogas can be utilized as a valuable renewable energy resource for electrical and/or heat generation if the system is designed, installed and maintained properly. There has been a noticeable number of digester systems fail over the years however. The primary reasons for failure in the past have been attributed to deficiencies in design and engineering deficiencies, labor skill, training and support, and equipment. Therefore, proper planning and management is crucial to the success of a digester system.

<u>Plug Flow Digesters</u>

Another type of anaerobic digester, which is more commonly in use, is called a plug-flow digester. A plug flow anaerobic digester is the simplest form of anaerobic digestion (Jewell, Kabrick et al. 1981). Consequently, it is the least expensive (Jewell, Dell-Orto et al. 1981). The plug flow digester can be a horizontal or vertical digester. The plug-flow design is usually a long trough with an air-tight expandable cover, similar to the one shown in the diagram below. Organic wastes are collected daily and added to one end of the trough. Each day a new "plug" of organic wastes is added, slowly pushing the other manure down the trough. Plug flow digesters are usually operated with a total solids concentration of 11 to 13 percent, at the mesophilic temperature range, and with a hydraulic residence time (HRT) from 20-

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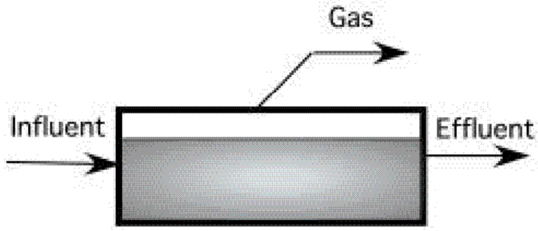
30 days. Bacteria in the manure, which is kept at an optimal 100 degrees, cause it to decompose in the warm slurry. This produces methane, VOCs, ammonia, and H_2S. Plug flow digesters have been used for more than 20 years to produce methane and control odors.[13]



Plug Flow Reactor

Currently there are many plug-flow digesters that are in operation at dairies in the United States, some of which are shown in the table below:

[13] Dairy Practices Council, "Guideline for Dairy Odor Management", 2001, p.19.

Plug-Flow Digesters in the United States			
Location	Year operational	Number of animals	Manure handling Method
CA	1982	400 Milkers	Scrape
CA	2002	650 Milkers	Solids separator; scrape
CA	2002	7,000 Milkers, 3,000 Others	Vacuum scrape
CT	1997	200 Milkers	Scrape
IA	2002	480 Cows	Scrape
IA	2002	800 Cows	Scrape
IA	2002	170 Cows	Scrape
IL	-	1,400 Milking	Scrape
MI	1981	730 Milkers	Scrape
MN	1999	850 Milkers	Scrape
NY	1998	500-550 Cows	Scrape
NY	2001	850 Milkers, 100 Dry	Continuous Scrape
PA[14]	1979, 1981, 1984 (3 digesters)	2,300 Milkers	Scrape

As shown in the table above, a plug-flow digester is mainly used with dairies that have a scrape or vacuum type of manure management. Therefore, this type of digester is ideal for slurry type manure.

Complete Mix Digesters

A less commonly used digester is a complete mix digester. A complete mix digester system consists of an engineered tank called a mixing pit, located above or below ground. In cold-weather regions, the tank is usually installed below ground for better insulation. The digester tank is covered with a fixed lid, often from poured concrete. Manure is collected in the mixing pit either by a gravity-flow or a mechanical pump system, where it is preheated to improve the anaerobic process and diluted if necessary. The manure is then sent to a reactor digester tank to be mixed, where a mechanical prop or blade system is used to keep the manure solids in suspension. As the biogas builds at the top of the digester tank during the anaerobic process,

[14] This is a mesophilic slurry loop type digester. This digester can be considered to be a variant of the plug-flow digester since it is a slurry-based system. Unlike plug-flow systems that are used only on dairy farms and that require manure TS concentrations of 11 to 13 percent, slurry-based digestion systems can operate with much lower solids concentrations and can be used to treat a variety of animal manures. Slurry systems require no mechanical mixing and are often found as silo-type reactors or in a loop or horseshoe configuration. Several operators believe the slurry design can enable greater convective currents in the digester, thereby helping to avoid the solids crusting problem commonly associated with the plug-flow design when TS concentrations fall below design parameters.

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methane is removed from the digester by pipe and transported to the end use application. The warmer the manure is in the mixing pit and digester, the shorter the retention time and the greater the biogas production.

The following table shows the some complete-mix systems that are currently in operation at dairies in the United States:

Complete-Mix Digesters in the United States			
Location	Year Operational	Number of Animals	Manure Handling Method
CA	2001	5,000 Cows	Vacuum Scrape
CT	1997	600 Milkers	Scrape
NY	1985	295 Milkers	Scrape
NY	2001	560 Milkers	Scrape and Gravity Flow

Covered Lagoon Digesters

The following table shows the some covered lagoon anaerobic digester systems that are currently in operation at commercial dairies in the United States:

Covered Lagoon Digesters in the United States				
Location	Year operational	Number of Animals	Manure Handling Method	Biogas End-Use
CA	2004	2,500 Milkers	Flush	Flare
WI	1999	1,300 Milkers	Scrape	Flare
WI	1998	1,100 Milkers	Scrape	Flare

Note: There are currently 4 more new covered lagoon digester systems planned to begin construction at dairies in California alone in 2003 (“Dairy Power Production Progress Report”, California Energy Commission, Western United Resource Development, May 2003).

Aerobic Treatment Lagoon

Another type of lagoon is the aerobic lagoon. The main advantage of aerobic lagoons is the relatively odor-free end products. Negligible amounts of VOC, H2S and NH3 emissions will be created from completely aerobic lagoons. However, vast amounts of land are required for naturally aerobic lagoons, when compared to anaerobic or mechanically aerated lagoons. Thus, naturally aerobic lagoons are not very common.

Mechanically aerated lagoons also result in minimal or no odors (assuming complete aeration), but also have the added benefit of minimizing land surface area.

A major disadvantage of the mechanically aerated lagoon though, is the high electrical expense to run the aerators continuously. For this reason, they have not been in common practice to date.

Top-Down BACT Analysis

1. VOC Emissions

a) Step 1 - Identify All Possible Control Technologies.

(1) Anaerobic digester system with 95% VOC control of captured biogas (IC engine w/catalyst or equivalent):

As mentioned above, there are dairies that operate with a two-stage lagoon system (anaerobic treatment lagoon followed by open overflow lagoon). There are also many more dairies that operate a plug-flow digester and some that operate a complete-mix digester. For this reason, a *properly designed* anaerobic digester system will be deemed achieved in practice. Therefore, all new and modified dairies that trigger BACT for VOC emissions will be required to install and operate an anaerobic digester system as discussed in this evaluation.

However, as mentioned above, proper design and maintenance of the entire system is crucial. For instance, adequate biogas moisture and H2S removal prior to combustion is necessary for proper ongoing functioning of the equipment. The removal of the influent H2S also reduces combustion SOx emissions and secondary PM10 emissions. Consultation of experts prior to construction is crucial to the ongoing success of a functioning digester system. EPA's AgSTAR Handbook is one available reference for a list of designers, equipment suppliers and vendors.

The biogas captured by the digester must be sent to an IC engine or another type combustion device. Combustion (thermal incineration) is a generally accepted, well-established VOC control technique. During combustion, gaseous hydrocarbons are oxidized to form CO_2 and water. VOC's in the captured biogas can be reduced by 95% with the use of a flare or an IC engine equipped with after control.[15] A catalyst may be installed on a dairy-biogas IC engine for NOx, CO and VOC control for additional pollution control.[16]

Flare systems can be designed to automatically handle large fluctuations in gas flow rate and concentration. For these reasons, flares are a

[15] According to the District BACT determination for soil remediation operations, a minimum VOC destruction efficiency of 95% may be assumed for IC engine control.

[16] Since siloxanes and other "catalyst poisoning" compounds that are present in human waste are not present in dairy-biogas, a catalyst after control may be considered for these applications.

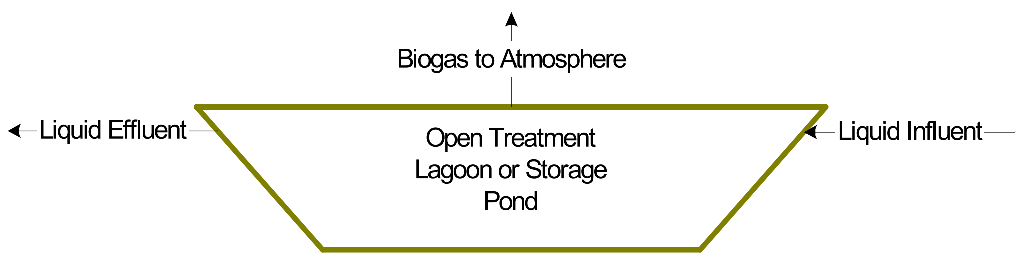
common biogas control at landfills and municipal wastewater treatment facilities; and have also been used at dairies.

Flares can be categorized as open or enclosed. Enclosed flares are typically more elaborate, and can achieve a desired VOC control from 98% - 99.99% to meet customer demands. This high level of control is due to specific excess air, residence time and temperature design. Enclosed flares can be tested for emission control efficiency due to the presence of an exhaust stack.

Open flares are usually a more simple design, where the flame may be visible to bystanders. Open flares cannot be tested for control efficiency since there is not exhaust stack present. A properly designed and operating flare can achieve 98% VOC control.[17] Proper operation of a flare may be assumed if the standards in 40 CFR 60.18 (General control device requirements, flares) are met.

<u>Overall Control Efficiency Determination:</u>

The overall VOC control efficiency of a covered lagoon manure handling system may be determined by comparing emissions to an open lagoon manure handling system. An open lagoon or storage pond will be considered the uncontrolled emissions unit. The emissions from the open lagoon system are the total of the amount volatilized off the surface of the lagoon plus the amount of the liquid effluent that is volatilized.



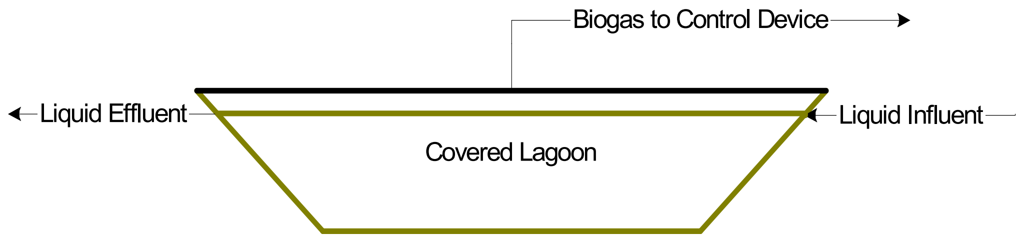
With a covered lagoon system however, a fraction of the VOC, NH_3 and H_2S gases that would be emitted from the surface of an open lagoon will remain in liquid form upon installation of a surface cover. This is partially due to a decrease in surface turbulence (primarily due to a lack of air movement), which in turn decreases volatilization. It may also be due to an increase in saturation of the air/biogas inside the headspace under the lagoon cover. Based on the best available information at this time, the following assumptions will be made:

[17] AP-42, Section 13.5.2, 1995.

- 48% of VOC's in lagoon may be captured with the installation of a cover and biogas collection system[18].

- 52% of VOC's in covered lagoon remain in liquid form (lagoon effluent).

- 100% of VOC's that remain in the lagoon effluent may potentially be lost to atmosphere via overflow lagoon, flushing and/or irrigation.



Covered lagoon emissions = Uncontrolled × {[Captured × (1 - CE)] + Effluent}

Covered lagoon emissions = Uncontrolled × {[0.48 × (1 - 0.95)] + 0.52}
= Uncontrolled × 0.54

As shown here, a covered lagoon system has 54% the VOC emissions of an open lagoon system. Therefore, the VOC control efficiency or the amount of VOC reductions that may be achieved by the use of a covered system with combustion of the captured biogas when compared to an open system is 46%. This control will also be applied to mixed and plug flow digester systems.

Overall VOC control efficiency of anaerobic digester system with combustion of captured biogas = 46%

<u>Note:</u> A 50% control efficiency for both VOC and ammonia was estimated for an anaerobic digester/IC engine system.[19]

(2) Permeable floating lagoon covers:

Permeable covers reduce perceived gas and odor emissions from the lagoon by creating a physical barrier that suppresses volatile compounds

[18] Based on information provided by Agri-Food Research & Development Initiative, "Earthen Manure Storage Covers: Their Role in Nutrient Conservation and Manure Stabilization", 2001.
[19] Tetra Tech, "Task 3 - Identify Potential Waste Management Practices Reducing Ammonia and VOC's", March 2003.

from escaping the liquid. As mentioned above for solid cover lagoons, a fraction of these compounds will thus remain in liquid form and can potentially be released as effluent from the lagoon. Some researchers believe that the reduction in emissions occurs from the aerobic treatment of the compounds that do escape the liquid surface. The idea for this control technique is the aerobic microbial activity on the underside of the porous cover at the liquid/cover interface. This may diffuse the odorous gases that enter the atmosphere.

Permeable floating lagoon covers may be classified into two main categories: synthetic and biological. Some synthetic cover types include polystyrene foam, geotextile (porous felt-like fabric), Leca^R (air-filled clay balls) and other plastic. Some biocover types include straw, grass, peat, and chopped cornstalks. Typically, four to 12 inches of biocover is blown onto the liquid manure surface.

To date there is not an established method to determine VOC, NH_3 or H_2S emission reductions due to a floating permeable cover. However, there have been some general estimates on odor control effectiveness:

Permeable Lagoon Cover Estimates*		
Cover Type	**Odor Control (%)**	**Life Expectancy**
Straw (4-12 in. thick)	40-90	Up to 6 mo.
Geotextile (0.3-6 mm thick)	10-75	3-5 years
Leca (clay balls)	40-90	<10
Other Composites	40-90	<10

*This table summarizes information provided in the following literature:

- University of Kentucky, “Using Covers to Minimize Odor and Gas Emissions from Manure Storages”, 2004.
- Iowa State University, “Emission Control Systems - Chapter 10”, page 207.
- University of Minnesota, “Reducing Odor, Hydrogen Sulfide, and Ammonia Emissions from Manure with Straw and Geotextile Covers”, 1999.
- Iowa State University, “Geotextile Covers for Liquid Manure Storages”, 1999.
- ASAE, “Two Year Study of the Effectiveness of Geotextile Covers to Reduce Odor and Gas Emissions from Manure Storages”, 2002.

(3) Aerobic Lagoon:

Aeration is an excellent way to minimize VOCs, H_2S and NH_3 from liquid manure decomposition. This process is sometimes referred to as Nitrification (especially when discussing NH_3 transformation). Complete aerobic digestion (100% aeration) nearly eliminates malodors and undesirable gases. The reduction percentage of these pollutants may near 99% upon complete aeration. However, quantified data of reductions from various aeration levels is not available.

Aerated lagoons may be considered aerobic by providing enough oxygen to achieve a dissolved oxygen content greater than 1 mg/L. Suggested dairy aerator design requires 0.1 hp/animal to achieve an aerobic lagoon.[20]
However, due to limited literature on aeration requirements, it will be estimated that a 50% aeration level may be achieved with the design criteria of 0.1 hp/animal (milking cow). It will also be assumed that the level of emission control is directly proportional to the level of aeration. Therefore, an aerobic lagoon will be assigned a 50% control for each pollutant VOCs, H_2S and NH_3.

(4) Anaerobic Digester system with 80% VOC control of captured biogas (biofiltration):

As mentioned above, an anaerobic digester system is required if BACT is triggered for VOC's. The captured biogas from the digester may be sent to a biofilter for VOC, H2S and NH3 control.

Biofiltration after control systems are available now for dairy animal wastegas treatment. VOC's in the captured biogas can be reduced by at least 80% with biofiltration:

- According to Joseph Devinny, Ph.D. (213-740-0670) for TRG Biofiltration Systems (714-730-5397) in Tustin, CA; biofiltration (compost/greenwaste media) can achieve at least 80% control efficiency for VOC containing digester gas.

- According to Rob Johnson (520-624-4644) at Bohn Biofilter, their activated soil biofilter can achieve 90% VOC control for dairy lagoon wastegas. The unit also controls H_2S by 99% and NH_3 by 90%.

[20] "Lagoon Design and Management for Livestock Waste Treatment and Storage", James Barker - NC State University, 1996.
http://www.bae.ncsu.edu/programs/extension/publicat/wqwm/ebae103_83.html

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- According to Robert Bianchi (519-767-9100 x233) at Biorem Technologies (Ontario, Canada), the VOC control efficiency is about 80% with their BIOMIX^{TM} (wood based) or BIOSORBINS^{TM} (inert hydrophilic cores) media technology. The unit also controls H_2S by 99%.

- According to Martin Crawford at Bay Products, Inc. (1-800-429-0150), 95% VOC control is possible with their OdorDigest^{TM} unit. The unit also controls NH_3 by 97% and H_2S by 99%.

<u>Overall Control Efficiency Determination:</u>

As shown in above, the overall control efficiency may be calculated by comparing emissions from a digester system to that of an open lagoon system.

Therefore, the overall control efficiency of a digester system with biofiltration of captured biogas is:

Covered lagoon emissions = Uncontrolled × {[Captured × (1 - CE)] + Effluent}

Covered lagoon emissions = Uncontrolled × {[0.48 × (1 - 0.80)] + 0.52}
= Uncontrolled × 0.62

As shown here, a covered lagoon system has 62% the VOC emissions of an open lagoon system. Therefore, the VOC control efficiency or the amount of VOC reductions that may be achieved by the use of a covered system with biofiltration of captured biogas when compared to an open lagoon system is 38%.

Overall VOC Control Efficiency of anaerobic digester system with biofiltration of biogas = 38%

<u>Note:</u> Since biofiltration controls three pollutants (VOC, H2S and NH3), there is a multi-pollutant cost effectiveness benefit.

(5) Manure additives:

Chemical (non-microbiological) or enzymatic (microbiological) manure additives may be used to reduce emissions.

Chemical additives for VOC, H2S and NH3 control can be categorized by their control mechanism. The primary chemical additive categories are pH control, oxidation, and precipitation.

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Digestive deodorants, some types of counteractants and adsorbents are generally known as enzymatic or microbiological additives. These types of additives generally contain mixed cultures of enzymes or microorganisms designed to enhance the decomposition of solids and reduce H_2S and NH_3 emissions.

Commercial additive products on the market though, claim to provide odor control and solids reduction of livestock manures, where results are not based on research data. All side effects and secondary impacts of manure additives must be identified prior to implementation. The limited research done to date has been inconclusive.[21] Since additives must be thoroughly tested and evaluated before producers can use them, there is a need to perform farm-scale testing over extended periods (6-12 months) in order to establish product effectiveness under practical conditions. For these reasons, it will be assumed that additives have zero control for VOC, H2S and NH3.

b) Step 2 - Eliminate Technologically Infeasible Options.

All control options not eliminated in step 1 are technologically feasible.

c) Step 3 - Rank Remaining Control Technologies by Control Effectiveness.

VOC Control Method	Control Efficiency (%)
Aerobic lagoon (aeration)	50
Anaerobic digester system with 95% VOC control of captured biogas (IC engine w/catalyst or equivalent)	46
Anaerobic digester system with 80% VOC control of captured biogas (biofiltration)	38
Permeable floating lagoon covers	10
Manure additives	0

All controls that have been assigned a zero control will be eliminated at this time. The remaining controls to be listed in the Clearinghouse are as follows:

[21] "Odour Control for Livestock Facilities", Canada Plan Service, B. West.

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VOC Control Method	Control Efficiency (%)	AIP
Aerobic lagoon (aeration)	50	No
Anaerobic digester system with 95% VOC control of captured biogas (IC engine w/catalyst or equivalent)	46	Yes
Anaerobic digester system with 80% VOC control of captured biogas (biofiltration)	38	No
Permeable floating lagoon covers	10	No

d) Step 4 - Cost Effectiveness Analysis

Control technologies that have been deemed to be technologically feasible but have not been deemed to be achieved in practice can only be required as BACT if shown to be cost effective. By law, control techniques that have been achieved in practice for a class and category of source establish a floor and must be required for that class and category of source regardless of cost.

For technologically feasible measures that are more effective than achieved-in-practice controls, a detailed, site-specific cost effectiveness analysis is required. Such analysis will consider all costs that are attributable to the control technology beyond those for a standard device that is typically used by the industry. Examples of the types of costs that would be included in such an analysis are capital cost, utility cost, labor, and other operational and maintenance costs. For VOC emissions, any control with an annual cost of more than $5,000 per ton of emission reduced is not considered to be cost effective.

A case-by-case analysis cannot be included here without site-specific data. Instead, for each pollutant, this document will identify the controls that have been AIP for each pollutant and those that were found to be technologically feasible.

e) Step 5 - Select BACT

The following is a summary of the District's BACT determination for this class and category of source for ***VOC*** emissions:

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Achieved in Practice	Technologically Feasible	Alternate Basic Equipment
• Anaerobic digester system with 95% VOC control of captured biogas (IC engine w/catalyst or equivalent)	• Aerobic lagoon (aeration or equivalent)	

2. H_2S Emissions

a) Step 1 - Identify All Possible Control Technologies.

(1) Permeable lagoon covers:

See Section III.A.2 above for discussion.

(2) Anaerobic digester system with 99% H_2S control of captured biogas (biofiltration):

As mentioned above, biofiltration systems are available now for dairy animal wastegas treatment.

- According to Rob Johnson (520-624-4644) at Bohn Biofilter, their activated soil biofilter can achieve 99% H_2S control for dairy lagoon wastegas. The unit also controls VOCs by 90% and NH_3 by 90%.

- According to Robert Bianchi (519-767-9100 x233) at Biorem Technologies (Ontario, Canada), the H_2S control efficiency is about 99% with their BIOMIX^{TM} (wood based) or BIOSORBINS^{TM} (inert hydrophilic cores) technology.

- According to Mike Sprague (989-725-8184 x115) at Duall Division, 99% H_2S control is possible with their AroBIOS^{TM} unit. Local supplier contact for Duall is Kirk Keefer at Effective Air Systems (916-988-4913). The unit also controls NH_3 by 99%.

- According to Martin Crawford at Bay Products, Inc. (1-800-429-0150), 99% H_2S control is possible with their OdorDigest^{TM} unit. The unit also controls NH_3 by 97% and VOCs by 95%.

<u>Overall Control Efficiency Determination</u>

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The amount of H2S that will remain in liquid form due to a solid covered lagoon has not been quantified to date. The overall control efficiency of a digester system with biofiltration of captured biogas is:

Covered lagoon emissions = Uncontrolled $\times$ {[Captured $\times$ (1 - CE)] + Effluent}

Covered lagoon emissions = Uncontrolled $\times$ {[0.48 $\times$ (1 - 0.99)] + 0.52}
= Uncontrolled $\times$ 0.52

As shown here, a covered lagoon system has 52% the H2S emissions of an open lagoon system. Therefore, the H2S control efficiency or the amount of H2S reductions that may be achieved by the use of a covered system with biofiltration of captured biogas when compared to an open lagoon system is 48%.

Overall H2S control efficiency of anaerobic digester system with biofiltration of captured biogas = 48%

(3) Anaerobic digester system with 99% H_2S control of captured biogas (caustic scrubber):

A 99% H_2S control for wastegas by a caustic scrubber is common technologically according to the following:

- Elena M. Repidonis, an engineer at Ceilcote Air Pollution Control (440-243-0700).
- Martin Crawford at Bay Products, Inc. (1-800-429-0150)
- RK Fabrication (714-630-9654)
- Dave Robertson at W.E.S., Inc. (941-371-7617)

However, this type of control produces a secondary liquid waste stream that would need to be removed from the site; and there is not a multi-pollutant cost effectiveness benefit. Therefore, this type of control will not be considered feasible for any site at this time and will not be ranked in step 3 below.

(4) Aerobic lagoon:

See section III.A.4 of this document for discussion.

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(5) Anaerobic digester system with 90% H_2S control of captured wastegas (iron sponge scrubber - ferric chloride, iron oxide or equivalent):

- The Varec 234/235 Series Purifier (hydrated iron oxide (Fe_2O_3) sponge bed) scrubber can achieve 90% H_2S control.
- Ferric Chloride scrubbers are common control for H_2S and can achieve at least 90% H_2S control.

The overall control efficiency of a digester system with H2S scrubbing of captured biogas is:

Covered lagoon emissions = Uncontrolled × {[Captured × (1 - CE)] + Effluent}

Covered lagoon emissions = Uncontrolled × {[0.48 × (1 - 0.90)] + 0.52}
= Uncontrolled × 0.57

As shown here, a covered lagoon system has 57% the H2S emissions of an open lagoon system. Therefore, the H2S control efficiency or the amount of H2S reductions that may be achieved by the use of a covered system with H2S scrubbing of captured biogas when compared to an open lagoon system is 43%.

Overall H2S Control Efficiency of anaerobic digester system with biofiltration of capture biogas = 43%

(6) Manure additives:

See Section III.A.7 above for discussion.

b) Step 2 - Eliminate Technologically Infeasible Options.

All control options not eliminated in Step 1 above are technologically feasible.

c) Step 3 - Rank Remaining Control Technologies by Control Effectiveness.

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H2S Control Method	Control Efficiency (%)
Aerobic lagoon (aeration)	50
Anaerobic digester system with 99% H_2S control of captured biogas (biofiltration)	48
Anaerobic digester system with 90% H_2S control of captured biogas (iron sponge scrubber - ferric chloride or iron oxide)	43
Permeable floating lagoon covers	10
Manure additives	0

The remaining controls to be listed in the Clearinghouse are as follows:

H2S Control Method	Control Efficiency (%)	AIP
Aerobic lagoon (aeration)	50	No
Anaerobic digester system with 99% H_2S control of captured biogas (biofiltration)	48	No
Anaerobic digester system with 90% H_2S control of captured biogas (iron sponge scrubber - ferric chloride or iron oxide)	43	No
Permeable floating lagoon covers	10	No

d) Step 4 - Cost Effectiveness Analysis

A cost effectiveness analysis will not be performed at this time (see Section III.D of this document for further discussion).

e) Step 5 - Select BACT

The following is a summary of the District's BACT determination for this class and category of source for ***H_2S*** emissions:

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Achieved in Practice	Technologically Feasible	Alternate Basic Equipment
	• Aerobic lagoon (aeration) • Anaerobic digester system with 99% H_2S control of captured biogas (biofiltration) • Anaerobic digester system with 90% H_2S control of captured biogas (iron sponge scrubber - ferric chloride or iron oxide)	

3. NH_3 Emissions:

a) Step 1 - Identify All Possible Control Technologies.

(1) Permeable lagoon cover:

See Section III.A.2 above for discussion.

(2) Anaerobic digester system with 90% NH_3 control of captured biogas (biofiltration):

- According to Rob Johnson (520-624-4644) at Bohn Biofilter, their activated soil biofilter can achieve 90% NH_3 control for dairy lagoon wastegas.
- According to Mike Sprague (989-725-8184 x115) at Duall Division, 99% NH_3 control is possible with their AroBIOS™ unit. Local supplier contact for Duall is Kirk Keefer at Effective Air Systems (916-988-4913). The unit also controls H_2S by 99%.
- According to Martin Crawford at Bay Products, Inc. (1-800-429-0150), 97% NH_3 control is possible with their OdorDigest™ unit. The unit also controls H_2S by 99% and VOCs by 95%.

The amount of NH3 that will remain in liquid form due to a solid covered lagoon has not been quantified to date. However, based on the best available information at this time, the following assumptions will be made:

- 18% of N in lagoon may be captured as NH3 with the installation of a cover and biogas collection system.[22]

- 82% of N in covered lagoon remains in liquid form (lagoon effluent).

- 100% of N that remains in the lagoon effluent may potentially be lost to atmosphere as NH3 via overflow lagoon, flushing and/or irrigation.

The overall control efficiency of a digester system with biofiltration of captured biogas is:

Covered lagoon emissions = Uncontrolled × {[Captured × (1 - CE)] + Effluent}

Covered lagoon emissions = Uncontrolled × {[0.18 × (1 - 0.90)] + 0.82}

Covered lagoon emissions = Uncontrolled × 0.84

As shown here, a covered lagoon system has 84% the NH3 emissions of an open lagoon system. Therefore, the NH3 control efficiency or the amount of NH3 reductions that may be achieved by the use of a covered system with biofiltration of captured biogas when compared to an open lagoon system is 16%.

Overall NH3 Control Efficiency of anaerobic digester system with biofiltration of biogas = 16%

(3) Aerobic lagoon:

See Section III.A.4 above for discussion.

(4) Anaerobic digester system with 99% NH_3 control of captured biogas (sulfuric acid scrubber):

A wastegas sulfuric acid scrubber is common technologically for 99% NH_3 control of biogas according to the following:

- Elena M. Repidonis, Ceilcote Air Pollution Control (440-243-0700)
- Martin Crawford at Bay Products, Inc. (1-800-429-0150)
- Darryl Haley at Tri-Mer (989-723-7838)

However, this type of control produces a secondary liquid waste stream that would need to be removed from the site; and there is not a multi-pollutant cost effectiveness benefit. Therefore, this type of control will not

[22] Based on research by Agri-Food Research & Development Initiative, “Earthen Manure Storage Covers: Their Role in Nutrient Conservation and Manure Stabilization”, 2001.

be considered feasible for any site at this time and will not be ranked in step 3 below.

(5) Solids separation:

See Section III.A.3 above for discussions.

(6) Minimize lagoon surface area, maximize lagoon depth:

See Section III.A.5 above for discussion.

(7) Manure additives:

See Section III.A.7 above for discussion.

b) Step 2 - Eliminate Technologically Infeasible Options.

All control options not eliminated in Step 1 are technologically feasible.

c) Step 3 - Rank Remaining Control Technologies by Control Effectiveness.

NH_3 Control Method	Control Efficiency (%)
Aerobic lagoon (aeration)	50
Anaerobic digester with 90% NH3 control of captured biogas (biofiltration)	16
Permeable floating lagoon covers	10
Manure additives	0

The remaining controls to be listed in the Clearinghouse are as follows:

NH_3 Control Method	Control Efficiency	Achieved in Practice
Aerobic lagoon (aeration)	50	No
Anaerobic digester system with 90% NH3 control of captured biogas (biofiltration)	16	No
Permeable floating lagoon covers	10	No

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d) Step 4 - Cost Effectiveness Analysis

A cost effectiveness analysis will not be performed at this time (see Section III.D of this document for further discussion).

e) Step 5 - Select BACT

The following is a summary of the District's BACT determination for this class and category of source for ***NH_3*** emissions:

Achieved in Practice	Technologically Feasible	Alternate Basic Equipment
	• Aerobic lagoon (aeration) • Anaerobic digester system with 90% NH3 control of captured biogas (biofiltration) • Permeable floating lagoon cover	

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San Joaquin Valley Unified Air Pollution Control District

Best Available Control Technology (BACT) Guideline 5.7.X

Emission Unit: Dairy Waste Treatment Lagoon or storage pond **Industry Type:** Dairy

Equipment Rating: All **Last Update:** April 21, 2004

Pollutant	Achieved in Practice or contained in SIP	Technologically Feasible	Alternate Basic Equipment
VOC	• Anaerobic digester system with 95% VOC control of captured biogas (IC engine w/catalyst or equivalent)	• Aerobic lagoon (aeration)	
H_2S		• Aerobic lagoon (aeration) • Anaerobic digester system with 99% H_2S control of captured biogas (biofiltration) • Anaerobic digester system with 90% H_2S control of captured biogas (iron sponge scrubber - ferric chloride or iron oxide) • Permeable floating lagoon cover	
PM_{10}*		• Aerobic lagoon (aeration) • Anaerobic digester system with 90% NH_3 control of captured biogas (biofiltration) • Permeable floating lagoon cover	

* Includes ammonia emissions

BACT is the most stringent control technique for the emissions unit and class of source. Control techniques that are not achieved in practice or contained in a state implementation plan must be cost effective as well as feasible. Economic analysis to demonstrate cost effectiveness is required for all determinations that are not achieved in practice or contained in an EPA approved State Implementation Plan.

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X. DAIRY OPERATIONS – SOLID MANURE STORAGE AND MILKING CENTER

A. Process Description

Based on the current industry emissions information available at this time, emissions from manure storage and emissions from the milking center consist of the following compounds: Nitrogen (N_2), Oxygen (O_2), Ammonia (NH_3), various Volatile Organic Compounds (VOCs) and pathogens, Carbon Dioxide (CO_2), and Methane (CH_4). The scope of this BACT determination includes only VOCs and NH_3 emissions.

Refer to Section VII of this evaluation for a detailed process description.

B. Best Available Control Technology (BACT) for Solid Manure Storage and Milking Center

BACT may potentially be triggered for any affected pollutant generated from the milking center and manure storage. The following pollutants that are emitted from the storage of manure are: Ammonia (NH_3) and Volatile Organic Compounds (VOCs).

A search was conducted of EPA, CARB and SCAQMD websites for applicable BACT determinations for VOC and NH_3 emissions from manure storage piles and the milking center. A search was also done using an internet search engine (Google). No determinations for these classes and sources of operations were found.

Since no BACT determination exists for this class and category of operations in the District's Clearinghouse, pursuant to the District's BACT policy, a Top-Down BACT analysis will be performed for inclusion of a new determination in the District's BACT Clearinghouse.

1. Achieved in Practice Determination

The U.S. Environmental Protection Agency (USEPA) RACT/BACT/LAER Clearinghouse, the California Air Pollution Control Officers Association (CAPCOA) BACT Clearinghouse the Bay Area Air Quality Management District (BAAQMD), and the South Coast Air Quality Management District (SCAQMD) BACT Guidelines were reviewed to determine potential control technologies for this class and category of operations.

No BACT guidelines were found for either of the operations (solid manure storage or milking center) in any of the clearinghouses mentioned above. However, almost all of the dairy operations utilize some sort of flush/spray system to wash out the manure and urine from their milking center. This system is primarily used for cleanliness purposes but also serves as an emission control for reducing VOC and ammonia emissions. Therefore the flush/spray will be considered an achieved in practice control for the milking center.

2. Top-Down Best Available Control Technology (BACT) Analysis for VOC emissions from the milking center

a) Step 1 - Identify All Possible Control Technologies

General control for VOC emissions include the following options:

1. Flush/spray after each batch of milking
2. Enclose, capture and incineration

b) Step 2 - Eliminate Technologically Infeasible Options

All the listed controls are considered feasible for this application.

c) Step 3 - Rank Remaining Control Technologies by Control Effectiveness

Control efficiencies for VOC:

VOC Emission Control Technology Rankings	
Rank	Control Efficiency
1) Enclose, capture with incineration	98% [23]
2) Flush/spray after each batch of milking	--% [24]

d) Step 4 - Cost Effectiveness Analysis

A cost effectiveness analysis must be performed for all control options in the list from step 3 in the order of their ranking to determine the cost effective option with the lowest emissions.

(1) Enclose, VOC capture and control with incineration:

The cost analysis will first be performed solely using natural gas to see if this alone will exceed the cost effective threshold. If this does not, then the cost of the incinerator and associated equipment will be added.

[23] OAQPS Control Cost Manual, 4th Edition, EPA 450/3-90-006, January 1990, page 3-8.
[24] The control efficiency for this type of control is not exactly known, however it is quite effective in reducing the emissions from the milking center.

(2) Design Parameters:

In order to effectively do a cost analysis on this type of control some assumptions will first be made. The following design parameters are partially based on a existing dairy. The milking center at the dairy is designed to milk approximately 1,200 –1,800 cows and the dimensions are as follows:

Length: 160 feet
Height: 15 feet
Width: 70 feet

Volume = 160 ft x 15 ft x 70 ft = 168,000 ft^3/hr

Natural Gas Requirement = (flow)(Cp_{Air})(ΔT)(HEF) - standard thermodynamic equation

Where:

Flow (Q) = exhaust flow rate of VOC contaminated air stream: 672,000 ft^3/hr[25] total

Cp_{Air} = specific heat of air: 0.0194 Btu/scf - °F

ΔT = increase in the temperature of the contaminated air stream required for catalytic oxidation to occur (It will be assumed that the air stream would increase in temperature from 100 °F to 600 °F.)

HEF = heat exchanger factor: 0.7

Gas Requirement = (672,000 scf/hr)(0.0194 Btu/scf - °F)(600 °F - 100 °F)(1 - 0.7) = **1,955,520 Btu/hr**

In order to calculate the annual cost of natural gas the following assumptions will be made:

Oxidizer Operating hours = (20 hr/day)(365 day/yr) = 7,300 hr/year
Cost of Gas: $5.00/MMBtu[26]

[25] OSHA's Laboratory Standard 1910 calls for "4-12 room air changes per hour." For this BACT determination a very conservative number of 4 air changes will be used to determine the exhaust flow rate, therefore 168,000 ft^3/hr x 4 = 672,000 ft^3/hr

(3) Worst case emissions (based on 1,800 cows):

Assumptions:

- The maximum amount of hours a cow spends in a milking center will not exceed 3 hours (based on industry input).
- The emission factor currently being used for the entire dairy is 12.8 lbs-VOC/head-yr[27]

Therefore, the emission factor from the milking center can be calculated as follows:

(12.8 lbs-VOC/head-yr) x (3hrs ÷ 24hrs) = 1.6 lbs-VOC/head-yr

Total emissions = 1,800 cows x 1.6 lbs-VOC/head-yr= 2,880 lb-VOC/year.

(4) Total Annual Cost

The fuel usage will be reduced by the heating value of the influent VOC stream. The heating value of the VOC's being controlled is not known so the heating value of MEK (13,729 Btu/lb) will be utilized in the calculation.

Btu content: (2,880 lb-VOC/year)(13,729 Btu/lb) = 39,539,520 Btu/yr

Gas Cost = [(1,955,520 Btu/hr × 7,300 hr/year) – 39.539,520 Btu/yr]
× ($5.00/MMBtu × MMBtu/$10^6$ Btu)

Gas Cost = $71,179/yr

(5) VOC Reduction

Reductions = (2,880 lb-VOC/year)(0.98) = 2,822 lb/year = 1.41 ton/year

(6) Cost of VOC Emission Reduction

Cost of reductions = $71,179/yr ÷ 1.41 ton/year
= **$50,481/ton of VOC reduced**

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[26] Natural gas price based on an average of $4.92 => $5.00 taken from March 2003 from the Oil Energy website, http://www.oilnergy.com/1gnymex.htm#year Therefore, the cost of $5.00/MMBtu will be used for natural gas.
[27] 12.8 lbs-VOC/head-yr is the currently the emission factor that CARB is using. This emission factor is based on a 1938 cow chamber study.

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As shown above, the cost of using natural gas alone for VOC reduction is far greater than the $5,000/ton cost effectiveness threshold of the District BACT policy. There are also other costs associated in achieving this type of control, such as the cost of enclosing the building, the cost of the incineration equipment, and also the cost of an air conditioning system to ensure the cows are comfortable and are not endangered due to heat stress during the hot summers in the San Joaquin Valley. The equipment is therefore not cost effective and is being removed from consideration at this time.

e) Step 5 - Select BACT

The following is a summary of the District's BACT determination for the milking center.

BACT Summary Table		
Pollutant	Achieved in Practice	Technologically Feasible
VOC	Flush/Spray after each batch of milking	Enclose, Capture and control with incineration

3. Top-Down Best Available Control Technology (BACT) Analysis for Ammonia Emissions from the milking center:

a) Step 1 - Identify All Possible Control Technologies

General control for Ammonia emissions include the following options:

1. Flush/spray after each batch of milking
2. Enclose, capture and incineration

b) Step 2 - Eliminate Technologically Infeasible Options

All the listed controls are considered feasible for this application.

c) Step 3 - Rank Remaining Control Technologies by Control Effectiveness

Control efficiencies for ammonia:

Ammonia Emission Control Technology Rankings	
Rank	Control Efficiency
1) Enclose, capture with incineration	98% [23]
2) Flush/spray after each batch of milking	--% [24]

d) Step 4 - Cost Effectiveness Analysis

A cost effectiveness analysis must be performed for all control options in the list from step 3 in the order of their ranking to determine the cost effective option with the lowest emissions.

(1) Enclose, Ammonia capture and control with incineration:

The cost analysis will first be performed solely using natural gas to see if this alone will cost the system out. If this does not, then the cost of the incinerators and associated equipment will be added to the cost.

(2) Design Parameters:

In order to effectively do a cost analysis on this type of control some assumptions will first be made. The following design parameters are partially based on an existing dairy. The milking center at the dairy is designed to milk approximately 1,200 –1,800 cows and the dimensions are as follows:

Length: 160 feet
Height: 15 feet
Width: 70 feet

Volume = 160 ft x 15 ft x 70 ft = 168,000 ft^3/hr

Natural Gas Requirement = (flow)(Cp_{Air})(ΔT)(HEF) - standard thermodynamic equation

Where:

Flow (Q) = exhaust flow rate of VOC contaminated air stream: 672,000 ft^3/hr[25] total

Cp_{Air} = specific heat of air: 0.0194 Btu/scf - °F

ΔT = increase in the temperature of the contaminated air stream required for catalytic oxidation to occur (It will be assumed that the air stream would increase in temperature from 100 °F to 600 °F.)

HEF = heat exchanger factor: 0.7

Gas Requirement = (672,000 scf/hr)(0.0194 Btu/scf - °F)(600 °F - 100 °F)(1 - 0.7) = **1,955,520 Btu/hr**

In order to calculate the annual cost of natural gas the following assumptions will be made:

Oxidizer Operating hours = (20 hr/day)(365 day/yr) = 7,300 hr/year
Cost of Gas: $5.00/MMBtu[26]

(3) Worst case emissions (based on 1,800 cows)

Worst case emissions = 1,800 cows x 1.6 lbs-VOC/head-yr= 2,880 lb-VOC/year.

(4) Total Annual Cost

The fuel usage will be reduced by the heating value of the influent VOC stream. The heating value of the VOC's being controlled is not known so the heating value of MEK (13,729 Btu/lb) will be utilized in the calculation.

Btu content: (2,880 lb-VOC/year)(13,729 Btu/lb) = 39,539,520 Btu/yr

Gas Cost = [(1,955,520 Btu/hr $\times$ 7,300 hr/year) – 39.539,520 Btu/yr]
$\times$ ($5.00/MMBtu $\times$ MMBtu/10^6 Btu)

Gas Cost = $71,179/yr

(5) Ammonia Reduction

Reductions = (2,880 lb-VOC/year)(0.98) = 2,822 lb/year = 1.41 ton/year

(6) Cost of Ammonia Emission Reduction

Cost of reductions = $71,179/yr $\div$ 1.41 ton/year = **$50,481/ton of ammonia reduced**

As shown above, the cost of using natural gas alone for ammonia reduction is greater than the $5,700/ton cost effectiveness threshold of the District BACT policy (based on PM_{10} threshold value). There are also other costs associated in achieving this type of control, such as the cost of enclosing the building, the cost of the incineration equipment, and also the cost of an air conditioning system to ensure the cows are comfortable and are not endangered due to heat stress during the hot summers in the San Joaquin Valley. The equipment is therefore not cost effective and is being removed from consideration at this time.

e) Step 5 - Select BACT

The following is a summary of the District's BACT determination for the milking center.

BACT Summary Table		
Pollutant	Achieved in Practice	Technologically Feasible
Ammonia	Flush/Spray after each batch of milking	Enclose, Capture and control with incineration

4. Top-Down Best Available Control Technology (BACT) Analysis for VOC and ammonia emissions from solid manure storage:

Solid manure refers to manure that has a solid content of 20% or greater. [28]

a) Step 1 - Identify All Possible Control Technologies

General control for VOC and ammonia emissions include the following options:

1. Open Windrow Composting
2. Open Aerated Static Pile (ASP)
3. Open negatively aerated static pile vented to biofilter $\geq$ 80% destruction efficiency for both active and curing phases (or a combination of controls)
4. Enclosed Aerated Static Pile
5. In-Vessel/Enclosed negative aerated static piles vented to biofilter $\geq$ 80% destruction efficiency for both active and curing phases (or a combination of controls)
6. Send Manure to Digester with Incineration

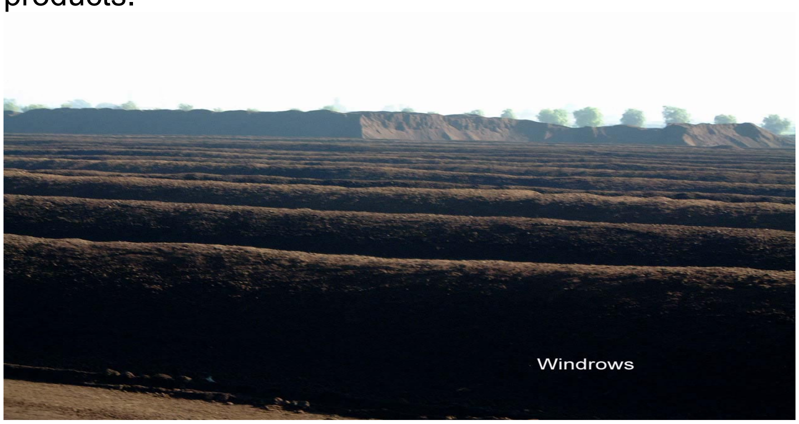
[28] Separated solids that are separated by a mechanical separator, however, will not be included in the definition for solid manure at this time since there is not much emissions data available to prove that there is a significant amount of emissions from this source. Separated solids will therefore be assumed of having negligible emissions. Separated solids will be reevaluated once further research is done and better data is available. Until then emission controls for separated solids will not be considered in this evaluation.

(1) *Control Descriptions*

(a) *Open Windrow Composting*

Composting is the aerobic decomposition of manure or other organic materials in the thermophilic temperature range (104 –149 degrees F). It is the same process that decays leaves and other organic debris in nature. Composting merely controls conditions so that materials decompose faster. Composting can be performed using windrows. A windrow process involves forming long piles (windrows as shown in the picture below) turned by specially designed machines. Typically the rows are 1 to 2 meters high and 2 to 5 meters at the base. The piles are turned periodically to mix and introduce and rebuild bed porosity. This helps to insure that all the material is uniformly composted.

Co-composting is a three-stage process that begins as soon as appropriate materials are combined and piled together. The initial stage of the process is referred to as active composting followed by curing or finishing, and storage and/or processing of composted products.



The composted material is usually odorless, fine-textured, and low-moisture and can be bagged and sold for use in gardens, nurseries or used as fertilizer on cropland. Composting improves the handling characteristics of any organic residue by reducing its volume and weight. Composting also kills pathogens and weed seeds. Composting reduces material volume through natural biological action and produces a product that enhances soil structure and benefits new growth.

Active composting phase (Thermophilic stage):
Based on SCAQMD Rule 1133.2, titled “Emission Reductions from Co-Composting Operations” the active composting phase is the phase of

the composting process that begins when organic materials are mixed together for composting purposes and lasts approximately 22 days. According to SCAQMD, 80% of VOC emissions and 50% of NH3 emissions occur during the first 22 days of composting.[29] The active phase of composting is where the thermophilic microorganisms' population is usually the highest. This stage is characterized by high temperatures, high level of oxygen demand and high evaporation rates due to temperature.

Curing phase (Mesophilic stage):
Conversely, the curing stage of the process is where the mesophilic microorganism population is the highest and the need for oxygen and evaporation rates decreases. The curing phase is defined in SCAQMD Rule 1133.2 as "a period that begins immediately after the active phase and lasts 40 days or until the compost exhibits a Solvita Maturity Index of 7, or the product respiration rate is below 10 milligrams of oxygen per gram of volatile solids per day as measured by direct respirometry". 20% of VOC emissions and 50% of NH3 emissions are expected to occur during this phase.[30]

VOC emissions from composting:
VOC emissions primarily occur during the active and curing phases of the composting. To ensure consistent temperatures within the piles, the applicant proposes to place a layer of finished compost on top of the active and curing phase piles. This also helps minimize volatility of VOCs at the surface of the compost piles.

There is a linkage between the microbial activity and the VOC emissions profile from composting operations. Emissions are generally higher during thermophilic temperatures and lower during mesophilic temperatures. The figure below illustrates the oxygen demand and microbial profile of the various composting stages. This figure also illustrates the corresponding VOC emissions primarily occurring during active and curing phases of composting[31].

During the composting process the volume of waste will be reduced anywhere from 40-50 percent. The rate at which manure will compost depends on the following:[32]

[29] Page 8 of SCAQMD Rule 1133 final staff report
[30] SCAQMD Rule 1133 Technology Assessment
[31] Page 9-10, SCAQMD Final Staff Report for Proposed Rules 1133, 1133.1, and 1133.2.
[32] Definitions are defined in Technology assessment for Proposed SCAQMD Rule 1133 (Pages 1-6)

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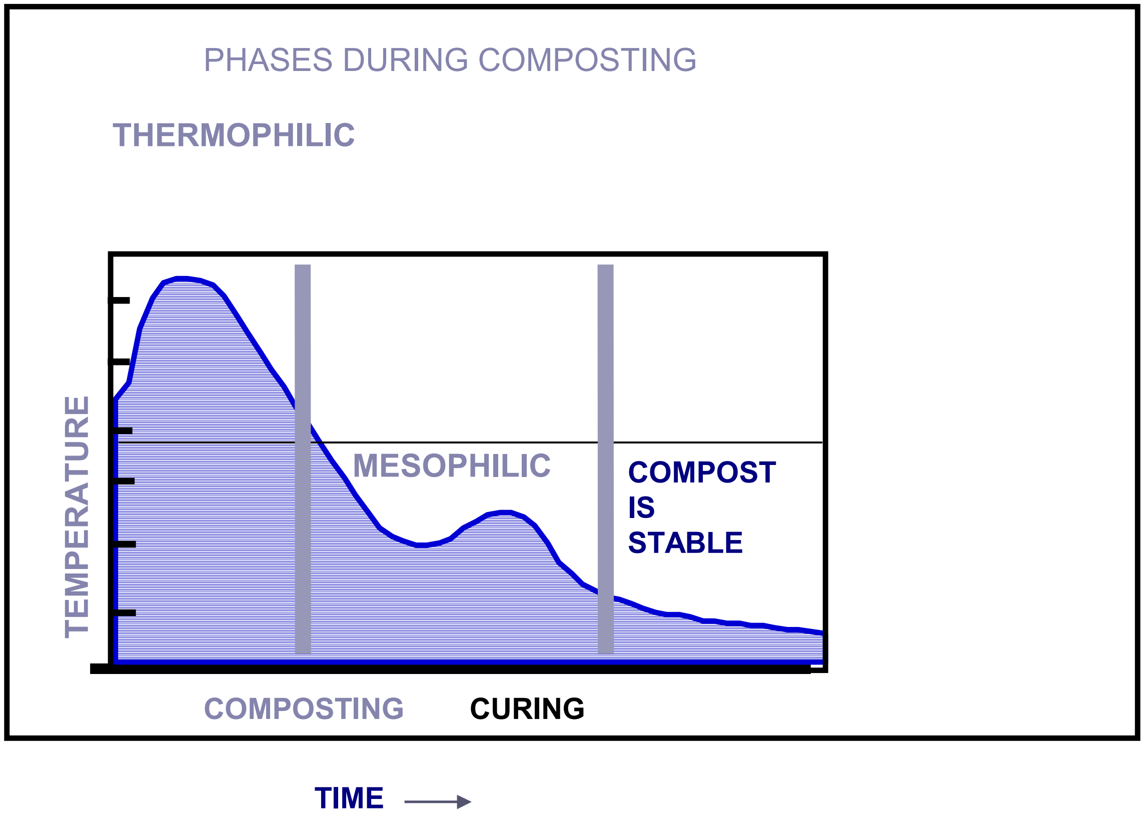

This graphic was provided by Eliot Epstein, Ph.D. Chief Environmental Scientist, Tetra Tech, Inc.
*VOC emissions are expected to follow the similar profile as oxygen demand.

portion of the material's total weight, expressed in a percentage. Moisture is an essential part of composting. It allows microorganisms to move about and transport nutrients, as well as provides the medium for chemical reactions. Insufficient moisture content will lead to microorganisms entering a dormant stage. Excessive moisture will limit air movement to and in the compost pile, causing an anaerobic decomposition that generates unpleasant odors. In addition, excessive moisture will also result in leachate. Since moisture content decreases as composting proceeds, a starting moisture content of 40% to 60% is recommended, and 50% to 60% is considered to be ideal. Usually, a mixture that feels moist, like a well-wrung sponge, indicates sufficient moisture. Moisture content can be adjusted either by adding water or moisture-rich organic materials, such as liquid sewage sludge, or by adding dry bulking agents such as leaves or wood chips.

- **pH** – this value indicates the level of acid or base in the compost. pH value is critical to composting since it affects the nutrient and metabolism of the microorganisms. Microorganisms consume organic acid very quickly; however, the majority of them cannot survive an extreme acidic environment (i.e., where the pH value is far less than 7). According to composting experts, optimum pH values range between 6.5 and 8.0. Increasing the pH value by the addition of lime or other additives is not advised because of the potential ammonia loss. pH values above 8.5 encourage the conversion of nitrogen compounds to ammonia, creating an odor problem. pH value changes during the composting process, and it can be adjusted by aeration or through a natural process called carbonate buffering. Through the carbonate buffering process, carbon dioxide combines with water to produce carbonic acid that will lower the compost pH. As a result, the final compost product always has a stable, close to neutral pH value.

- **Temperature** - is an important aspect of composting since composting occurs within two temperatures ranges, known as mesophilic (50^oF to 105^oF) and thermophilic (over 105^oF). Thermophilic temperatures are preferred because they promote rapid composting, and destroy pathogens, weed seeds, as well as fly larvae. However, extreme temperatures (above 160^oF) will kill most of the active, important microorganisms. According to composting experts, temperatures in the range of 110^oF to 150^oF are best for composting. The U.S. EPA requires that a minimum temperature of 131^oF be maintained for several days to eliminate bacteria and pathogens. Usually, adding external heat is unnecessary because during the composting process, heat is generated by microorganisms and is accumulated due to the pile's self-insulation. To prevent the temperature from rising to an extreme level that creates a fire hazard, frequent aeration is necessary.

- **Level of oxygen available** – this is critical to composting, especially during the early stage when microorganisms rapidly metabolize and grow. Insufficient oxygen supply will slow down the composting process and lead to an anaerobic decomposition that generates obnoxious odors, and ammonia and VOC emissions. Excess oxygen (or air) will also lower the pile's temperature slowing down the composting rate. Oxygen concentration fluctuates in response to the microbial activity. Usually, at the beginning of the composting process, oxygen concentration within the pore spaces is identical to oxygen concentration in the air (about 15% to 20%). However, as the compost ages, the oxygen concentration decreases and carbon dioxide concentration increases. A 5% to 15% oxygen concentration must be maintained for fast, aerobic composting. Oxygen (or air) can be provided by mechanical turning or by forced aeration, where air is either drawn or forced through the compost pile.

- **Size of manure particles** - particle size affects the efficiency of the composting process. Generally, microbial activity occurs on the surface of the particles. Therefore, an increase in the surface area by using smaller particles will increase the rate of decomposition. However, smaller particles also reduce the porosity, which is a measurement of the air space within the composting mass. This can result in poor aeration and increased emissions. Good particle sizes range from 1/8 to 2 inches average diameter and can be achieved by chopping, shredding, mowing, or breaking up the materials.

- **Carbon-to-Nitrogen ratio (C:N)** – this represents the weight of decomposable carbon to the weight of total nitrogen in an organic material. Carbon and nitrogen are 2 fundamental elements for microbial activity. Microorganisms utilize carbon for energy growth, and nitrogen for protein production. C:N ratio is significant to the composting process because insufficient nitrogen (higher ratio) will limit microbial growth, but excess nitrogen (lower ratio) will generate ammonia or other compounds that cause odors. For the best composting, the recommended C:N ratio range from 25:1 to 40:1, and a ratio of 30:1 is ideal.

The bacterial breakdown of substrates also produces various organic and inorganic gases that can contribute to several different air pollution problems. Source testing conducted by the SCAQMD District in 1994 and early 1995 indicated that outdoor windrow composting of dewatered sewage sludge releases significant levels of ammonia, methane and VOCs (SCAQMD, 1995)). Of these compounds ammonia emissions were the highest. Ammonia is of concern because once airborne, it reacts with atmospheric nitric acid to form particulate nitrate. Particulate nitrate makes up a substantial portion of PM_{10}.

Disadvantages of composting organic residues include loss of nitrogen and other nutrients, time for processing, cost for handling equipment, available land for composting, odors, marketing, and slow release of available nutrients. During a three year Nebraska study as much as 40 percent of total beef feedlot manure nitrogen and 60 percent of total carbon was lost to the atmosphere during composting.[33] Increasing the carbon-to-nitrogen ratio by incorporating high carbon materials (leaves, plant residue, paper, sawdust, etc.) can reduce nitrogen loss.

(b) Aerated Static Pile (ASP)

Aerated static piles are aerated directly with forced or drawn air systems to speed up the compost process. The aerated static pile is constructed to allow forced airflow (low pressure-high volume blowers and a piping system) so that the oxygen supply can be more accurately controlled. The material is piled over perforated pipes connected to a blower to withdraw air from the pile. The result is improved control of aerobic degradation or decomposition of organic waste and biomass bulking agents. This is considered a more efficient composting method than the industry standard windrow composting (non-aerated piles turned mechanically with front-end loaders or scarabs as discussed above).

VOC emissions primarily occur during the active and curing phases of the composting. To ensure consistent temperatures and prevent escape of odors and VOCs, the piles should be covered with a thick layer (12 to 18 inches) of finished compost or bulking agent.

With positive pressure aeration, contaminated air is pushed through the pile to the outer surface; therefore, making it difficult to be collected for odor treatment. However, positive pressure aeration is more effective at cooling the pile because it provides better airflow.

With negative aeration, air is pulled through the pile from the outer surface. Contaminated air is collected in the aeration pipes and can be directed to an odor treatment system. To avoid clogging, condensed moist air drawn from the pile must be removed before reaching the blower. Negative aeration might create uneven drying of the pile due to its airflow patterns.

[33] University of Nebraska-Lincoln

A study conducted by City of Columbus, Ohio, demonstrated that the weighted-average odor emissions from an outdoor negative aeration pile is approximately 67% lower than those from an outdoor positive aeration pile. Negative aeration is usually used during the beginning of the composting process to greatly reduce odors. In enclosed active composting area, negative pressure aeration also reduces moisture released into the building, and thus, reduces fogging. Positive aeration is used mostly near the end of the composting cycle for more efficient drying of the compost.[34]

An odor and emissions study done at the City of Philadelphia biosolids co-composting facility by the Department of Water[35] also concluded that controlling the temperature by controlling the oxygen availability using negative aeration composting is expected to result in lower emissions than those from open windrow composting.

(c) *Open negatively aerated static pile with exhaust vented to a biofilter > 80% control efficiency*

This technology is basically the same as described above except that the exhaust gases are vented to a biofilter and the aerated static pile must be in negative pressure. As shown above negative aeration appears to be more efficient in reducing odors and emissions than positive aeration.

Biofiltration as defined in Section II.A, is an air pollution control technology that uses a solid media to absorb and adsorb compounds in the air stream and retains them for subsequent biological oxidation. A biofilter consists of a series of perforated pipes laid in a bed of gravel and covered with an organic media. As the air stream flows up through the media, the odorous compounds are removed by a combination of physical, chemical and biological processes. However, depending upon the airflow from the composting material and the design and material selection for the biofilter, the organic matter could quickly deteriorate.

In the biofiltration process, live bacteria biodegrade organic contaminants from air into carbon dioxide and water. Bacterial cultures (microorganisms that typically consist of several species coexisting in a colony) that use oxygen to biodegrade organics are

[34] Technology Assessment for SCAQMD proposed Rule 1133 Page 3-2
[35] Conclusion # 2, "Measurement and Control of Odor and VOC emissions from the largest municipal aerated-static pile biosolids composting facility in the United States". William Toffey, Philadelphia Water Department; Lawrence Hentz, Post, Buckley, Shuh and Jerigan.

called aerobic cultures. These bacteria are found in soil, peat, compost and natural water bodies including ponds, lakes, rivers and oceans. They are environmentally friendly and non-harmful to humans unless ingested.

Chemically, the biodegradation reaction for aerobic cultures is written as:

Organic(s) + Oxygen + Nutrients + Microorganisms => CO_2 + H_2O + Microorganisms

The organic(s) are air contaminants, the oxygen is in air, the nutrients are nitrogen and phosphorus mineral salts needed for microbial growth and the microorganisms are live bacteria on the biofilter media.

Biofiltration is a well-established emission and control technology in Europe where over two hundred biofilters were in use as of 1984 and even more are expected today. In the United States, biofilters have been mainly utilized for the treatment of odors as well as VOCs in wastewater treatment plants. Based on the information collected by SCAQMD, existing biofilter composting applications have achieved control efficiencies of about 80% to 90% for VOC and 70% to over 90% for ammonia (one of this composting applications reported an initial control efficiency of 65 percent for VOC but was later improved to achieve an 80 percent control efficiency). This specific field example along with other available data presented in SCAQMD's Technology Assessment Report clearly demonstrates that a well-designed, well-operated, and well-maintained biofilter is capable of achieving 80 percent control efficiency for VOC and ammonia.[36]

(d) <u>Enclosed Aerated static Pile</u>

An enclosed aerated static pile uses the same forced aeration principle of an open ASP, except that the entire pile is fully enclosed. There are a handful of companies that are promoting this type of system. In this evaluation, the following two companies will be discussed: AgBag International Ltd and the Gore Cover. Both technologies are briefly described below:

[36] SCAQMD Final Staff Report for Rule 1133, page 18

(e) AgBag International Ltd.

The AgBag system was developed by Compost Technology International and is based in Oregon. The system has controlled aeration capabilities and has minimal space requirements. It is suited for small to mid-size composting. The system is comprised of the following components:

- Large sealed bags (pods) of adjustable length up to 200 ft, either 5 ft or 10 ft diameter
- 9 mm recyclable plastic (not re-usable)
- Adjustable aeration system with inserted valved vents
- Hopper, mixer & compost compactor
- Misc. equipment

The Ag-Bag Environmental system provides a cycle time of as little as 8 weeks. Curing adds another 30 to 60 days. AgBag states that three annual composting cycles could be obtained. Site locations close to urban areas, and the waste stream is on-site, therefore there are no hauling costs. The area needed to compost is determined by the volume of waste material.

Mixing – A composite mix of materials needs to be balanced for proper carbon to nitrogen (C:N) ratio. This means a mix of greens (nitrogen sources) to browns (carbon sources). The best ratio that AgBag recommends is between 20 to 40:1, with 30:1 being ideal.

The oxygen supply is replenished by forced aeration and eliminates the labor-intensive need to turn. Temperature monitors indicate when the airflow needs adjusting to maintain proper temperatures. Moisture is adjusted at time of filling or added to the total mixture upon blending. The compost matrix is sufficient in size to maintain heat, even in cold climates. The system contains vents throughout to allow air to escape. These vents are controlled by the operator. Ag-Bag is considered an in-vessel system.

After 8-12 weeks of composting, the compost cycle is completed. The “Pod”, as AgBag likes to call it, is opened and the material is static piled for 30-60 days to cure or mature. The table below shows some of the locations where this technology is currently being used:

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Location	Operating Since	Items Composted
Wisconsin municipality	1994	Yard waste and green waste
Wyoming air force base	1995	Yard waste and green waste
California Landfill	1995	Yard waste, green waste & biosolids
California zoo	1995	Animal manure, straw, yard waste
West Virginia Composter	1997	Poultry litter, cardboard, sawdust
Florida air force base	1998	MSW, biosolids, wood waste
Maryland Dairy	**1999**	**Dairy manure, wood chips, hay**
Ohio Composter	1999	Manure, yard waste
California University	2000	Rice straw, cow manure
Oregon Municipality	2001	Biosolids, wood waste
Wisconsin Dairy	**2001**	**Dairy manure, bedding, straw**
French Composter	1999	Manure, food waste, tree bark
Korean Composter	1999	Wood chips, saw dust, MSW
Japanese Farmer	2000	Feedlot cattle manure, bedding
Spain Composter	2001	Mixed organics
Swedish municipality	2002	MSW, yard waste, wood waste

As shown in the table above, there are two facilities that are currently using this control technology for composting dairy manure and one facility composting feedlot cattle manure. A representative of AgBag has claimed very high control efficiencies for both VOCs and ammonia and have also claimed that the system acts as its own biofilter, thus reducing emissions. However, VOC and ammonia control efficiencies are not readily available at this time. Furthermore, AgBag has not provided any technical information to support their claimed level of control. Therefore, this technology cannot be considered Achieved in Practice at this time.

AgBag, however is closely working with SCAQMD and the Milk Producers Council to perform a pilot study in evaluating the efficiency of this technology. AgBag is currently establishing the protocols of this study before any testing can begin. Until the study is conducted, this technology will be conservatively assumed to control emissions by at least 10% more than open aerated static piles, with a minimum control efficiency of 33.2%. Once the study is conducted, the District will be able to more accurately determine the control efficiency for this technology.

(f) *Gore Cover*

The Gore Cover, manufactured by Gore Creative Technologies Worldwide, utilizes positive aeration, control and a specially designed cover to create an enclosed system that controls odors, microorganisms and creates consistent product unaffected by outside environmental conditions. Medium pressure aerators connect to on-floor aeration pipes or in-floor aeration ducts. Stainless steel probes inserted into the pile monitor oxygen and temperature parameters. The data is relayed to and stored in a computer. This data controls the aerators to keep pile conditions consistent. The GORE Cover system can significantly reduces odors by the controlled use of a semi permeable membrane that is permeable to oxygen but impermeable to large molecules (shown in table below). The cover protects the pile from weather conditions, but allows release of CO_2. These controlled conditions allow consistent product to be produced without risk of damp pockets, resulting in anaerobic conditions and, therefore increased odors.

In addition to the membrane, which covers the organic material during composting, the system includes a concrete floor and wall, blowers for aeration, and a winder for efficient movement of the cover. The system also requires consistent management including preparation of materials to achieve a homogenous mixture with moisture content of 55-60 % and monitoring of temperature and oxygen levels. With this system, the composting process takes eight weeks. The “heap” of organic material is covered by the membrane, which is secured to the ground, allowed to compost for four weeks, then moved and re-covered for two weeks for stabilization. During the final two weeks of curing, the heap is uncovered.

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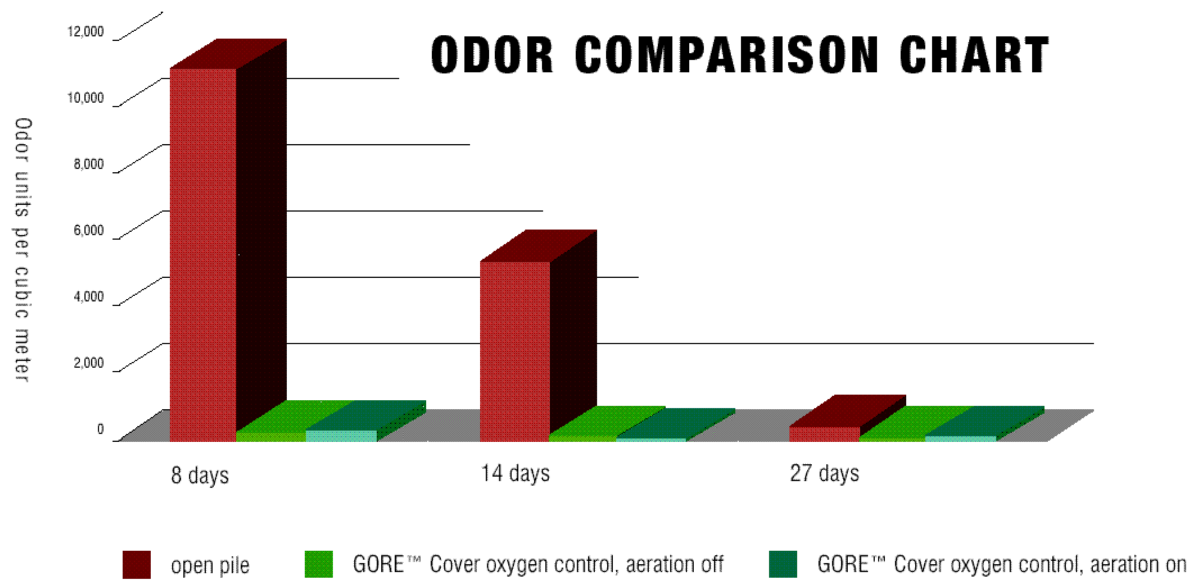
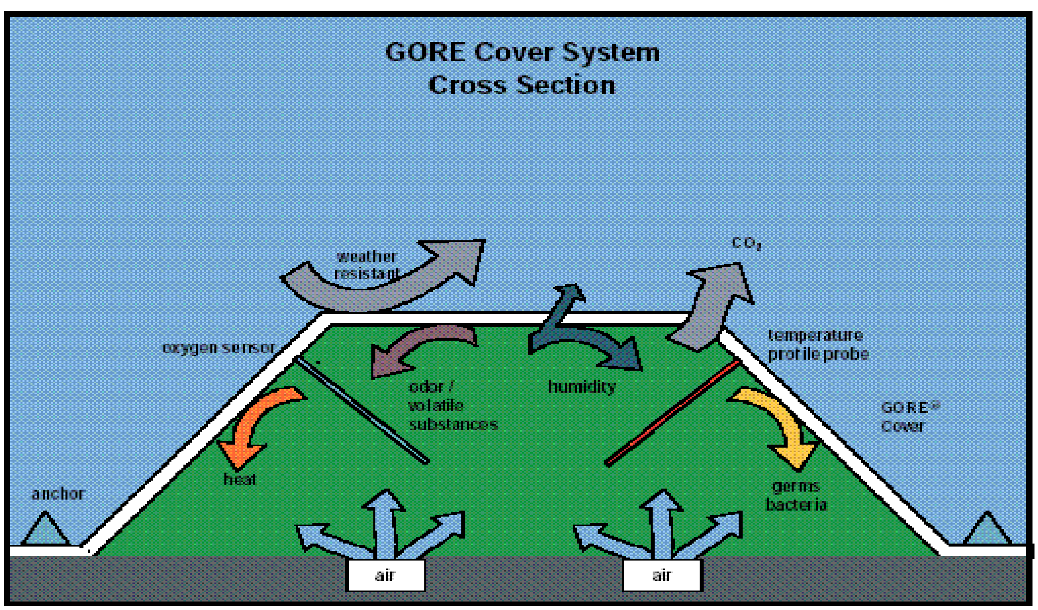
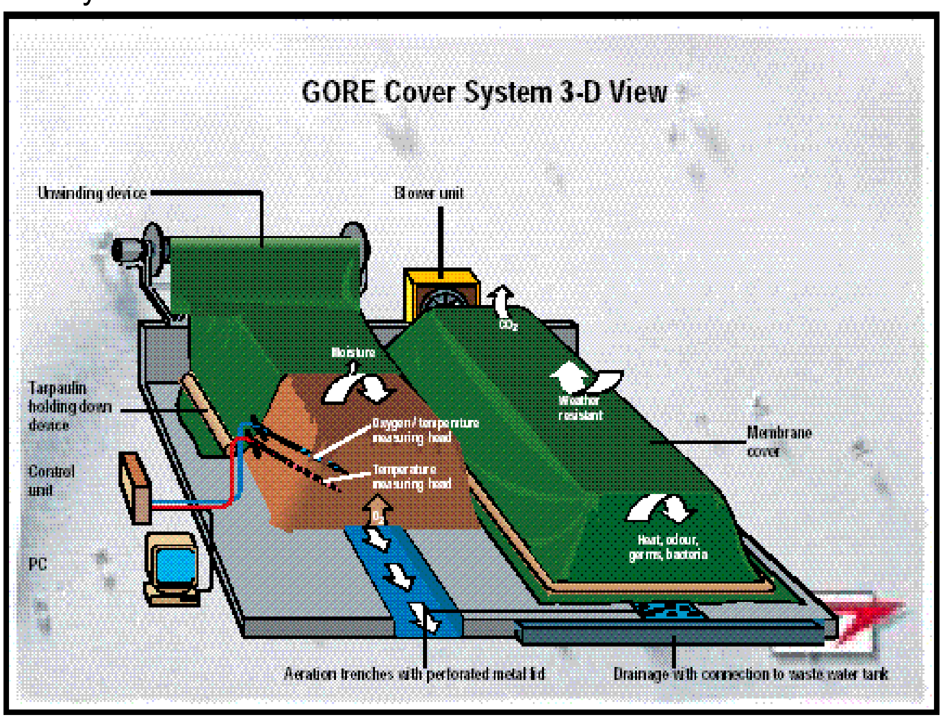


A fine film of condensation develops during the composting process that collects on the inside cover. According to the manufacturer, the moisture helps to dissolve the gases. The condensation then drips back onto the pile, where they can continue to be broken down by the composting process.



The system, according to Gore Cover, shortens the time required to produce finished, premium compost, as follows:

- First zone – four weeks – Material stays on the initial placement zone in-vessel
- Second zone – Two weeks – Material moved to another in-vessel zone with minimized addition of water. Water addition is nominal because the in-vessel system retains the initial moisture within the system and only releases minimal amounts.
- Third zone – Two weeks – the final move is to a third uncovered zone.
- Screening – Material will be screened then ready to sell within 15 days.



The Gore Cover technology is being implemented in over 140 facilities, mainly in Europe and the Mid East. As shown in the odor comparison chart, this technology is capable of reducing anywhere from 90-97% of the odor created. However, not much is known regarding the control efficiencies for VOC and ammonia emissions. Oley Shermeta from Oley Shermeta Environmental has stated that this technology is superior to other in-vessel systems and has control efficiencies greater

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than 80% for both VOC and ammonia. However, there is no data at this point in time to prove those numbers. Mr. Shermeta is in the process of gathering all the information necessary to uphold his claims and will provide them to the district as soon as he is able to gather them. Mr. Shermeta will also include cost data to show the cost effectiveness of this technology.

Until the true data is presented, this technology will also be conservatively assumed to control emissions by at least 10% more than open aerated static piles, with a minimum control efficiency of 33.2% (similar to AgBag). Once the data is available, the District will be able to more accurately determine the control efficiency for this technology.

(g) In-Vessel/Enclosed negatively aerated static piles with exhaust vented to biofilter > 80% control efficiency

An in-vessel system confines the composting material within a building or container and uses forced air and mechanical turning to speed up the composting process. The systems discussed above (AgBag and the Gore Cover) are also considered in-vessel systems. In these types of systems, close to 100% capture efficiency can be achieved. The captured gases can be sent to a control device such as a biofilter.

The contained systems typically allow treatment to be completed in less time than the windrow or aerated pile by providing better control of composting conditions. Rapid treatment time is offset by the high initial cost of the composting reactor.

There are a few co-composting facilities that compost in a fully enclosed building. One of these facilities is located in Rockland County, New York. This facility began operations in February of 1999. However, this facility processes biosolids from five publicly owned treatment works (POTWs) in the county which do not include dairy manure. A brief summary of the facility as discussed below, will be explained to show the intricacies and partial cost of this type of system.

The facility was designed to handle 110 wet tons/day. The facility had to go through a 12-week odor control acceptance test, which included performance testing of ammonia, reduced sulfur compounds, VOCs and hydrogen sulfide. The facility is located approximately 1,000 feet away from a residential development. New York state regulations required that the facility not cause any objectionable odor impacts, however the required removal rates could not be guaranteed with conventional open biofilter systems. Consequently, proposals for proprietary biofilter systems were evaluated where the required performance could be guaranteed. A system was selected supplied by Envirogen with a guaranteed odor removal rate of 94 percent. The Envirogen package cost $1,670,000 and included supply and construction/installation of the exhaust fans, dual pretreatment scrubbers with chemical feed system, enclosed biofilter, and discharge stack. In addition to odor concentration, removal rate guarantees were provided for ammonia, hydrogen sulfide, and methyl mercaptn. Ammonia removal of 99% was achieved. VOC concentrations in the inlet averaged in the 20-ppmv range with peaks exceeding 200 ppmv as propane. Based on the data collected, VOCs were reduced from an average 15 ppmv in the inlet to less than 0.5 ppmv in the outlet, or a removal rate greater than 95 percent.

There are also two in-vessel composting systems that are currently being operated in the South Coast AQMD. Both use control equipment for ammonia, VOCs, and odors as well. However, these operations are currently composting other materials besides manure.

The in-vessel systems, although very efficient in controlling emissions can be extremely costly and may not be a cost effective solution for dairy farms. Currently there is no dairy farm that is utilizing this type of system at their facility.

(h) <u>Manure sent to Digester with Incineration</u>

This type of manure management system can be very efficient in controlling emissions from manure. We already know that very high percentages of odor reductions can be achieved through this type of technology. However, this type of technology is mainly used in conjunction with liquid or slurry type manure. Dry manure sent to a digester may cause certain problems for a particular dairy and may work very well for another. The problems associated with sending the dry manure and the separated solids to a digester are as follows:

1. A digester works properly when most of the manure is in a liquid form (anywhere from 4% to 18% solids). Dry manure, depending on how long it has been sitting or stored may have almost no or a very small amount of moisture content. Therefore, in order to make the system work, water must be added along with the dry manure to the digester in order to have a proper environment for the bacteria to do their job.

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This addition of water may increase the volume of the manure/slurry approximately three times the original amount, resulting in the dairy having to handle more manure/slurry/liquid upon completion of the digestion process. Dairies that have sufficient amount of land can apply the extra slurry/liquid to land. However, it would cause a huge problem for dairies that are not capable of handling the increase in volume of manure/slurry/liquid. For these dairies, it would not be feasible for them to go this route.

   a. It is very important, in order for a dairy to utilize a digester for their dry manure to have run-off water or run-off from their corrals available to minimize the addition of excess fresh water. The mixing of the run-off liquids and dry manure, makes this option more feasible

2. Most dairies that have a liquid manure management system will have some sort of a solids separator (mechanical or a solids settling basin). The reason for the solids separator is to minimize the unwanted solids into the lagoons. The separated solids, currently are either stock piled or applied directly to land. The separated solids consist of fibers, lignin's, cellulose and other fibrous materials that are not digestible in the lagoons or the digesters. Sending these solids into the covered lagoon or digester may also result in a reduction of methane production and an increase in sludge build up on the bottom of the covered lagoon, which over time will reduce the efficiency of the system and require the sludge to be drawn out in the future.
3. Some dairies may not have a liquid manure management system at their facility and may be able to achieve emissions reductions using other control technologies (such as composting).

Digesters, although a good control technology, may not be the best solution as a control technology for all dairies as discussed above. Therefore, this control technology will be listed as an Alternate Basic Equipment (ABE).

Please refer to BACT analysis for digesters for further information.

b) Step 2 - Eliminate Technologically Infeasible Options

All the listed controls are considered feasible for this application.

c) Step 3 - Rank Remaining Control Technologies by Control Effectiveness

Control efficiencies for VOC and Ammonia:

Emission Control Technology Rankings	
Rank	Control Efficiency
1) Send Manure to Digester with Incineration	95%[37]
2) In-Vessel/Enclosed negatively aerated static piles with exhaust vented to biofilter $\geq$ 80% control efficiency	86.6%[38]
3) Open negatively aerated static pile with exhaust Vented to a biofilter $\geq$ 80% control efficiency	84.6%[39]
4) Enclosed Aerated Static Pile	33.2%[40]
5) Open Aerated Static Pile (ASP)	23.2%[41]
6) Open Windrow Composting	0%

d) Step 4 - Cost Effectiveness Analysis

A cost effectiveness analysis must be performed for all control options in the list from step 3 in the order of their ranking to determine the cost effective option with the lowest emissions.

(1) Send Manure to Digester with Incineration:

Please refer to cost analysis in the BACT analysis for Lagoons. As discussed in Section F Step 1, this technologically feasible option will be placed in the Alternate Basic Equipment section of the BACT to allow the

[37] Refer to BACT analysis for Lagoons

[38] According to the SCAQMD Rule 1133.2 final staff report (page 18) "Technology Assessment Report states a well designed, well operated, and well-maintained biofilter is capable of achieving 80% destruction efficiency for VOC and NH3." The overall control efficiency of this technology is equal to the combined control efficiencies of the enclosed aerated system (33.2%) and the biofilter. (80%), calculated as follows: (0.332) + (1-0.332)*0.8 =86.6%

[39] The overall control efficiency of this technology is equal to the combined control efficiencies of the open aerated system (23.2%) and the biofilter. (80%), calculated as follows: (0.232) + (1-0.232)*0.8 =84.6%

[40] There is no control efficiency available at this time for enclosed aerated static piles, however vendors for this technology are claiming a high degree of control. A study is under way by SQAQMD and the Milk Producers Council to determine the control efficiencies for VOCs and ammonia emissions from some enclosed aerated composting systems. Until the study is conducted, this technology will be conservatively assumed to control emissions by at least 10% more than open aerated static piles, with a minimum control efficiency of 33.2%.

[41] Control Efficiency is based on emissions capture efficiency of 25 to 33% from an open ASP multiplied by a conservative 80% control equipment efficiency from the Technology Assessment for Proposed Rule 1133 Table 3-2. The average control efficiency for open aerated static piles based on the Technology Assessment is 23.2%. Additional emission reduction potential from ASP cannot be quantified at this time.

facility the option to send the manure to a digester if it is cost effective or feasible for their operation.

(2) In-vessel/enclosed composting vented to a biofilter, Open Aerated Static Pile (ASP) vented to a biofilter, Enclosed ASP, and Open ASP

A cost effectiveness was evaluated by SCAQMD for a variety of controls for new and existing co-composting facilities based on implementation of several possible scenarios. The cost effectiveness for new co-composting facilities was estimated to be about $24,000 to $27,000 per ton of VOC reduced or $11,000 to $12,000 per ton of VOC and ammonia reduced based on fabric or concrete type of enclosure for the active phase of composting and forced aeration system for the active and curing phases of operations vented to a bio-filter.[42]

For existing co-composting operations, SCAQMD analyzed a few different scenarios. Under one of the scenarios, assuming enclosure without an aeration system for active phase of composting and a forced aeration system for curing phase (both vented to a biofilter) and depending on the type of enclosure, the cost-effectiveness ranged from $11,400 to $15,400 per ton of VOC and ammonia reduced, or $30,000 to $40,000 per ton of VOC reduced. Under another scenario, using enclosure and aeration system for active phase, and aeration system for curing phase, both vented to biofilter, the cost effectiveness ranged from $8,700 to $10,000 per ton of VOC and ammonia reduced or $23,000 to $26,500 per ton of VOC reduced (depending on the type of enclosure). Under another scenario, assuming that forced aeration system (in combination with process controls, optimized feedstock mix ratios, and best management practices) for both active and curing phases (combined with a biofiltration system) could achieve the required reductions (i.e., 70% for VOC and ammonia), the cost-effectiveness could be as low as $6,500 per ton of VOC and ammonia reduced or $17,000 per ton of VOC reduced. However, SCAQMD stated that additional test data would be necessary to validate the efficiency of such control methods.[43]

The VOC and ammonia baseline emission factors, used in determining the cost effective analysis (also included in Rule 1133.2), were developed based on the AQMD source tests conducted in 1995 and 1996 for three windrow co-composting facilities (1.78 pounds of VOC and 2.93 pounds of ammonia per ton of throughput). These emission factors do not

[42] Final Staff report for proposed Rule 1133, 1133.1, and 1133.2)
[43] The cost assumptions used in this analysis (capital and operating cost) are included in the Technology Assessment Report for SCAQMD PR1133 (Attachment A to the Final Staff Report)

accurately represent the baseline emissions of manure storage piles from dairy farms, however it is the best data that is available to the District at this time.

Alternatively, the facility would also have the option to utilize any combination of the composting and control methods to demonstrate an overall control efficiency of 80 percent for VOC and ammonia emissions from active and curing phases.[44]

The Technology assessment for the proposed SCAQMD Rule 1133 also states that there are feasible control options for this industry that are not yet affordable.[45]

Enclosed ASP or in-vessel systems with control equipment, while feasible and effective at significantly reducing emissions, are costly. There may be additional emission reductions associated with ASP systems that have not been quantified in this evaluation. Additional testing of ASP systems, such as the ones discussed in this evaluation would allow the emission reduction potential of all control scenarios to be refined.

e) Step 5 - Select BACT

The following is a summary of the District's BACT determination for the discussed systems.

[44] Also allowed by SCAQMD Rule

[45] Technology assessment for the proposed SCAQMD Rule 1133 also states on page 4

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BACT Summary Table			
Pollutant	**Achieved in Practice**	**Technologically Feasible**	**Alternate Basic Equipment**
VOC		➢ In-Vessel/Enclosed (Building, AgBag, Gore Cover, or equivalent) negatively Aerated Static Piles (ASP) vented to biofilter (or equivalent) ≥ 80% destruction efficiency for both active and curing phases (or a combination of controls) ➢ Open negatively ASP piles (covered with thick layer of bulking agent or equivalent) vented to biofilter (or equivalent) ≥ 80% destruction efficiency for both active and curing phases (or a combination of controls) ➢ Enclosed ASP (AgBag, Gore Cover, or equivalent) with minimum of 23.2 % control efficiency ➢ Open ASP (covered with thick layer of bulking agent or equivalent) with minimum of 23.2 % control efficiency	➢ Send manure to digester capable of 98% Incineration
Ammonia		➢ In-Vessel/Enclosed (Building, AgBag, Gore Cover, or equivalent) negatively Aerated Static Piles (ASP) vented to biofilter (or equivalent) ≥ 80% destruction efficiency for both active and curing phases (or a combination of controls) ➢ Open negatively ASP piles (covered with thick layer of bulking agent or equivalent) vented to biofilter (or equivalent) ≥ 80% destruction efficiency for both active and curing phases (or a combination of controls) ➢ Enclosed ASP (AgBag, Gore Cover, or equivalent) with minimum of 23.2 % control efficiency ➢ Open ASP (covered with thick layer of bulking agent or equivalent) with minimum of 23.2 % control efficiency	➢ Send manure to digester capable of 98% Incineration

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Proposed Pages for the BACT Clearinghouse
San Joaquin Valley Unified
Air Pollution Control District

Best Available Control Technology (BACT) Guideline 5.7.X*

Last Update: April 27, 2004

Emissions Unit: Milking Center

Pollutant	Achieved in Practice or contained in SIP	Technologically Feasible	Alternate Basic Equipment
VOC	Flush/Spray after each batch of milking	Enclose, Capture and Incineration	
Ammonia	Flush/Spray after each batch of milking	Enclose, Capture and Incineration	

BACT is the most stringent control technique for the emissions unit and class of source. Control techniques that are not achieved in practice or contained in a state implementation plan must be cost effective as well as feasible. Economic analysis to demonstrate cost effectiveness is required for all determinations that are not achieved in practice or contained in an EPA approved State Implementation Plan.

***This is a Summary Page for this Class of Source - Permit Specific BACT Determinations on Next Page(s)**

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San Joaquin Valley Unified
Air Pollution Control District

Best Available Control Technology (BACT) Guideline 5.7.X*
Last Update: April 27, 2004

Emissions Unit: Manure storage

Pollutant	Achieved in Practice or contained in SIP	Technologically Feasible	Alternate Basic Equipment
VOC		➢ In-Vessel/Enclosed (Building, AgBag, Gore Cover, or equivalent) negatively Aerated Static Piles (ASP) vented to biofilter (or equivalent) $\geq$ 80% destruction efficiency for both active and curing phases (or a combination of controls) ➢ Open negatively ASP piles (covered with thick layer of bulking agent or equivalent) vented to biofilter (or equivalent) $\geq$ 80% destruction efficiency for both active and curing phases (or a combination of controls) ➢ Enclosed ASP (AgBag, Gore Cover, or equivalent) with minimum of 23.2 % control efficiency ➢ Open ASP (covered with thick layer of bulking agent or equivalent) with minimum of 23.2 % control efficiency	➢ Send manure to digester capable of 95% Incineration
Ammonia		➢ In-Vessel/Enclosed (Building, AgBag, Gore Cover, or equivalent) negatively Aerated Static Piles (ASP) vented to biofilter (or equivalent) $\geq$ 80% destruction efficiency for both active and curing phases (or a combination of controls) ➢ Open negatively ASP piles (covered with thick layer of bulking agent or equivalent) vented to biofilter (or equivalent) $\geq$ 80% destruction efficiency for both active and curing phases (or a combination of controls) ➢ Enclosed ASP (AgBag, Gore Cover, or equivalent) with minimum of 23.2 % control efficiency ➢ Open ASP (covered with thick layer of bulking agent or equivalent) with minimum of 23.2 % control efficiency	➢ Send manure to digester capable of 95% Incineration

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BACT is the most stringent control technique for the emissions unit and class of source. Control techniques that are not achieved in practice or contained in a state implementation plan must be cost effective as well as feasible. Economic analysis to demonstrate cost effectiveness is required for all determinations that are not achieved in practice or contained in an EPA approved State Implementation Plan.

***This is a Summary Page for this Class of Source - Permit Specific BACT Determinations on Next Page(s)**

XI. DAIRY ON-FIELD BACT ANALYSIS

A. Process Description

Dairies typically grow crops such as corn, wheat, barley, and hay to feed their dairy cows. Commonly, these crops are raised on properties contiguous and adjacent to the dairy and are also under the same ownership as the dairy. Thus, emissions generated from the application of liquid and solid manure to the crops and from the on-field farming activities are part of the same stationary agricultural source. In growing these crops significant amounts of Particulate Matter emissions, less than 10 micrometers in size (PM_{10}), and to a lesser extent Volatile Organic Compounds (VOC), Ammonia (NH_3), and Hydrogen Sulfide (H_2S) emissions are emitted from the dairy farming operation. This BACT section will specifically deal with the application of liquid and solid manure to the crops and the on-field farming activities.

Liquid manure is used to irrigate crops on land that is contiguous and adjacent to the dairy and is also under the same ownership. It can either be injected into the soil or left on the surface of the soil and allowed to soak in. Because the liquid manure is high in Nitrogen, Phosphorus, and Potassium (N-P-K), it supplies nutrients to the crops in addition to water. With liquid manure there is usually a nutrient management program used at the facility. This program is used to balance the N applied to the crops with how much N can be used by the crops. By balancing the N needs of the crop with what is supplied helps to minimize ground water nitrate leaching issues. In using the liquid manure on the crops VOC, NH_3, and H_2S are emitted.

Solid manure that is stored or stockpiled is used at the dairy to fertilize crops on land that is contiguous and adjacent to the dairy and is also under the same ownership. It can then either be incorporated into the soil or left on the surface of the soil. Because the solid manure is high in N-P-K, it supplies nutrients to the crops. In using this solid manure on the crops PM_{10}, VOC, NH_3, and H_2S are emitted.

B. Top Down BACT Analysis for the application of liquid manure to crops on land contiguous and adjacent and under common ownership of the dairy

1. BACT analysis for VOC emissions

VOC will be emitted as a result of the application of liquid manure to crops.

a) Step 1 - Identify all control technologies

Through research by District staff the following control technologies for VOC emissions from the application of liquid manure to crops have been identified:

1) Liquid manure injection
2) Irrigation of crops using liquid manure after being processed in an open lagoon settling basin

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b) Step 2 - Eliminate technologically infeasible options

The liquid manure can only be injected during the time when the crop is not fully mature. This is because a tractor must be used to pull a cultivator with the liquid manure shanks. Once the crop is planted and grown to a certain height, it is no longer feasible for the tractor to get into the field due to the potential of damaging the crop. In talking with Ron Prong of Till-Tech Systems, at (519) 775-2575, he states that his company's liquid manure injection system can be used up to four weeks after planting of the crops without causing damage. Therefore, injection of liquid manure can only be required until the crops become so high that damage will occur.

Pictures are of a liquid manure injector from Till-Tech Systems, R.R.#5, 6993 Quaker Road, St. Thomas, ON CANADA N5P 3S9, http://www.tilltech.ca/gallery2.htm

c) Step 3 - Rank remaining options by control effectiveness

VOC Control Effectiveness Ratings		
Effectiveness Rating	Treatment	VOC Reduction Efficiency
1	Liquid manure injection	> 10%[46]
2	Irrigation of crops using liquid manure after being processed in an open lagoon settling basin	ND[47]

The Iowa study was for odor emissions from the land application of liquid manure. From the study it was determined that odors were reduced from 60 to 90% by using direct injection prior to crop planting. Because VOC emissions contribute to odors from the liquid manure, this control technology was assumed to provide a minimum VOC control of 10%[48].

d) Step 4 - Cost effectiveness analysis

Liquid manure injection until the crops become so high that damage would occur has not been determined to be Achieved in Practice. Therefore, per SJVAPCD BACT policy, a cost effectiveness analysis for liquid manure injection will be required for each specific dairy application that the District receives.

No cost effectiveness analysis needs to be done for irrigation of crops using liquid manure after being processed in an open lagoon settling basin because the District has determined this control technology is Achieved in Practice. Therefore, per SJVAPCD BACT policy, the cost effectiveness analysis is not required.

e) Step 5 - Select BACT

Liquid injection of manure can only be required until the crops become so high that damage would occur is considered to be Technologically Feasible BACT for VOC emissions from the land application of liquid manure.

Irrigation of crops using liquid manure after being processed in an open lagoon settling basin is considered to be Achieved in Practice BACT for VOC emissions from the land application of liquid manure.

2. BACT analysis for NH_3 emissions

NH_3 will be emitted as a result of the application of liquid manure to crops.

[46]"Iowa Odor Control Demonstration Project", 1998, pg. 1, http://www.extension.iastate.edu/Publications/PM1754E.pdf .
[47]No control efficiency was determined (ND).
[48]"Emissions From Animal Feeding Operations – Draft", US EPA – Emissions Standards Division, August 15, 2001, pg. 2-13

a) Step 1 - Identify all control technologies

Through research by District staff the following control technologies for NH_3 emissions from the application of liquid manure to crops have been identified:

1) Liquid manure injection
2) Irrigation of crops using liquid manure after being processed in an open lagoon settling basin

b) Step 2 - Eliminate technologically infeasible options

See previous discussion of liquid manure injection for VOC emissions.

c) Step 3 - Rank remaining options by control effectiveness

NH_3 Control Effectiveness Ratings		
Effectiveness Rating	Treatment	VOC Reduction Efficiency
1	Liquid manure injection	87%[49]
2	Irrigation of crops using liquid manure after being processed in an open lagoon settling basin	ND[50]

d) Step 4 - Cost effectiveness analysis

Liquid injection until the crops become so high that damage will occur has not been determined to be Achieved in Practice. Therefore, per SJVAPCD BACT policy, a cost effectiveness analysis for liquid injection will be required for each specific dairy application that the District receives.

No cost effectiveness analysis needs to be done for irrigation of crops using liquid manure after being processed in an open lagoon settling basin because the District has determined this control technology is Achieved in Practice. Therefore, per SJVAPCD BACT policy, the cost effectiveness analysis is not required.

e) Step 5 - Select BACT

Liquid injection of manure can only be required until the crops become so high that damage would occur is considered to be Technologically Feasible BACT for NH_3 emissions from the land application of liquid manure.

Irrigation of crops using liquid manure after being processed in an open lagoon settling basin is considered to be Achieved in Practice BACT for NH_3 emissions from the land application of liquid manure.

[49] Emissions From Animal Feeding Operations – Draft, Table 9-2, pg. 9-4
[50] No control efficiency was determined (ND).

C. Top Down BACT Analysis for the application of solid manure to crops on land contiguous and adjacent and under common ownership of the dairy

1. BACT analysis for VOC emissions

VOC will be emitted as a result of the application of solid manure to crops.

a) Step 1 - Identify all control technologies

Through research by SJVAPCD staff the following control technologies for VOC emissions from the application of solid manure to crops have been identified:

1) Land application of solid manure that has been processed by an in-vessel/enclosed negatively aerated static piles with exhaust vented to biofilter $\geq$ 80% control efficiency prior to land application
2) Land application of solid manure that has been processed by an open negatively aerated static pile with exhaust Vented to a biofilter $\geq$ 80% control efficiency prior to land application
3) Rapid incorporation into the soil after land application of solid manure.
4) Land application of solid manure that has been processed by an enclosed aerated static pile (ASP).
5) Land application of solid manure that has been processed by an open ASP prior to land application

b) Step 2 - Eliminate technologically infeasible options

There are no options that are technologically infeasible.

c) Step 3 - Rank remaining options by control effectiveness

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Table 2: VOC Control Effectiveness Ratings		
Effectiveness Rating	Treatment	VOC Reduction Efficiency
1	Land application of solid manure that has been processed by an in-vessel/enclosed negatively aerated static piles with exhaust vented to biofilter $\geq$ 80% control efficiency	≅ 86%
2	Land application of solid manure that has been processed by an open negatively aerated static pile with exhaust Vented to a biofilter $\geq$ 80% control efficiency	84.6%
3	Rapid incorporation into the soil after land application of solid manure	63 to 73%
4	Land application of solid manure that has been processed by an enclosed aerated static pile (ASP)	33.2%
5	Land application of solid manure that has been processed by an open ASP	23.2%

The control effectiveness for VOC emissions was taken from the previous section for solid manure management.

d) Step 4 - Cost effectiveness analysis

All of the control technologies, except for rapid incorporation, have not been determined to be Achieved in Practice. Therefore, per SJVAPCD BACT policy, a cost effectiveness analysis for all four technologies will be required for each specific dairy application that the District receives.

Rapid incorporation of the manure into soil is something that is easily done by following the manure-spreading pass through the field with a discing pass to cover the manure with soil. The District has determined that this operation is Achieved in Practice. Therefore, per SJVAPCD BACT policy, the cost effectiveness analysis is not required.

e) Step 5 - Select BACT

The following are considered to be Technologically Feasible BACT for NH_3 emissions from the land application of liquid manure.

- Land application of solid manure that has been processed by an in-vessel/enclosed negatively aerated static piles with exhaust vented to biofilter $\geq$ 80% control efficiency
- Land application of solid manure that has been processed by an open negatively aerated static pile with exhaust Vented to a biofilter $\geq$ 80% control efficiency
- Land application of solid manure that has been processed by an enclosed ASP
- Land application of solid manure that has been processed by an open ASP

Achieved in Practice BACT for NH_3 emissions from the application of solid manure to crops is using rapid incorporation of the manure into the soil.

2. BACT analysis for PM_{10} emissions

PM_{10} will be emitted as a result of the application of solid manure to crops.

a) Step 1 - Identify all control technologies

Through research by District staff the following control technologies for PM_{10} emissions from the application of solid manure to crops have been identified:

1) Maintaining a moisture content of > 3% in the solid manure so as to minimize emissions during on-field application.

b) Step 2 - Eliminate technologically infeasible options

There are no options that are technologically infeasible.

c) Step 3 - Rank remaining options by control effectiveness

Maintaining a moisture content of > 3% in the solid manure so as to minimize emissions during on-field application is the only remaining control technology.

d) Step 4 - Cost effectiveness analysis

No cost effectiveness needs to be done because the District has determined the control technology in the ranking list from Step 3 is Achieved in Practice. Therefore, per SJVAPCD BACT policy, the cost effectiveness analysis is not required.

e) Step 5 - Select BACT

BACT for PM_{10} emissions from the application of solid manure to crops is maintaining a moisture content of > 3% in the solid manure so as to minimize emissions.

D. Top Down BACT Analysis for on-field activities for crops on land contiguous and adjacent and under common ownership of the dairy

1. BACT analysis for PM_{10} emissions

PM_{10} will be emitted as a result of on-field crop activities.

a) Step 1 - Identify all control technologies

Through research by SJVAPCD staff the following control technologies for PM_{10} emissions from on-field crop activities have been identified:

1) Minimizing the number of passes through the field,

2) Practicing conservation tillage practices,
3) Restricting on-field activities during high wind events (> 20 mph),
4) Surface roughening of fallow fields, and
5) Track-out prevention.

b) Step 2 - Eliminate technologically infeasible options

There are no options that are technologically infeasible.

c) Step 3 - Rank remaining options by control effectiveness

All five of the control technologies control PM_{10} emissions from on-field crop activities. These technologies all control different aspects of PM_{10} emissions from on-field activities. Each activity is a unique control, thus they do not need to be ranked. Instead they will all be considered the best available control technology for each specific activity.

d) Step 4 - Cost effectiveness analysis

No cost effectiveness analysis needs to be done because the District has determined all five of the control technologies in the ranking list from Step 3 are Achieved in Practice. Therefore, per SJVAPCD BACT policy, the cost effectiveness analysis is not required.

e) Step 5 - Select BACT

BACT for PM_{10} emissions from on-field crop activities is minimizing the number of passes through the field, practicing conservation tillage practices, restricting on-field activities during high wind events, surface roughening of fallow fields, and track-out prevention.

San Joaquin Valley
Unified Air Pollution Control District

Best Available Control Technology (BACT) Guideline 5.7.X*

Last Update: April 27, 2004

Emissions Unit: Manure Application and On-field Activities on Contiguous and Adjacent Croplands at Dairies with VOC emissions > 12.5 tons/yr

Pollutant	Achieved in Practice or contained in SIP	Technologically Feasible	Alternate Basic Equipment
NO_x	N/A	N/A	
VOC	**Liquid Manure Handling:** 1. Irrigation of crops using liquid manure after being processed in an open lagoon settling basin prior to land application **Solid Manure Handling:** 1. Rapid incorporation of the manure into the soil after land application	**Liquid Manure Handling:** 1. Liquid injection of manure until the crops become so high that damage would occur **Solid Manure Handling:** 1. Land application of solid manure that has been processed by an in-vessel/enclosed negatively aerated static piles with exhaust vented to biofilter ≥ 80% control efficiency 2. Land application of solid manure that has been processed by an open negatively aerated static pile with exhaust Vented to a biofilter ≥ 80% control efficiency 3. Land application of solid manure that has been processed by an enclosed ASP 4. Land application of solid manure that has been processed by an open ASP	
NH_3	**Liquid Manure Handling:** 1. Irrigation of crops using liquid manure after being processed in an open lagoon settling basin prior to land application	**Liquid Manure Handling:** 1. Liquid injection of manure until the crops become so high that damage would occur	
PM_{10}*	**Solid Manure Handling:** 1. Maintain a moisture content of > 3% in the solid manure so as to minimize emissions **On-field Crop(s) Activities:** 1. Minimize passes 2. Practice conservation tillage 3. Restrict field activity during high wind events (>20 mph) 4. Surface roughening of fallow fields 5. Track-out prevention	N/A	
SO_x	N/A	N/A	
CO	N/A	N/A	

BACT is the most stringent control technique for the emissions unit and class of source. Control techniques that are not achieved in practice or contained in a state implementation plan must be cost effective as well as feasible. Economic analysis to demonstrate cost effectiveness is required for all determinations that are not achieved in practice or contained in an EPA approved State Implementation Plan.

This is a Summary Page for this Class of Source - Permit Specific BACT Determinations on Next Page(s)

APPENDIX A: APR 1305

San Joaquin Valley
Unified Air Pollution Control District

BEST AVAILABLE CONTROL TECHNOLOGY (BACT) POLICY

Approved By: ***Signed*** Seyed Sadredin, Director of Permit Services	**Date Revised:** **November 9, 1999**

I. Purpose

The purpose of this policy is to ensure that Best Available Control Technology (BACT) Determinations are made in a timely and uniform manner and in accordance with the BACT definition in District Rule 2201 - New and Modified Stationary Source Review (NSR).

II. Applicability

This policy applies to all emissions units that are subject to BACT requirements under the District's NSR Rule.

III. Definitions

A. **Alternate Basic Equipment or Process:** Equivalent basic equipment or process emitting less air pollutants than the basic equipment or process proposed by the applicant. This provision applies only to applications for new equipment.

B. **Best Available Control Technology (BACT)**: is the most stringent limitation or control technique of the following:

1. Has been achieved in practice for such emissions unit and class of source; or

2. Is contained in any State Implementation Plan (SIP) approved by the Environmental Protection Agency (EPA) for such emissions unit category and class of source. (A specific limitation or control technique shall not apply if the owner or operator of the proposed emissions unit demonstrates to the satisfaction of the APCO that such limitation or control technique is not presently achievable); or

3. Is any other emission limitation or control technique, including alternative basic equipment or process or changes of control equipment, found by the APCO to be technologically feasible for such class or category of sources or for a specific source, and cost effective as determined by the APCO.

C. **Cost Effective Control**: a control alternative, including alternate basic equipment or process, for which a cost effectiveness analysis, performed in accordance with Section X of this policy, reveals that the annual cost per ton of controlling each affected air pollutant is less than the Cost Effective Threshold(s) specified below or the Multi-Pollutant Cost Effectiveness Threshold calculated according to Section X:

Pollutant	Cost Effective Threshold ($/ton)
VOC	5,000
NOx	9,700
PM10	5,700
SOx	3,900
CO	300

D. **Small emitter**: A small emitter is any stationary source with annual, post-project potential emissions less than 2 tons per year of each affected pollutant or maximum daily emissions below the following levels:

Pollutant	Maximum Daily Emissions (lb /day)
VOCs	30
NOx (as NO2)	40
PM_{10}	30
SOx (as SO2)	30
CO	220

A facility with an annual, post-project potential to emit which exceeds both the daily and the annual limits for at least one of the criteria pollutants is not a small emitter.

IV. BACT Determination Cutoff Date

For emission sources that apply for Authority to Construct, as required by Rule 2010, prior to installation or alteration of an emissions unit, BACT Determinations are to be based upon the control technologies and methods for the same or similar source categories, listed in the District's BACT Clearinghouse for the calendar quarter during which the application is deemed complete.

If the proposed emission source is not covered in the District's BACT Clearinghouse as of the date the application is deemed complete, then all other control technologies or methods available as of the date the application is deemed complete must be considered in determining BACT for the project.

In any case, for projects subject to the administrative requirements of District Rule 2201, if written public comments subsequent to the District's preliminary decision identify other control technologies or methods, such technologies or methods must be considered in determining BACT prior to taking final action on the application.

V. District's BACT Clearinghouse

To assist applicants in selecting appropriate control technology for new and modified sources, and to assist the District staff in conducting the necessary BACT analysis, the District will actively update and maintain a BACT Clearinghouse. An updated BACT Clearinghouse will be published at the beginning of each calendar quarter. Upon publication, the BACT Clearinghouse, to the extent provided by this policy, will be used for determining BACT requirements for applications deemed complete during the succeeding calendar quarter.

The District's BACT Clearinghouse, for various class and categories of sources, will include available control technologies and methods that meet one or more of the following conditions:

A. Have been achieved in practice for such emissions unit and class of source; or

B. Are contained in any SIP approved by the EPA for such emissions unit category and class of source; or

C. Are any other emission limitation or control technique, including process and equipment changes of basic or control equipment, found to be technologically feasible for such class or category of sources or for a specific source.

The approval of the Director of Permit Services must be obtained prior to incorporation of new BACT requirements in permits issued by the District. Additionally, the BACT Clearinghouse must be updated for each new Determination in accordance with the procedures outlined in this policy. New Determinations include those made for a class or category of source not covered in the District BACT Clearinghouse and new Determinations made for control equipment or techniques not listed the District BACT Clearinghouse for a particular class or category of source.

VI. Updates to the District's BACT Clearinghouse

A. New and Revised BACT Determinations

The District will take a proactive approach to update the BACT Clearinghouse. Updates to the BACT Clearinghouse may occur when evaluating applications for new and modified sources, or when the District is made aware of and documents any of the following:

1. A new control technology or method is deemed as achieved in practice for a class or category of sources.

2. A new control technology or method is required as a part of any SIP approved by the EPA for a class or category of sources.

3. A new control technology or method is found to be technologically feasible for a class or category of sources.

B. Procedures for Updating the BACT Clearinghouse

Updates to the District's BACT Clearinghouse shall be made in accordance with the following procedures:

1. New or revised BACT proposals may be made by the District staff, the applicants, or the public. New or revised control technology or methods are incorporated in the District's BACT Clearinghouse as the District staff review applications for new and modified sources, or as they become aware of new or revised control technologies or methods that are technologically feasible, achieved in practice, or incorporated in an EPA approved SIP. In order to update the District's BACT Clearinghouse, the following information must be documented:

    a. Name and location of the source utilizing the control technology. Include the type of business and the size of the source. When necessary, information on the size of source should include data on the emissions unit as well as the stationary source.

    b. Manufacturer and type of pollution control device.

c. Performance requirements specified under applicable permits issued by this district or any other permitting agency, or contained in an EPA approved SIP. Include the date of BACT Determination or the effective date of the new standard.

d. Available test or performance data.

e. For addition of a technologically feasible control measure, appropriate technical and engineering data to substantiate technological feasibility for the affected class and category of sources.

2. After review by the Regional Permit Services Manager, the above documentation must be forwarded to the Director of Permit Services. The District's BACT Clearinghouse update forms and the CAPCOA BACT reporting forms should also be included with the new or revised Determinations.

3. Additional and revised Determinations will only be approved if they comply with the definition of BACT in District Rule 2201.

4. Upon approval by the Permit Services Director, additional and revised Determinations will be reported to each of the District's regional offices, and incorporated into future updates to the BACT Clearinghouse. The CAPCOA BACT reporting form for the approved Determination will be forwarded to the Project Assessment Branch of ARB.

VII. Determination of Achieved-in-Practice

In order for a control technology to be deemed as having been achieved in practice, the following conditions must be met:

A. The rating and capacity for the unit where the control was achieved must be approximately the same as that for the proposed unit.

B. The type of business (i.e. class of source) where the emissions units are utilized must be the same.

C. The availability of resources (i.e. fuel, water) necessary for the control technology must be approximately the same.

Under the above circumstances, a control technology can be deemed as having been achieved in practice, and can be required as BACT without having to make a cost effectiveness determination.

VIII. BACT Analysis During the Preliminary Review of Applications

The primary purpose of the Preliminary Review of an application is to determine its completeness within the 30-day statutory deadline. To deem the application complete, in addition to the other necessary information, it must contain the necessary data to conduct a top-down BACT analysis, and to ensure compliance with the BACT requirements.

Ordinarily, a detailed BACT analysis will be performed as a part of the Application Review after the application is deemed complete. However, in cases where without a detailed BACT analysis, it is obvious that the proposal does not comply with the BACT requirements, the applicant must be notified of the BACT deficiencies in the form of an application incompleteness letter.

IX. Top-Down BACT Analysis

A top-down BACT analysis shall be performed as a part of the Application Review for each application subject to the BACT requirements pursuant to the District's NSR Rule. This analysis shall be included in the Control Equipment Evaluation section of the Application Review. The following steps shall be documented in a top-down analysis: (For source categories or classes covered in the BACT Clearinghouse, relevant information under each of the following steps may be simply cited from the Clearinghouse without further analysis.)

A. Step 1 - Identify All Control Technologies

The first step in a top-down analysis is to identify, for the emissions unit in question, all available control options. Available control options are those air pollution control technologies or techniques, including alternate basic equipment or process with a practical potential for application to the emissions unit in question. The control alternatives should include not only existing controls for the source category in question, but also through technology transfer, controls applied to similar source categories and gas streams.

For classes and categories covered in the District's BACT Clearinghouse, the list of available control technologies shall be limited to those listed in the Clearinghouse as of the date the application is deemed complete, except when allowed pursuant to Section IV of this policy.

B. Step 2 - Eliminate Technologically Infeasible Options

In the second step, the technological feasibility of the control options identified in Step 1 is evaluated with respect to the source- specific or emissions unit- specific factors. To exclude a control option, a demonstration of technical infeasibility must be clearly documented and should show, based on physical, chemical, and engineering principles, the technical difficulties would preclude the successful use of the control option for the emissions unit under review.

For classes or categories of sources covered in the District's BACT Clearinghouse, all controls listed as technologically feasible must be considered in the final BACT selection and must not be eliminated in this step.

C. Step 3 - Rank Remaining Control Technologies by Control Effectiveness

In Step 3, all remaining control alternatives not eliminated in Step 2 must be ranked and then listed in order of overall control effectiveness for the pollutant under review, with the most effective control alternative at the top. A separate list should be prepared for each pollutant and for each emissions unit subject to the BACT requirement. The list should present the array of control alternatives and should indicate the effectiveness of each alternative. The list should also indicate if the alternative has been achieved in practice for the class and category of source in question.

D. Step 4 - Cost Effectiveness Analysis

After the identification of available and technologically feasible control options, economic impacts are considered to arrive at the final level of control. After performing a cost effectiveness analysis, in accordance with the procedures outlined in Section X of this policy, control options that are not cost effective, except for controls that are achieved in practice or are required by an EPA approved SIP, shall be eliminated from consideration.

Cost effectiveness analysis is not required under the following circumstances:

1. The applicant is proposing the most effective alternative in the ranking list from Step 3.

2. The most effective alternative in the ranking list from Step 3 has been achieved in practice or is required pursuant to an EPA approved SIP for the class and category of source in question.

3. Cost effectiveness analysis is not required for control alternatives which are deemed achieved-in-practice, except for achieved-in-practice alternate basic equipment or process. (A cost effectiveness analysis must always be conducted before requiring alternate basic equipment or process.)

4. Except for alternate basic equipment or process, a new cost effectiveness analysis is not required if cost effective analysis for the specific piece of equipment or operation was conducted by the District within 12 months preceding the date an application is received. A copy of the old cost effectiveness analysis shall be attached to the Application Review, and its applicability must be documented in the Application Review.

E. Step 5 - Select BACT

The most effective control option not eliminated in Step 4 is select as BACT for the pollutant and emissions unit under consideration, except for the following:

1. Unless proposed by the applicant, technologically feasible and cost effective control that is more effective than the achieved-in-practice option shall not be required for a small emitter. A small emitter shall be required to use the most effective control technology or equipment that has been achieved-in-practice, including achieved-in-practice alternate basic equipment and process for new equipment.

2. Alternate basic equipment or process shall not be required for modifications to, or transfer of location of existing equipment with valid District Permit to Operate.

3. Alternate basic equipment or process shall not be required if its use results in an increase in emissions within the District.

4. The applicant may propose to use any control technology other than the control technology required by the District if he/she can demonstrate that the proposed control technology can reduce air pollutant(s) as effectively, or more effectively than the required control technology.

X. Procedures for Conducting Cost effectiveness Analysis

A. Technologically Feasible Alternatives

1. Calculate an equivalent annual cost from a capital cost using a capital recovery factor as shown below:

$$A = P \frac{i(1+i)^n}{(1+i)^n - 1} \qquad \text{where;}$$

A = Equivalent Annual Control Equipment Capital Cost

P = Present value of the control equipment, including installation cost

i = interest rate (use 10%, or demonstrate why alternate is more representative of the specific operation).

n = equipment life (assume 10 years or demonstrate why alternate is more representative of the specific operation)

2. Determine annual operating cost (labor, fuel, maintenance, utilities, etc.).

3. Calculate the total annual cost by summing the equivalent annual control equipment cost and the annual operating cost (Steps 1 and 2 above).

4. If BACT controls only one type of air pollutant, calculate the control cost per ton of air pollutant reduced by dividing the total annual cost (Step 3) by the annual emission reduction for the air pollutant. If the control cost per ton exceeds the cost effectiveness threshold, the BACT control option is not required.

   Example: If a control strategy reduces 2 tons of NO_x compared to the industry standard, at an increased total annual cost of $16,900, the control cost effectiveness would be calculated as follows:

   Control Cost = ($16,900/year) / (2 tons NOx/yr)
   = $8,450/ton

   Since the calculated annual control cost is below the NOx Cost Effectiveness Threshold of $9,700/year, the control technology or equipment under review is required as BACT.

5. If a BACT option controls more than one type of air pollutants, calculate a Multi-Pollutant Cost Effectiveness Threshold (MCET) for the control option using the process shown below.

   Example: If a control strategy reduces 2 tons of NO_x, 4 tons of SO_x, and 0.1 ton of particulate matter, the MCET would be calculated as follows:

$$
\begin{aligned}
\text{MCET} &= (2 \text{ tons NOx/yr}) * (\$9700/\text{ton NOx}) + \\
&\quad (4 \text{ tons SOx/yr}) * (\$3900/\text{ton SOx}) + \\
&\quad (0.1 \text{ ton PM/yr}) * (\$5700/\text{ton PM}) \\
&= \$35{,}570 \text{ per year}
\end{aligned}
$$

   If the total annual cost, (Step 3) exceeds this MCET, the control technology or equipment under review can not be required as BACT.

6. When multiple control strategies are available, each BACT scenario shall be evaluated as a package instead of evaluating the individual components on an incremental basis.

7. If the a control technology or equipment is not cost effective, perform the cost effectiveness analysis for the next less stringent control technology or equipment as appropriate.

B. Alternate Basic Equipment or Process:

1. Calculate the cost effectiveness of alternate basic equipment or process using the following formula:

$$CE_{alt} = (COST_{alt} - COST_{basic}) / (EMISSION_{basic} - EMISSION_{alt})$$

   where,

   CE_{alt} = the cost effectiveness of alternate basic equipment expressed as dollars per ton of emissions reduced

   $COST_{alt}$ = the equivalent annual capital cost of the alternate basic equipment plus its annual operating cost

   $COST_{basic}$ = the equivalent annual capital cost of the proposed basic equipment, without BACT, plus its annual operating cost

$EMISSION_{basic}$	=	the emissions from the proposed basic equipment, without BACT.
$EMISSION_{alt}$	=	the emissions from the alternate basic equipment

XI. Enhanced Procedures to the BACT Policy

As authorized and directed by the Governing Board on August 19, 1999, the District implemented the following measures aimed at enhancing public participation and involvement in the BACT Determination process:

1. The District will hold public workshops prior to finalizing BACT Determinations that will have a potential impact on a large category for which the new Determination may represent a significant change in technology,

2. The District will develop and maintain an electronic BACT Information Exchange Center. The Center will

   a. Offer a forum for interested parties to share pertinent information on various air pollution control technologies, including feedback on operator's experience with the control technology and other related information;
   b. Provide information on new control technologies which are being proposed by facilities within the District, are under development by manufacturers, or have bee approved as BACT by other agencies;
   c. Make available comments received from oversight agencies on District projects involving BACT Determinations; and
   d. Inform the public of pending new and revised BACT Determinations.

3. The District will provide a quarterly report to the Governing Board summarizing new and revised BACT Determinations for the preceding quarter.