Dairy Permitting Advisory Group

Recommendations to the San Joaquin Valley Air Pollution Control Officer Regarding Best Available Control Technology for Dairies in the San Joaquin Valley

Draft Report – December 13~~8~~, 2005

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I. INTRODUCTION

This report is a compilation of issues and factors that the Dairy Permitting Advisory Group (DPAG) recommends the San Joaquin Valley Air Pollution Control District consider as the District proceeds with determining the best available air pollution control technology (BACT) for future new and modifying dairy permitting applications.

DPAG attempted to identify every potential air pollution reduction technique currently available to dairies. In identifying potential controls, we did not limit ourselves to "engineered" mechanical equipment, but attempted to look at all possible mechanisms for reducing emissions from dairies. For example, we reviewed the potential of altering the diets of lactating cows and we examined the potential impacts of increasing the frequency of common manure management techniques, like feed lane flushing, in addition to looking at mechanical systems like biogas digesters and enclosed housing vented to air pollution control devices.

Each potential control analyzed is listed in the following pages, grouped by each of the following areas, or "permit units", at a dairy: cow housing and milking parlor; solid manure handling; liquid manure handling; feed and nutrition; and land application.

After identifying the potential controls, we then attempted to gather the available information to determine whether, and to what extent, the technique could be expected to control dairy emissions. Finally, based on the information gathered, we identified the issues and factors that we recommend that the District consider in making BACT determinations relative to the listed potential control technique.

It is important to note that this report is not a recommendation on a specific level of air pollution control that should be required as BACT for all future new and modifying dairies in the San Joaquin Valley. There are several reasons for this:

1. BACT is not stagnant. BACT is determined on a case-by-case basis, for each permit application, and must be determined at the time the application is received. The best available controls determined for an application today will almost certainly not be the same as an application received ten years from now, because of the evolution of air pollution controls, and of our understanding of emissions from dairies and the best ways to control them.

2. BACT is not universal. BACT is determined on a case-by-case basis, for each permit application, and is based on the specifics of each application. For example, a BACT determination for a flush dairy is likely to differ from BACT for a dairy that proposes to operate vacuum trucks to remove manure from feed lanes, which in turn is quite likely to be different from

BACT determined for a dry-lot dairy. In addition, varying sizes of dairies can have an impact on BACT – for instance a BACT determination for a 10,000-cow dairy may be quite different from that for a 1,500-head dairy. Finally, consideration of a proposed dairy's manure management practices and techniques will likely influence the level of control required by BACT in complex and varying ways that are recognized as being beyond the scope of this group's review.

3. Time allowed by the settlement agreement, and the resources available. According to the legal settlement that established DPAG, we must complete and submit our recommendations to the District's executive officer before the end of 2005. While we believe we have used the available time wisely, much remains to be done before conclusions can be reached about many of the air pollution control techniques examined. For instance, in many cases DPAG has recommended that the District attempt to gather more information about a given technology, or perform testing or other research that will provide additional certainty about a technology's ability to control emissions. DPAG believes that this process of gathering additional information, and incorporating that information into the BACT process, will be an ongoing effort that the District must be vigilant in pursuing for many years to come.

DPAG held four public meetings in the last half of 2005 to discuss this BACT report, and to gather comments from the public. We set up five work groups – one for each of the sections of this report that follow. These work groups invested a tremendous amount of time into this process, identifying resources, researching potential air pollution controls, drafting the individual sections of this report, and addressing and incorporating comments received.

We would like to thank those that we turned to for assistance in this project, and those that offered comments, guidance, and suggestions throughout the process. This report is more complete because of your participation.

II. NEXT STEPS

The District has committed to considering DPAG's BACT recommendations in future BACT determinations for new and modifying dairies. While the District has repeatedly stated that individual final BACT determinations must be made on a case-by-case basis, the District has also committed to compiling a BACT guidance document for dairies, and then updating this guidance as additional information becomes available. This document can then be used by future dairy proponents, and other interested parties, to understand the types of controls that will be a part of the District's application-specific BACT analyses in the future.

The District is expected to complete their review of DPAG's work, and incorporate it into a BACT guidance document, by the end of February 2006.

The District is required by the settlement agreement to hold at least one public workshop to discuss the document with interested parties and receive comments, before finalizing it. The District has reported that this guidance document will then continue to evolve to incorporate new knowledge of dairy control technologies and emissions.

III. BACKGROUND

A. What is DPAG?

The Dairy Permitting Advisory Group is comprised of Air District staff, dairy industry representatives, academics, environmentalists, and other parties interested in dairy air emissions, and was set up to provide recommendations to the District's executive officer in three areas:

1. VOC emission factors for dairies.
2. "Modifications" at existing dairies.
3. Best Available Control Technology (BACT) for dairies.

This BACT project is the final task for the group to complete, and must be finalized by the end of 2005, according to the settlement agreement that established the group.

B. What is BACT?

BACT, or Best Available Control Technology, is, generally speaking, the most effective way to reduce emissions that is either achieved in practice for a given emitting process, or is technologically feasible and cost-effective to apply to that process (even if the technically feasible control has never actually been used anywhere). BACT is required for any equipment or process that proposes to increase emissions by more than 2 lb/day in the San Joaquin Valley, as defined in District Rule 2201 (http://www.valleyair.org/rules/currntrules/r2201.pdf), and is based on both the federal and state Clean Air Acts.

It's important to reiterate that only new or modifying equipment or processes are subject to BACT. This report is not intended to provide guidance on the air pollution controls that can or should be applied to existing dairies, other than those that are modifying in a way that triggers BACT.

The District's methods for determining BACT are further described in District policy (http://www.valleyair.org/policies_per/Policies/APR%201305.pdf).

IV. GENERAL RECOMMENDATIONS

DPAG's recommendations to the District regarding specific control technologies are detailed in the following pages, but we also wanted to take this opportunity to provide some more general recommendations that we believe should also be incorporated into all of the District's future dairy BACT-related activities:

1. We believe that it is vital that the District encourage research into, and development of, innovative and cost-effective dairy controls. To that end we recommend that the District continue to actively promote and fund research into these areas, and financially incentivize innovative air pollution controls that achieve reductions in actual emissions from existing dairies by allowing ~~them~~ them access to District emissions reduction grant programs.

2. We recommend that the District quickly incorporate new and updated information, as it becomes available, in revisiting and revising its BACT guidance for dairies on an ongoing basis, and at least once per year in a formal public process. We expect research into the areas of dairy emissions and control technologies to proceed at a rapid pace. For instance two major California dairy emissions studies are expected to be completed in early 2006. In addition, another study on dairy emissions controls, called the San Joaquin Valley Manure Management Technology Feasibility Study, headed up by the federal EPA and the state ARB, is expected to become available before the end of this 2005. Such research and information may have a dramatic effect on BACT determinations, and so should be watched and incorporated quickly into District processes.

3. ~~We~~ Some DPAG members are concerned that, once a dairy has installed a new air pollution control technology, the District will require that technology on all subsequent dairies. We recommend that the District provide the flexibility to future dairy proponents to use other technologies or process changes that are equally effective at reducing pollution, rather than requiring a specific technology. We believe this to be a vital component to efforts to develop alternative and cost-effective methods to reduce emissions.

4. The following pages contain recommendations that are specific to various potential control techniques, but very little analysis of the affects those individual techniques may have on other parts of the dairy, or on the dairy as a whole. We recommend that future District analyzes include a look at the impacts on the whole dairy, including but not limited to the following considerations:
    a. Do reductions in one area cause increases in another area?
    b. Does a given control provide emission reductions in more than one area of the dairy?

c. How do whole-dairy approaches (such as feed management) reduce overall emissions?

V. MILKING CENTER (PARLOR)

A. Description

Lactating cows require milking at least twice per day but can be milked several times a day. Milking centers, also referred to as milk 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. 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 occur from the enteric emissions from the cows and when the cows defecate and urinate.

B. Control Technologies/Practices for the Milking Center

1. Flush/Wash Down after each milking

1.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC: 90%
NH_3: 90%

1.2 Where technology comes from

This practice is currently used at existing dairies.

1.3 Description of "technology"

This practice involves the flushing or washing down of manure after each milking. This allows the manure to be channeled to a place where it can be stored or treated.

1.4 Control Efficiency

Since the manure from the milk parlor is continuously being flushed away to a storage or treatment system, significant emission reductions would be achieved. Assuming fresh excreted manure has negligible emissions due to the lack of decomposition or anaerobic conditions, control efficiency could be as high as 100%. However, a conservative control efficiency of 90% will be applied. This control efficiency does not apply to the enteric emissions generated from the cows themselves.

1.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- High control efficiency.
- Additionally benefits sanitation of the milking center.

b) Cons

None

1.6 Cost

The associated costs will be considered as acceptable-.

1.7 Feasibility at dairies

This technology/practice is currently used on all dairies and is therefore, feasible.

1.8 Missing Data

Additional information is needed to assess control effectiveness.

1.9 Further Resources

California Dairies

1.10 Recommendation

Achieved in Practice, BACT

2. Milk Parlor – vented to incinerator with 98% control

2.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC & NH_3

2.2 Where technology comes from

Technology transfer from other industry - This technology has been evaluated for other operations (painting, coating, printing operations, etc) by the District to control emissions.

2.3 Description of "technology"

This technology consists of the milk barn being fully enclosed and the biogas vented to some sort of incineration device.

2.4 Control Efficiency

Control Efficiency for VOC incineration devices have been proven to be greater than 98% for other operations, as provided in 21.2.

2.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- High control efficiency
- Potential for large emission reductions

b) Cons

- Expected to consume large amounts of energy
- Untested at the scale necessary for a dairy
- Natural gas supplies may not be available on site
- Animal health and welfare may be compromised

2.6 Cost

Expectations are that the associated costs will be large because of high-energy requirements.

2.7 Feasibility at dairies

Due to the high-energy costs alone, this technology may not be cost effective on dairies.

2.8 Missing Data

Additional information is needed to assess control effectiveness and the feasibility of this technology on dairies.

2.9 Further Resources

Technology transfer from other industries.

2.10 Recommendation

Based on the amount of natural gas required as a supplemental fuel for the incineration of VOCs in a large volume of air inside the barn, this technology could outweigh the benefit from the incineration of VOCs. The costs for the supplemental fuel, including the design and incineration system are believed to be very costly. Although technologically feasible, the District should perform a generic cost-effectiveness analysis to establish that it is not reasonable to consider in future dairy proposals.

3. Milk Parlor Enclosure – Vented to a Biofilter with 80% Control

3.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC & NH_3

3.2 Where technology comes from

Bioreactors have been used for centuries to treat sewage and other malodorous, water-borne waste. About sixty years ago, bioreactors began to be used in Europe to treat contaminated air. Bioreactors are extensively used to treat air at wastewater treatment plants, rendering plants, and composting operations. They are also used to control emissions from landfills, solid waste processing plants, and soil remediation operations. Today there are more than 500 biofilters in Germany and in the Netherlands. In agriculture, biofiltration is widely used to control emissions from enclosed swine facilities and have been reported to be used in dairy situations from enclosed, mechanically ventilated housing and manure storage areas.

3.3 Description of "technology"

This technology consists of the milk barn being fully enclosed and the biogas vented to a biofilter.

3.4 Control Efficiency

Control Efficiency for Biofilters have been proven to be higher than 80%. Therefore the control efficiency for this technology will be 80%. Refer to section ~~2.5~~ VI.B.2 for further discussion.

3.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- High control efficiency
- Potential for large emission reductions

b) Cons

- Expected to consume large amounts of energy
- Untested at the scale necessary for a dairy
- Natural gas supplies may not be available on site
- Animal health and welfare may be compromised

3.6 Cost

Expectations are that the associated costs will be large because of high-energy requirements.

3.7 Feasibility at dairies

This technology is feasible at dairies. However, a detailed cost effectiveness analysis of such a system needs to be performed prior to its application.

3.8 Missing Data

Additional information is needed to assess control effectiveness and the feasibility of this technology on dairies.

3.9 Further Resources

Refer to Section B.2.2 for references.

3.10 Recommendation

Although technologically feasible, the District should perform a generic cost-effectiveness analysis to establish that it is not reasonable to consider in future dairy proposals.

VI. COW HOUSING

A. Description

There are a variety of types of housing at a dairy as described below: This BACT guideline will evaluate controls to attain an overall reduction in emissions including individual controls for the various types of housing.

i Dry Lots

Drylots, also referred to as open lots or corrals are used for confining lactating cows, dry cows, heifers, and calves being raised as replacements. Manure is generally removed from the open lot by means of 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. However, many dairies also use a flush manure management to remove the manure from these areas, especially for their milk cows.

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 cattle.

ii Freestall Barns

In the freestall barn, cows are grouped in large pens under a roof with free access to feed bunks, waterers, and stalls for resting. A standard free-stall barn design has a feed alley in the center of the barn separating two feed bunks on each side. A variety of types of bedding materials are used for animal comfort and to prevent animal injury.

Dairy cattle manure accumulations in freestall barns are typically collected and removed by a flush system. However, mechanized scraping systems and vacuum type manure management systems are also used. The three types of methods are described below:

1. 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.

2. 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. Scrapers reduce daily labor requirements, but have a higher maintenance cost due to corrosion and deterioration.

3. 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 or can be directly applied or injected to land. 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.


Vacuum Truck Collecting Manure Solids

iii Special Needs Housing

The special needs area serves the gestating cows at the dairy or any cow that may have a medical condition. This area acts as a veterinary area and gives the cows special attention as they move from dry cow[1] to maternity to milking status or until their health improves.

iv Calf Housing

This dairy has a separate housing for the calves. The calves are housed individually until they are ready to wean[2].

B. Control Technologies/Practices for Cow Housing

1. Freestall/housing Enclosure – Vented to Incinerator

1.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC: 98% control reported by District for other industries
NH_3: ?

1.2 Where Technology Comes From

Technology transfer from other industries - This technology has been evaluated for other operations (painting, coating, printing operations, etc) by the District to control emissions.

[1] A mature cow that is gestating and not lactating.
[2] To accustom to take nourishment other than by suckling.

1.3 Description of Technology or Practice

This technology consists of the freestalls being fully enclosed and biogas vented to some sort of incineration device.

1.4 Control Efficiency

Control Efficiency for VOC incineration devices have been proven to be greater than 98% for other operations, as identified in 1.2.

1.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- High control efficiency
- Potential for large emission reductions

b) Cons

- Expected to consume large amounts of energy both to keep cows cool and to incinerate the large volumes of air flow required.
- Untested at the scale necessary for a dairy.
- Natural gas supplies may not be available at the dairy site.
- May make manure handling more difficult
- Animal health and welfare may be compromised

1.6 Cost

Expectations are that the associated costs will be large because of high-energy requirements.

1.7 Feasibility at Dairies

Due to the high-energy costs alone, this technology may not be cost effective at dairies.

1.8 Missing Data

This type of control system has never been tested on a California dairy. Such a test in a field situation will be necessary before consideration is possible.

1.9 Further Resources

None

1.10 Recommendation

Based on the amount of natural gas required as a supplemental fuel for the incineration of VOCs in a large volume of air inside the barn, this technology could easily outweigh the benefit from the incineration of VOCs. The costs for the supplemental fuel, including the design and incineration system are believed to be very costly. Although technologically feasible, the District should perform a generic cost-effectiveness analysis to establish that it is not reasonable to consider in future dairy proposals. Additional consideration should be given to the off-site impacts of energy production, as energy use is expected to be high.

2. Freestall/housing Enclosure – vented to a Bioscrubber/biofilter

2.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC:	80% control reported in other industries and for various types (see below)
NH_3:	80% control reported in other industries and for various types (see below)
H_2S:	80% control reported in other industries and for various types (see below)

2.2 Where Technology Comes From

Biofilters have been used for centuries to treat sewage and other malodorous, water-borne waste. About sixty years ago, bioreactors began to be used in Europe to treat contaminated air. Bioreactors are extensively used to treat air at wastewater treatment plants, rendering plants, and composting operations. They are also used to control emissions from landfills, solid waste processing plants, and soil remediation operations. Today there are more than 500 biofilters in Germany and in the Netherlands. In agriculture, biofiltration is widely used to control emissions from totally enclosed swine facilities and have been reported, but not verified to be used in dairy situations from totally enclosed, mechanically ventilated housing and manure storage areas.

2.3 Description of Technology or Practice

This technology consists of fully enclosing the freestall barns with the exhaust air vented to a bioreactor with expectation of at least 80% control.

a) Biofilter

Biofiltration is a method of reducing pollutants in which exhaust air that contains contaminants is blown through a media (e.g. soil, compost, wood chips) that supports a microbial population. The microbes utilize the pollutants such as VOCs and ammonia as nutrients and oxidize the compounds as they pass through the filter.

b) Biotrickling Filter

The biotrickling filter is a treatment process that uses an aggregate, ceramic, or plastic media to support a microbial population. A biofilm, layers of a biologically active mass, forms on the surface of filter media. As contaminated air passes through the media, the pollutants are absorbed from the air into the biofilm, which increases their availability to the microbes. The pollutants are then decomposed by the microbes. Moisture is continually added to compensate for water that has evaporated. Nutrients required by the microbes are also periodically added. Excess bio-sludge may be periodically removed and disposed.

c) Bioscrubber

The bioscrubber is a bioreactor process in which contaminated exhaust air is scrubbed in an absorber with a scrubbing liquid. The discharge effluent from the bioscrubber is collected in an activation tank (sump) where the absorbed constituents are degraded by microorganisms.

Use of a scrubbing liquid increases the absorption of pollutants into the liquid phase because the impact of liquid and contaminated air forms tiny bubbles, which increases the contact surface area between the gas and liquid phases. Increasing the contact surface area improves the liquid's ability to absorb pollutants. The sump acts as reservoir for the filter liquid and allows additional reaction time for the microbes to degrade pollutants. The biosrubber may be supplied with additional filter material to provide surface for microorganisms to form a biofilm. Formation of the biofilm increases the efficiency of the bioscrubber.

2.4 Control Efficiency

Biofiltration has been shown to have control efficiencies greater than 80%[3]. Biotrickling filters and bioscrubbers have VOC removal efficiencies ranging from 60% to 99.9% [4]. However, the airflow rates and biofilter capacity and performance are untested in a dairy freestall enclosure situation which is expected to need a very high airflow.

Nonetheless, page 15 of the EPA document states the following:

> *"Just as the biotrickling filter is an enhancement of the biofilter, the bioscrubber is an enhancement to the biotrickling filter. The bioscrubber attempts to solve two problems with the biotrickling filter: 1) improve the absorption of pollutants into the liquid, and 2) lengthen the time the microbes have to consume the pollutants."*

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[3] 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 NH_3."

[4] EPA-456/R-03-003, Using Bioreactors to Control Air Pollution, Clean Air Technology Center (CATC), September 2003, page 15.

Therefore, it can be presumed that bioscrubbers are more efficient than their counterpart woodchip media filters. Based on that and the fact that biofilters can be designed to meet a range of control efficiencies, a control efficiency of 80% will be applied towards this technology. However, additional consideration should be given to the off-site impacts of energy production, as energy use is expected to be high.

2.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- Believed to accomplish a great deal of capture and destruction of VOC emissions, thereby, resulting in a significant overall reduction from the dairy housing area and the entire dairy as a whole.
- Bio-filter operating costs usually less than other control technologies, such as incineration.
- Bioreactors have high destruction and removal efficiency for certain compounds such as organic acids (volatile fatty acids), hydrogen sulfide, and aldehydes.
- Bioscrubbers can treat emissions containing particulate matter.
- A proposal is being presented to the dairy marketplace. The following claims are being made:
    - Reduced capital costs in comparison to other control technologies.
    - Operating costs usually less than other control technologies.
    - Potential benefits in milk production by maintaining the proper temperature inside the freestall – keeping cows cool.
    - Potential benefits of improved conception rates from reduced heat stress.

b) Cons

- Untested, with likely very high-energy requirements for airflow.
- High water requirements for evaporative cooling.
- Multiple variables (temperature, pH, nutrients, etc.) affect efficiency of bioreactors.
- Over feeding microbes in a bioscrubber can cause excessive biomass growth.
- Manure handling may be more difficult to perform
- Animal health and welfare may be compromised
- A significant risk to animals overheating in event of a power failure.
- Confined space requirements of OSHA must be in compliance

2.6 Cost

A proposal is being presented to the dairy marketplace, but cost estimates remain to be proven.

Based on costs provided to the District by the proponent of the above referenced system, the estimated difference in cost between standard freestall housing and enclosed freestall housing for a 3,600 milk cow dairy is $1,765,000. No attempt to challenge or verify this estimate has been conducted at this time.

2.7 Feasibility at Dairies

This technology is theoretically possible at dairies. However, a detailed cost effectiveness analysis of such systems needs to be performed prior to their application. A demonstration installation would be helpful in determining feasibility.

2.8 Missing Data

No data is available beyond theoretical engineering computations provided by the proponent.

2.9 Further Resources

David Avila – Western Dairy Design

Biofiltration of Air: A Review, Marie-Caroline Delhomenie and Michele Heitz, Critical Reviews in Biotechnology, 25:53-72, 2005

Development of an efficient Bioscrubber System for the Reduction of Emissions, Hinrich GJ Snell, Research Centre for Animal Production and Technology

http://www.epa.gov/ttn/catc/dir1/fbiorect.pdf

http://www-rcf.usc.edu/~bfilter/intro.html

http://manure.coafes.umn.edu/assets/biofilters.pdf

http://manure.coafes.umn.edu/assets/baeu18.pdf

http://www.beiagsolutions.com/BioCurtain.htm

2.10 Recommendation

The recommendation is for the District to perform a cost-effective analysis for this technology and if the costs are above the cost effective threshold level, consideration of this technology for application on dairies should be considered not cost effective. In addition, considerations such as animal care perceptions of the consuming public should be examined.

3. Concrete freestall, drylot feed lanes, and walkways

3.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC: 0% (Included in baseline emissions estimates)
PM_{10}: 0% (Included in baseline emissions estimates)
NH_3: 0% (Included in baseline emissions estimates)

3.2 Where Technology Comes From

SJVAPCD Draft Dairy BACT document dated April 27, 2004

3.3 Description of Technology or Practice

This technology simply refers to all feedlanes and walkways to be concreted.

3.4 Control Efficiency

The control efficiency of concreting walkways, freestalls, and drylot feedlanes is not exactly known. However, there is an expected reduction in VOC, ammonia, and PM_{10} emissions, since the manure can be flushed away into a treatment or storage system. Although there is some control efficiency from concreting these areas, the baseline emissions already account for this reduction. Therefore, the control efficiency of this beyond the 19.3 lbs/hd-yr is equal to 0 lbs/hd-yr.

3.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- Facilitates control, collection and transportation of manure to a more stable storage facility or location
- Additionally, is protective of groundwater

b) Cons

None

3.6 Cost

Detailed costs are available from contractors, but are generally considered acceptable by the dairy industry.

3.7 Feasibility at Dairies

Concreting walkways, freestalls, and drylot feedlanes is a standard practice on dairies, therefore this practice is considered feasible.

3.8 Missing Data

3.9 Further Resources

Current dairy facilities

3.10 Recommendation

Since the concreting of walkways, freestalls, and drylot feedlanes is a standard practice at dairies, the recommendation is to place this practice under the Achieved in practice category of the BACT guideline.

4. Increased frequency of flushing, scraping, or vacuuming

4.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC:
NH_3:

4.2 Where Technology Comes From

Biological and engineering judgment

4.3 Description of Technology or Practice

The logic behind increase in flushing, scraping, and/or vacuuming is to remove the manure from the feedlanes and alleys as quickly as possible in order to result in lower VOC emissions and the stabilization of the feces and urine contact, preventing ammonia emissions at this stage of the manure system.

Emissions can potentially be reduced by the increase in flushing, vacuuming or scraping. With multiple cleanings/day, the unprocessed manure has had little time for anaerobic degradation. Minimization of anaerobic degradation of the raw manure in the flush alleys is thought to result in less manure odor and emissions from the barn.

Manual scraping and vacuuming must be performed when the cows are in the holding pen for milking, hence normally 2 or 3 times per day, depending on the milking schedule. Flushing is more flexible as cows do not need to be out of the alleys.

The standard practice at dairies is flushing two times/day, when milk cows are being milked in the milk barn, also two times per day. Therefore, the frequency of flush/scrape/vacuum should exceed two times in order for emission reductions to be applied.

It should be noted that the technology is limited to potential reductions in the feedlanes and alleys, not the entire manure management system, and that these potential reductions have not yet been measured.

4.4 Control Efficiency

The control efficiency of an increase in flushing/scraping/vacuum frequency is not known. However, it is clear that if the manure has a less chance of being degraded/decomposed in the feedlanes, therefore fewer emissions would be expected from that area. The following control efficiencies for the number of increase in removal can be estimated.

Caution:
These calculations are based on the current estimates of volume and location of emissions ~~by the district staff~~some DPAG members, and revision will be necessary as more information becomes available. Comparative emissions data is not currently available so the basis for our calculations is tenuous

-Actual emission changes must also be considered speculative at this time as the calculations below are based on a linear relationship. They are included here to demonstrate a possible method of calculation that can conceptually be used when adequate information becomes available. It must be recognized that a linear relationship does not exist under field conditions, and diurnal and seasonal influences must be considered.

Several committee members do not believe the calculations demonstrated below are suitable to quantify control efficiency, or are of limited utility.

The following assumptions are made by ~~SJVUAPCD staff~~some DPAG members:

- The bulk of the emissions will occur in the last few hours prior to flush, since it takes some time for decomposition and anaerobic conditions to subsist. However, to be conservative a linear approach will be taken which will most likely underestimate the emissions reductions.
- Emissions from the feed-lane will be considered negligible from the very fresh excreta, (first few hours after excretion)
- The emissions from the flush lanes based on two flushes is approximately 4.1 lbs/hd-yr[5]
- There may be an increase in emissions from increase in flushing from a typical dairy lagoon/storage pond water
- Flushing with cleaner source water such as flush from the secondary lagoon would result in additional emission reductions.

[5] Refer to document emailed by Dave Warner entitled "Breakdown of Dairy VOC Emission Factor into Permit Units. Enteric emissions of 8.3 lbs/hd-yr should be subtracted from the total 12.4 lbs/hd-yr from cow housing

- No increase in emissions from the storage pond/treatment lagoon is expected, since the same amount of manure is sent to the lagoon, regardless of how many flushes take place.
- Manure deposited in the flush lanes typically always remain in a wet condition and normally does not dry between flushes. By removing this manure more frequently, decomposition of manure would be minimized, thereby reducing emissions.

The following control efficiencies based on the increase in removal can be estimated:

Control efficiency estimation based on three flushes:

It is acknowledged, that there are emissions from flushing itself. However, emissions from the flush would be decreased if flushed from a secondary lagoon (two-cell system). The calculation below will estimate emissions from this type of system. A typical flush usually lasts about 15 minutes. Three flushes would equate to a total of 45 minutes of flush in one day. Due to the low-level of Volatile Solids (VS) in the flush, emissions are expected to be small; therefore, emissions from that time period can be subtracted linearly from the 4.1 lbs/hd-yr emissions factor as follows:

4.1 lbs/hd-yr ÷ 24 hours x 45 minutes/60 minutes = 0.13 lbs/hd-yr from the flush itself.

The remaining emission factor of 3.97 lbs/hd-yr occurs from the manure decomposition from the flush lanes. This factor will be broken up by each hour as follows:

3.97 lbs/hd-yr ÷ 24 hours = 0.165 lbs/hd-yr

The increase in flushing by one time a day, from 2-3 reduces the time manure decomposition takes place by a total of 8 hours. Therefore, instead of having the manure sit there for a total of 12 hours/day, by going to 3 flushes, four potentially crucial decomposition hours (last four hours of each flush period) are eliminated. The other 12-hour period will also benefit from a 4-hour reduction of manure decomposition, hence making the total hours of VOC reduction to 8.

Therefore, the emissions reductions from the 8 hours is as follows:

8 hrs x 0.165 lbs/hd-yr = 1.32 lbs/hd-yr

The emissions left over in the system would be equal to:

4.1 lbs/hd-yr – 1.32 lbs/hd-yr = 2.78 lbs/hd-yr

Therefore, the control efficiency for increasing the flush by 1 time is calculated as follows:

CE = 1 – (2.78 lbs/hd-yr ÷ 4.1 lbs/hd-yr) = 32.2%

Control efficiency estimation based on Four flushes:

As stated above, a typical flush usually lasts about 15 minutes. Four flushes would equate to a total of one hour of flush time in one day; therefore, emissions from that time period can be subtracted from the 4.1 lbs/hd-yr emissions factor as follows:

4.1 lbs/hd-yr ÷ 24 hours x 60 minutes/60 minutes = 0.171 lbs/hd-yr from the flush itself.

The remaining emission factor of 3.9 lbs/hd-yr occurs from the manure decomposition from the flush lanes. This factor will be broken up hourly as follows:

3.9 lbs/hd-yr ÷ 24 hours = 0.163 lbs/hd-yr

The increase in flushing by two times a day, from 2-4 reduces the time manure decomposition takes place by 12 hours. Therefore, the emissions reductions from the 12 hours is as follows:

12 hrs x 0.163 lbs/hd-yr = 1.956 lbs/hd-yr

The emissions left over in the system would be equal to:

4.1 lbs/hd-yr – 1.956 lbs/hd-yr = 2.144 lbs/hd-yr

Therefore, the control efficiency for increasing the flush by 2 times is calculated as follows:

CE: 1 – (2.144 lbs/hd-yr ÷ 4.1 lbs/hd-yr) = 47.7%

> The above estimates are based on the best available data at this time and are expected to be refined with new research as it becomes available.

4.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- Manure can be moved into storage facilities on a regular basis thereby interrupting emissions from the concrete collection surface. Additionally, the storage facilities are believed to be more stable from an emissions standpoint, and this stability can further control emissions.
- May have a slightly beneficial incremental effect for herd health and productivity, including feet and leg and udder health.

b) Cons

- Flushing more frequently may increase emissions from the flush water when recycled lagoon water is utilized for flushing. There may also be a possible increase in emissions from the lagoons/storage pond.
- The discussion of this technology is theoretical, since studies have not been performed

4.6 Cost

Associated costs for more frequent cleaning are basically a function of the increased wear and tear on the removal equipment. A strict analysis of these costs is not yet available.

4.7 Feasibility at Dairies

The increase in flushing/scraping/vacuuming at dairies is feasible for dairies.

4.8 Missing Data

Quantification of reduction potential using a linear equation is not technically supportable by some DPAG members.
Comparative studies have not been performed.

4.9 Further Resources

Effect of scraping frequency in a free stall barn on volatile N loss from dairy manure during summer. V. R. Moreira* and L. D. Satter U.S. Dairy Forage Research Center, Madison, USDA - Agricultural Research Service. 2003. J Anim Sci. Vol. 81, Suppl. 1/J. Dairy Sci. Vol. 86, Suppl.1

Digesters bring power and income to west coast dairy farms BioCycle November 2004, Vol. 45, No. 11, p. 54

4.10 Recommendation

The majority of dairies scrape or vacuum their feedlanes two times a day; however there are some dairies that flush their feedlanes three times a day or more, although common practice is twice. Therefore, flushing three or more times per day is possible to be considered Achieved in practice – BACT, depending on the system in use and the method of calculating potential reductions.

Some DPAG members believe that emissions reduction calculations should be calculated more carefully taking into considerations all necessary factors.

5. Frequency of manure removal from open corrals

5.1 Pollutants Targeted and Expected Range of Control Efficiencies

PM, VOC & NH_3

5.2 Where Technology Comes From

SJVAPCD Draft Dairy BACT document dated April 22, 2004

5.3 Description of Technology or Practice

Long periods of manure residence time in either confinement, storage, or stabilization facilities provide greater opportunities for anaerobic breakdown and volatilization to the air. Also, masses of substances emitted may increase with time. Volatile organic compounds are intermediate metabolites formed during the degradation of organic matter in manure in a moist environment. The most important principle of odor control (as an indicator, not a surrogate for VOCs) is avoiding anaerobic conditions by keeping (a) manure and other organic materials as dry as practical, (b) manure storages and surfaces exposed to oxygen, and (c) corral surfaces even, smooth, and free of compacted manure.

Under aerobic conditions, such as those found in dry manure management facilities, any VOCs that are formed are rapidly oxidized to carbon dioxide and water. Differences in operating practices can affect emissions substantially. For example, dry manure management systems that are well operated will not be significant sources of hydrogen sulfide, VOC, and methane, because the manure decomposes aerobically. However, a dry system that is poorly operated due to improper design or management (e.g., excessively high animal density, inadequate ventilation, poor drainage, watering system leaks) can prevent the manure from drying and allow anaerobic microbial activity.

Dairies vary in the frequency that manure is removed from the open corrals. The frequency of manure removal varies from weekly to yearly, with the majority in between.

The manure that is removed from the open corrals needs to be properly managed; otherwise there is simply just a displacement of manure and emissions from one place to another. Therefore, once the manure has been removed from the corrals, some manure management practice should be employed to ensure that emissions are reduced, such as rapid manure drying to prevent anaerobic digestion, ASP composting, etc.

However, some preliminary information received from field studies (Krauter) indicates that there may be benefits to managing a dry surface layer by harrowing - which brings the more fibrous material to the surface where it may either act as a bio-filter or protect the under layers from evaporation. It may actually work better to avoid disturbing the open corrals and maintaining a dry surface by regular harrowing until the manure can be taken directly to the field and avoiding the need to stockpile. Obviously a need exists to verify or disprove.

Dry lots need regular maintenance. Situations that increase cow density, such as the congestion of cattle under shaded areas, may require more maintenance than areas less intensively used or less populated. Once the dry lots are in shape it is easier to maintain them. Digging holes in the lots or bringing up rocks can be a problem when a lot has not been regularly maintained or with an inexperienced driver. Regardless, with regular maintenance the drylot should be smooth and level and provide a clean, comfortable surface. A well maintained drylot will require a reasonable amount of time after a rain to be dry enough to maintain. The time necessary will depend on the intensity and duration of the storm.

No matter how well an open lot AFO has been designed, corral maintenance will make or break the AFO with respect to organics emissions. Again, the key is to keep the corral surface smooth, and as dry as possible, maintaining a firm 1- to 2-inch base of compacted manure above the mineral soil. Corrals that shed water rapidly and completely have the least potential to create emissions of VOCs.

Frequent, proper manure harvesting is important. Open lot dairies need a regular removal program, dependent on the circumstances and conditions in the local area, and consistent with the seasonal aspects of the area. Additionally, the management scheme of the individual dairy will need consideration.

5.4 Control Efficiency

The combination of frequent manure removal and control of that manure after removal has the potential of reducing emissions. The degree of control can be quite large if manure is dried rapidly and maintained in dry conditions. However, at this time no control efficiency is available.

5.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- The increase in frequency of manure removal prevents the pulverization of dry manure by the cow's hooves, hence decreasing PM emissions.
- Reduces opportunity for anaerobic conditions to develop in manure pack. - Drier manure has the potential of emitting far less emissions than moist manure
- Facilitates other control measures in storage piles or field application.
- Will help keep animals cleaner

b) Cons

- May preclude other management options such as maintaining an aerobic fibrous layer over the manure pack as has been discussed above, and is a listed CMP in the PM10 plan.
- May increase PM emissions during removal activities
- Too much removal may have a negative impact on the 1- to 2-inch layer of compacted manure above mineral soil.

5.6 Cost

Not available and is dependent on equipment utilized. Can range from the use of additional hours of a dairy owned tractor and labor force, to the services of a commercial cleaning operation.

5.7 Feasibility at Dairies

Use of this technology is common, but the evaluation of feasibility for an individual operation must be considered in the context of the entire management plan. Frequent manure removal is not a stand-alone technology. However, it is very feasible in combination with rapid drying of manure.

5.8 Missing Data

Actual data from various management techniques must be compared. This type of information should be forthcoming from the CSUF work over the next two years.

5.9 Further Resources

SCAQMD, UC Davis
Air Emission Characterization and Management Workshop Review Draft: Supporting Documentation for the EPA Regional Science Workshop on Animal Feeding Operations (AFOs) - Science and Technical Support Needs December 6-9, 2004, College Park, Maryland

Free Stall and Corral Management as Related to Mastitis Control H. Spencer
Veterinary Medical Clinic, Aubrey, Texas. Presented at the 1998 National Mastitis Council Regional Meeting, Bellvue, Washington; Published in the 1996 National Mastitis Council Regional Meeting Proceedings page 60.

www.lpes.org/Lessons/Lesson42/42_3_Odor_Management.pdf
MODULE E Outdoor Air Quality Elements of an Odor Management Plan (OMP) for Open Lot Livestock Facilities
www.extension.iastate.edu/Publications/PM1970A.pdf. Practices to Reduce Odor from Livestock Operations
muextension.missouri.edu/explorepdf/agguides/agengin/G01884.pdf. Odors From Livestock Operations: Causes and Possible Cures

5.10 Recommendation

Since there are many dairies currently removing their manure from the open corrals on a regularly scheduled basis, this practice will be considered Achieved in practice BACT. The option of drying manure rapidly by keeping manure in thin layers and harrowing is also practiced by many dairies. Therefore, the combination of regular manure removal and/or rapid drying by keeping manure in thin layers and harrowing will be considered Achieved in Practice BACT. It should be noted that some members of the DPAG believe that the best control of emissions from the open corrals is to keep the surface well harrowed to accomplish an aerobic surface layer, delaying removal until possible to go directly to field application, thus avoiding disturbance of the compacted anaerobic layer and avoiding the need for stockpiling.

6. Vacuuming instead of flushing or scraping

6.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC & NH_3
One farm reports reductions of 50% to 90%, but district protocol requirements have changed substantially since the work was done. Reductions are dependent on how the vacuuming fits into the entire management scheme.

6.2 Where Technology Comes From

Dairy practice
Engineering Judgment

6.3 Description of Technology or Practice

Vacuuming instead of flushing has the potential of reducing emissions by eliminating a portion of the settling basins, lagoons, and storage ponds. However, in order to work, emissions from the slurry collected by the vacuum equipment need to be controlled, not just re-located into a storage system. Vacuumed manure can be directly applied to land either through injection or incorporation. Methods to dry manure out quickly may also be used as a means of control in the storage system.

6.4 Control Efficiency

As per the discussion above, the control efficiency of vacuuming rather than flushing or scraping will depend on how the manure is used or stored. Reports from one farm vacuuming and incorporating indicate 50 – 90 % reductions in emissions from immediate incorporation ~~incorporating~~. Some DPAG members believe that ~~T~~the measurement methodologies used must be further reviewed before utilizing this information.

If the manure is vacuumed then directly injected to land there is a partial elimination of the liquid manure management system. ~~(t~~The milking system will still be handled in a wet system by flushing the manure generated from the milk barn to the lagoon or a small storage pit~~)~~. The immediate control efficiency of vacuuming instead of flushing can be calculated as follows:

Caution:
The calculations below represent a best estimate by ~~district staff~~ some DPAG members at the current time, and are expected to be refined with new research soon to be available. All DPAG members do not share these calculations. Take note that the reported reductions were based on testing protocols in use before the DPAG emission factor discussions.

Total Dairy Emission Factor: 19.3 lbs/hd-yr
Liquid Manure Management System: 2.4 lbs/hd-yr

Control $\text{efficiency}_{\text{Elimination of Liquid manure}}$ = (19.3 lbs/hd-yr – 2.4 lbs/hd-yr / 19.3 lbs/hd-yr) – 1 = **12.5 %**

There may be additional overall dairy emissions reductions from vacuuming if the manure is either injected into the soil or immediately incorporated into the soil. Based on data from a Kern County dairy study, a 50% VOC emission reduction can be obtained through immediate incorporation. Therefore, the emissions reduction from land application would be as follows:

$CE_{immediate\ incorporation}$ = x 50% = 1.7 lbs/hd-yr

Total dairy-wide emissions reductions can then be calculated as follows:

(19.3 lbs/hd-yr – 2.4 lbs/hd-yr – 1.7 lbs./hd-yr / 19.3 lbs.hd-yr) – 1 = **21.2%**

6.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- May facilitate additional management options for handling manure as transport is provided by wheeled vehicles.
- Some of these options may be include a digester designed to handle slurry, field injection, field spreading, and/or windrow drying, etc.
- Costs of vacuum equipment can be partially offset to some extent by reducing the size of settling basins/lagoons/storage ponds.

b) Cons

- Is not a “stand alone” system, must be combined with other practices.
- If using year-round application as part of the process, it is not feasible in some areas of the state.
- If using injection as part of the process, it is not feasible at any time in some locations.
- Is not completely effective when used in non-concreted areas such as open corrals.
- Water quality considerations may limit the ability to land apply on a daily basis. The regional board may require manure to be applied only when a crop will be available to uptake the nutrients.
- Equipment failure can cause significant problems if vacuuming is the sole method of manure collection, so alternative measures must be provided for.

6.6 Cost

One dairy reported upfront costs are similar or less than scraping and flushing. For this dairy, the vacuum trailer and tractor was about $140,000. A large separation system can cost more. Dual separators and all the pumps. pipes and holding areas and storage facilities. Daily upkeep, energy, and manure removal costs for a flush or scrape system can also be substantial.

6.7 Feasibility at Dairies

- Vacuuming as an alternative to scraping or flushing is feasible in practice, but information is not yet available as to the cost effectiveness of emissions control and needs to be evaluated as an entire system.
- Regional weather and soil conditions will influence the scope and parameters of feasibility.
- Working life of the equipment will need to be compared between systems as well for an accurate feasibility analysis.

6.8 Missing Data

Analysis using current research protocols established by the District, CARB and approved by the CCOS Policy Committee.

6.9 Further Resources

Practice is currently in use at some existing dairies.

6.10 Recommendation

Achieved in practice as a means of removing manure, but if considering direct injection, recognize it is dependent on the fit with the entire management system and especially necessary to consider geographic location, expected weather conditions, type of crop and cropping patterns. All other factors discussed herein should be evaluated prior to the application of this technology.

7. Drying rate- regular leveling of open corrals

7.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC, NH_3, & PM_{10} – Expected Control is high, however no information available at this time

7.2 Where Technology Comes From

Dairy practice

7.3 Description of Technology or Practice

Corrals are harrowed on a regular schedule to breakup manure and facilitate rapid drying in aerobic conditions.

7.4 Control Efficiency

Dry manure is known to be more stable and have far lower emissions. The degree of control can be quite large if manure is dried rapidly and maintained in dry conditions. However, at this time no control efficiency is available.

7.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- Avoids anaerobic conditions at corral surface
- Enhances opportunity for an aerobic surface layer
- Dry manure is known to emit less VOC and NH_3 emissions
- Harrowing tends to keep the more fibrous manure particles at the corral surface, providing protection from disturbance or interception of the finer materials below
- Assists in fly control
- Helps keep cows cleaner

b) Cons

- Only appropriate in dry periods or summer months.
- Can create PM when performed - Drag scrapers or harrows stir up or move around the dry manure, and can create dust. This can be mitigated by harrowing in the morning hours when humidity is higher and winds lower.

7.6 Cost

Costs are not quantified, but considered reasonable, and are related to tractor use and labor requirements. Not available at this time but costs are part of a CDFA study that is currently underway.

7.7 Feasibility at Dairies

This control technology/practice is feasible at dairies since this practice is widely used on dairies.

7.8 Missing Data

Comparative studies of emissions

7.9 Further Resources

CSUF study in next two years regarding mitigation measures

7.10 Recommendation

Achieved in practice and is a menu option in the CMP plan, if performed in the morning hours.

8. Cleaning effectiveness of free stall lanes – Fresh water

8.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC & NH_3

8.2 Where Technology Comes From

Suggested by Dr. Byers and very limited dairy practice

8.3 Description of Technology or Practice

Flushing with fresh water was used in the early flush systems installed on dairies. Subsequent systems have used recycled water to reduce the demand on fresh water supplies.

8.4 Control Efficiency

The control efficiency of this technology is not known at this time. However, flushing with clean flush water has the potential of reducing much of the emissions associated from the action of flushing. A more detailed analysis of this technology is required before a control efficiency can be applied.

8.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- Residual flush water in feedlanes after flushing is complete will not have manure constituents.
- Eliminates emissions that may come from recycled water when using for flushing

b) Cons

- Most importantly, using fresh water to flush will place a severe strain on water resources of the state.
- It has not been shown that residual flush water left in the feedlanes after flushing is completed contributes very much to emissions
- Greatly larger storage facilities required.

8.6 Cost

No costs are available.

8.7 Feasibility at Dairies

Feasibility as a control measure cannot yet be determined as it will require a control efficiency, which is also yet to be determined. The practice of flushing is widely used and is considered feasible for a producer to implement. The use of fresh water will need to be evaluated to correctly account for demand on water resources. Fresh water is already a limited resource in California, so caution is advised when considering using substantially more for this purpose.

8.8 Missing Data

No data exists

8.9 Further Resources

None found

8.10 Recommendation

Due to the major increase in demand this technology will place on the limited water resources of the state, it should not be considered at this time.

9. Cleaning effectiveness of free stall lanes – Low BOD water

9.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC & NH_3

9.2 Where Technology Comes From

Suggested by Dr. Byers

9.3 Description of Technology or Practice

There are several ways to accomplish reduced BOD in water used for flushing. Two are mentioned here. One is to dilute the flush water with fresh water. Another is to construct and manage the lagoon system so that flush water is drawn from the end of the system, so that management practices and equipment, including solids separation, mechanical devices, digestion, and possibly others can exert their influence to lower the BOD load.

9.4 Control Efficiency

The control efficiency of this practice has not been measured, however, flushing with low BOD recycled water is expected to effectively clean feedlanes and has the probability of reducing emissions from the flush. However, a detailed analysis is required to demonstrate that there would be a reduction in emissions. ~~How important that fact is to emissions has not~~ This has yet to be~~en~~ determined.

9.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- Residual flush water in feedlanes after flushing is complete should have a reduced load of manure constituents.
- Expected to reduce emissions that might be associated from recycled water when using for flushing.

b) Cons

It has not been shown that residual flush water left in the feedlanes after flushing contributes very much to emissions.

9.6 Cost

No costs are available.

9.7 Feasibility at Dairies

Feasibility cannot yet be determined

9.8 Missing Data

Comparative emissions data are lacking

9.9 Further Resources

9.10 Recommendation

The use of low BOD water is a priority for study, both for its effect on emissions and how to accomplish it. Information is expected from the CSUF project now getting underway. Since there is not much data available for this technology, it should be listed for future evaluation.

10. Use of Collection (or Process) Pits for flushing

10.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOCs and NH_3

10.2 Where Technology Comes From

New dairy practice

10.3 Description of Technology or Practice

Utilizing a "fresher" water for flushing to accomplish better cleaning, is relatively new. It has been given its own category of technology. Some newly constructed dairies have built small "collection pits" into which they capture the fresh water used in the milking process (cooling of milk, washing of cows) along with the recent (same day) flushes of the corrals. This blended water is then used for flushing with the intent to do so before decomposition has commenced. The collection pit is discharged to the storage pond when full, usually at least daily in order to maintain the "freshness."

10.4 Control Efficiency

Unknown, never measured

10.5 Considerations Regarding Use of the Technology or Practice

a) Pros

Has a similar effect as low BOD water due to using water for flushing before decomposition sets in.

b) Cons

No documentation that it has a significant effect on emissions

10.6 Cost

Not yet available, suggest contact users

10.7 Feasibility at Dairies

Cannot be determined until emissions are measured

10.8 Missing Data

Quantification of emissions

10.9 Further Resources

10.10 Recommendation

Appears to have potential, should be prioritized for study

11. Depth of pack-frequency of removal – This practice has been combined with "Frequency of manure removal from open corrals" under section 5.0

12. Open corrals sloped to facilitate runoff and drying - Minimum of 3% slope

12.1 Pollutants Targeted and Expected Range of Control Efficiencies

~~Minimum of 3% slope~~
VOC & NH_3

12.2 Where Technology Comes From

SJVAPCD Draft Dairy BACT document dated April 22, 2004
Dairy practice

12.3 Description of Technology or Practice

This practice requires the corrals to be sloped so that runoff water having contacted manure can be channeled to a potential place of removal, storage, or treatment, rather than stay in the corrals and create anaerobic conditions.

12.4 Control Efficiency

The control efficiency of sloping corrals is not known, however, sloping corrals is a general practice encouraged on dairies and is considered to reduce emissions by reducing anaerobic conditions in the corrals. However, the baseline emission factor includes any reduction from sloped corrals; therefore, the control efficiency compared to the baseline is equal to zero.

12.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- Assists water quality compliance
- Avoids anaerobic conditions
- Dry corrals have fewer emissions
- Dry conditions better for cow health

b) Cons

Dry conditions can exacerbate PM problems

12.6 Cost

Initial construction costs and costs of timely maintenance of slope are likely available from local engineering firms and the USDA/NRCS.

12.7 Feasibility at Dairies

As for previous technologies, feasibility for emissions control is not possible to determine without a quantified control efficiency. However, this technology is often used when corrals are constructed, therefore, it is believed to be feasible. This technology will have a greater influence in the higher rainfall areas of the district and may be applied differently in low rainfall areas.

12.8 Missing Data

Quantification of emissions

12.9 Further Resources

12.10 Recommendation

Since most new dairies slope their corrals, this practice will be considered Achieved in practice BACT.

13. Manage feed bunks so that buildup of spoiled or refused feed is avoided.

13.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC and possibly ammonia

13.2 Where Technology Comes From

This practice was proposed by certain dairies in their Environmental Impact Report. It has also been shown through recent studies that feed has the potential of generating significant VOC emissions.

Also listed in Tetratech's report for SCAQMD Rule 1127

13.3 Description of Technology or Practice

The purpose of feed bunk management is to prevent the decomposition of refused or spoiled feed. It may be accomplished by several means, push-out for feeding to other animals, push-up to include with the next feeding, feeding so that all feed is consumed, etc.

Not all Total Mixed Rations (TMRs) are the same. Some use premium feed, others feed any by-product available. Lettuce, carrots, potato's etc. These items decompose quicker and could require daily cleaning. It is possible to clean to prevent moldy feed intake every 2-3 days depending on outside temp. When oranges and lemons are available bunk life is extended because they act as a preservative. Need to say "Frequency of cleaning depends on site specific feed type usage "Not mandatory once a day for all feed types.

13.4 Control Efficiency

The control efficiency of managing feed bunks is not known, however, this is a general practice encouraged on dairies and is considered to reduce emissions by reducing anaerobic conditions. More data is needed before a control efficiency can be applied.

13.5 Considerations Regarding Use of the Technology or Practice

a) Pros

Reduces emissions from decomposing feed, if feed is in fact decomposing

b) Cons

Cleaning everyday in many situations costs the farmer a lot of money because that feed can still be good for up to three days at many facilities. If it is required to be cleaned daily then one could be feeding a $3.50 per cow per day ration to a group of heifers that only need a $1 dollar per day ration.

13.6 Cost

Not quantified, additional tractor and labor time

13.7 Feasibility at Dairies

Considered feasible dependent on site-specific considerations

13.8 Missing Data

No data comparisons at this time

13.9 Further Resources

Dairy practice

13.10 Recommendation

Achieved in practice – frequency subject to individual determination

14. Windbreaks

14.1 Pollutants Targeted and Expected Range of Control Efficiencies

PM_{10}: 30%

14.2 Where Technology Comes From

SJVAPCD Draft Dairy BACT document dated April 22, 2004
Conservation Management Practices

14.3 Description of technology or practice

Artificial or vegetative wall/fence/treeline that serves to disrupt the erosive flow of wind over unprotected land, provides dispersion and possible trapping of emissions.

14.4 Control Efficiency

Based on the documents referenced under the *further resources* section, a 30% control efficiency will be assigned to wind barrier/ windbreaks for PM_{10}.

14.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- A vegetative buffer downwind of the housing area may possibly have a beneficial effect of trapping certain "sticky" VOCs and NH_3 that may be suspended in ambient air, but this effect is not documented and will need to be verified.
- Can trap and disperse dust plume.

b) Cons

None reported

14.6 Cost

Available from USDA/NRCS (they have construction designs and standards)

14.7 Feasibility at Dairies

Considered feasible

14.8 Missing Data

No data available

14.9 Further Resources

Conservation Management Practices (Rule 4550)

USDA/NRCS

Technical Support Document for Quantification of Agricultural Best Management Practices, Final Report, URS Corporation. Prepared for Arizona Department of Environment Quality, June 2001.

WRAP Fugitive Dust Handbook, Countess Environmental, prepared for Western Governors' Association, November 15, 2004. www.ndep.nv.gov/baqp/WRAP/final-handbook.pdf

Wind Fences: A Review of Dust Control Effectiveness", final report, MRI, October 16, 2000.

14.10 Recommendation

Achieved in practice

15. Restrict animal access to open corrals in dry conditions

15.1 Pollutants Targeted and Expected Range of Control Efficiencies

PM_{10}

15.2 Where Technology Comes From

SJVAPCD Draft Dairy BACT document dated April 22, 2004
UC Davis

15.3 Description of Technology or Practice

The practice requires that the cows be prevented from going out to the open areas (open corrals or exercise pens) during occasions when weather conditions are exceptionally hot and dry. during the daytime hours. They may be allowed out at night-time. The procedure would be to restrict their access to the exercise pens after the morning milking and allow them access after the afternoon milking. By limiting access during dry conditions, PM_{10}, emissions might be reduced.

15.4 Control Efficiency

Not available

15.5 Considerations Regarding Use of the Technology or Practice

a) Pros

Minimizes hoof action stirring up dust from the dry surface.

b) Cons

Limits opportunity for cows to exercise

15.6 Cost

No direct costs

15.7 Feasibility at Dairies

Mixed. If conditions are hot and dry the animals will likely not be moving around all that much. It may have better application if implemented for limited periods of time - if a producer wanted to try managing this technology – such as letting them out at night and mornings, and not during the afternoons.

15.8 Missing Data

Data not available for milking cows

15.9 Further Resources

UC Davis

15.10 Recommendation

Keep as a AIP BACT option

16. Water sprays or soil stabilizers

16.1 Pollutants Targeted and Expected Range of Control Efficiencies

PM_{10}: 40% to 90%

16.2 Where Technology Comes From

SJVAPCD Draft Dairy BACT document dated April 22, 2004

16.3 Description of Technology or Practice

The practices require suppression techniques either by water application or soil stabilizers to reduce the amount of PM that is generated.

16.4 Control Efficiency

Good control of dust (listed as 40 to 90 % in the Draft Dairy BACT document) can be accomplished with water sprays. In a cow housing situation control efficiency is not known for soil stabilizers. The use of stabilizers in a corral will be different than in a roadway use, and may not be equally effective.

16.5 Considerations Regarding Use of the Technology or Practice

a) Pros

Dust is reduced if the corral is wetted.

b) Cons

- Wet corrals and damp corrals are harmful to cow health.
- Damp or wet corrals can turn anaerobic and produce VOCs
- Ammonia releases increased.
- Efficacy of soil stabilizers is not known for this use.
- Increased fly production in damp pens.

16.6 Cost

Sprinkler systems to wet corrals involve substantial design and infrastructure. Costs for these systems have been recorded at Texas A&M for feedlot applications.

16.7 Feasibility at Dairies

Certain tradeoffs are necessary to consider. May have better application for heifer pens in open corral situations than for milk cows, but adverse implications similar to above apply equally in this use.

16.8 Missing Data

Comparative data unavailable

16.9 Further Resources

UC Davis
Texas A&M, CAAQS

16.10 Recommendation

Keep as BACT option, however, an analysis of the effects of excess moisture on increase in VOC and ammonia emissions should be evaluated, as well as animal health and vector control requirements.

17. National Colloid Research and Development (environmentally safe cleaning and degreasing products)

17.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC & NH_3

17.2 Where Technology Comes From

Don Cook with National Colloid Research and Development – Ph. # 949-433-8691

17.3 Description of Technology or Practice

A vendor has proposed to use a solution (NC 5000) on dairy manure, which has been used as a cleaning and degreasing agent for various other industries. The Solution (NC 5000) is a homogenous blend of colloids, sequestrants, and hyper-wetting agents that, by a proprietary process of formulation and concentration, becomes super active. NC 5000 penetrates and stirs things ups. It keeps stirring things up as long as there is a microscopic amount of moisture for it to work in. The vendor is claiming that this solution will eliminate all emissions from manure.

17.4 Control Efficiency

Not known

17.5 Considerations Regarding Use of the Technology or Practice

a) Pros

Not known

b) Cons

Not known

17.6 Cost

The cost of the application of this solution is claimed to be not very costly. However, no information as to how this solution reduces emissions is available and cost analysis is not possible.

17.7 Feasibility at Dairies

There is not enough data available to determine the feasibility of this product.

17.8 Missing Data

No data provided

17.9 Further Resources

www.nationalcolloid.com

17.10 Recommendation

More detailed information than is available on the website (which is testimonials), including a demonstration on a California dairy will be necessary before this product can be considered.

18. Moisture Minimization on the Facility (inspection and rapid repair of leaks in pipes and troughs)

18.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC & NH_3

18.2 Where Technology Comes From

SCAQMD – Rule 1127

18.3 Description of Technology or Practice

The purpose of this practice is to reduce the amount of moisture by eliminating leaky sources.

18.4 Control Efficiency

The control efficiency of this technology is not known, however, reduction in moisture has the potential or reducing anaerobic digestion, which in turn will reduce emissions. The amount of emission reductions has not been determined.

18.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- Eliminates wet areas that might turn anaerobic (VOCs)
- Reduces ammonia production
- Reduces fly production

b) Cons

None reported

18.6 Cost

Minimal

18.7 Feasibility at Dairies

Considered feasible

18.8 Missing Data

No data

18.9 Further Resources

South Coast Rule 1127 support documents at
http://www.aqmd.gov/rules/support.html#r1127
Dairy practice

18.10 Recommendation

Achieved in practice

19. Spreading lime in wet areas

19.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC & NH_3

19.2 Where Technology Comes From

Calf ranch in Hanford
Page 27 of SCAQMD Tetratech Task 2 -
http://www.aqmd.gov/rules/doc/r1127/pr1127_task2rpt_20030301.pdf

19.3 Description of Technology or Practice

The purpose of this practice is to reduce the amount of moisture by inhibiting sulfide production and preventing hydrogen sulfide off gassing. This has the potential of increasing ammonia emissions.

19.4 Control Efficiency

The control efficiency of this practice is not known

19.5 Considerations Regarding Use of the Technology or Practice

a) Pros

A practice that may potentially reduce moisture and odors

b) Cons

- Lime is caustic and can cause irritation to teats
- Lime will increase pH which in turn will enhance volatilization of ammonia

19.6 Cost

Amount and frequency of use dependent

19.7 Feasibility at Dairies

Has been used in small amounts and in small areas as a "traditional" technology in places like calf pens for bacteria control, but efficacy is questionable.

19.8 Missing Data

No data

19.9 Further Resources

South Coast Rule 1127 support documents at
http://www.aqmd.gov/rules/support.html#r1127
http://www.aqmd.gov/rules/doc/r1127/pr1127_task2rpt_20030301.pdf

19.10 Recommendation

There is no information or supporting documentation for this practice that shows that there would be an emissions reduction. It is also unclear as to how the lime addition would affect herd health. Therefore, this practice will not be considered as a BACT option at this time. This practice should be placed in the "further research" category if expectations of significant emissions reductions so indicate.

20. Pave Feedlanes at Least 8 ft on the Corral Side of the Fence

20.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC and NH_3

20.2 Where Technology Comes From

SCAQMD – Rule 1127 – pg 2 of rule
Dairy practice

20.3 Description of Technology or Practice

Feed lanes should be paved at least eight feet on the corral side of the fence.

20.4 Control Efficiency

The control efficiency of this practice is not known. However, this allows the capture and collection of manure, which would result in some emission reductions when compared to no concrete.

20.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- Facilitates cleaning of feeding areas and subsequent manure management
- Reduces dust
- Prevents anaerobic conditions from developing in feedlanes
- Keeps cows cleaner

b) Cons

None reported

20.6 Cost

Local contractors can provide current cost per ft^2

20.7 Feasibility at Dairies

Considered feasible

20.8 Missing Data

No data

20.9 Further Resources

South Coast Rule 1127 support documents at
http://www.aqmd.gov/rules/support.html#r1127

20.10 Recommendation

Achieved in practice

21. Commercial alternatives to traditional loose bedding materials

21.1 Pollutants Targeted and Expected Range of Control Efficiencies

PM_{10}

21.2 Where Technology Comes From

Vendor sources on the internet and at the Tulare Farm Show
Trademarked Examples: J&D Cow Mats
Pasture Mats

21.3 Description of Technology or Practice

- Several kind of artificial bedding systems are available to replace dried, loose bedding materials such as sand, manure solids, rice hulls, and such.
- Waterbeds are a pad filled with water.
- Solid rubber pads or mats
- Crumbled rubber in a canvas pillow
- These are installed over a compacted or concreted surface in the freestall.

21.4 Control Efficiency

Undetermined, but not expected to be large as little dust is generated from the bedding materials

21.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- Some reduction in dust may be expected
- Some producers have had a good experience and like a particular brand of mat or waterbed.
- Cow comfort may be improved for these producers and no adverse effects noticed

b) Cons

- Some loose bedding is still required in some applications so dust elimination is not total.
- Some producers have had bad experiences and dislike the use of them
- Cow comfort may be compromised for these producers and some have experienced animal health issues

21.6 Cost

Obtain from vendors, additional vendors are available if needed.

21.7 Feasibility at Dairies

Considered possible, but dependent on operator preference and experience

21.8 Missing Data

Additional information is needed to assess the feasibility and control effectiveness.

21.9 Further Resources

http://www.eduplace.com/kids/hmss05/bke/wklyrdr/u7_article1.shtml
http://waterbedsforcows.com/General%20Description.htm

21.10 Recommendation

Keep as a BACT option, not as a requirement

~~22.J&D Cow Mats (Discussed in Housing # 21)~~

~~23.Bio Curtain™ (Discussed in Housing #2)~~

VII. FEEDS & NUTRITIONAL MANAGEMENT

A. General statements applicable to feed related emissions control BACT options:

The following information is generally applicable to all BACT options for feed and nutritional management control strategies. This information is provided to establish the framework within which the BACT determinations are made, to establish universally applicable requirements for proposed BACT alternatives developed subsequent to approval of this initial listing of qualifying BACT measures.

B. Strategy

i Goals:

1) Reduce fugitive VOC emissions in feed preservation, processing, handling & feeding. Some of these compounds include acetic acid, butyric acid, alcohols.
2) Reduce animal VOC emissions in digesting and converting nutrients in rations to products (meat, milk, offspring)

3) Reduce VOC and digestible but undigested nutrients (readily available carbohydrates, proteins, pectins, fiber etc.) excreted in feces and as readily fermentable substrates for microbes to convert to VOC in the waste streams
4) Reduce VOC emitted/unit production-cows and milk
5) NOTE: Discussion of emissions/cow or unit product are needed. Feeding and management technologies normally enhance productivity, and likely in some circumstances emissions/cow while typically reducing emissions/unit milk produced. It is recognized that the opposite, i.e., poorer nutrition, poorer nutritional management and poorer animal health would reduce actual emissions/cow. Less productive cows are undesirable, and would require more cows for the same milk produced, and increase emissions for the industry as a whole when it produces milk at specific quantities to meet a market. Divergent opinions exist on the reference point for emissions reduction comparisons.

ii **<u>Achieved through:</u>**

1) Control fermentation of feed ingredients, managing storage conditions to minimize emissions, quick handling on removal, control bunk fermented & fermentable feed emissions, manage fermented feed storage and removal, and feeding management to minimize and properly handle waste or spoiled silage to minimize emissions. Fermentation technologies are available to direct fermentation to desired ends, one of which may be reduced acetic acid in the product, if volatilization is a problem in the feeding system. Usually selected individual vs. multiple technologies are used.

2) Optimize rations and rumen digestion of feed components to reduce rumination volatile emissions, optimize VFA fermentation, optimize rumen fermentation, reduce available fermentable nutrients in the lower gut which may lead to excreted volatiles and readily fermentable substrates in the wastes.
3) Maximize extraction of nutrients from feeds, protein, carbohydrates (starches, fiber), fat to minimize fermentable nutrients excreted as wastes. This is important if the post animal waste management strategy is not 100% effective in controlling volatile emissions.
4) Optimize production/cow and feed/unit milk and VOC to milk & meat etc. vs. emissions. This is important for the industry as a whole producing milk to meet a given market, and for producers marketing with structures such as a quota or base. It is anticipated that dairies will be initially regulated on a cow number basis, but total emissions/dairy will also be important. Feed strategies may enhance animal productivity, and may reduce emissions/unit milk, but with yet unknown impacts on total emissions/cow.

iii BACT Foundation Requirements:

1) The approach or methods proposed must achieve a documented emissions reduction to qualify as a BACT measure. This means that the emissions reduction potential must be clearly evident or have been measured in practice and documented.
2) The approach or methods must achieve a net reduction of emissions at the facility. Actions that shift emissions from one area of a facility to another without achieving an actual reduction do not qualify as BACT.
3) BACT implementation for feed must be flexible to allow adjustment to address herd health or nutrition issues and cyclical or seasonal changes in the types of feed available; however, if actions specified in a BACT determination must be modified or interrupted to address such operational issues and result in an increase in emissions from the feed or feed operations, temporary alternative or supplemental qualifying BACT measures would be considered.
4) The facility operator is responsible for the identification and selection of BACT measures that comply with other state guidelines and laws applicable to the facility. Identification of a measure as a candidate for BACT to achieve an emissions reduction does not supersede other applicable restrictions that would prohibit selection of the measure.

iv Performance indicators:

1) For feed additives or treatments that do not have documented or easily demonstrable emission reductions, measurement of feed or manure emissions or contents may be required to prove BACT eligibility and effectiveness.
2) Good housekeeping practices, such as timely removal of spoiled material, may be used as evidence of implementation of management practices to reduce spoilage related emissions. Visual inspection applies here.
3) The linkage between emission of certain compounds and identifiable odors, such as the rancid or rotten odors associated with spoiled silage, while not a surrogate for VOC assessment, may be used with visual cues to establish inadequate housekeeping practices for locations where reduction of silage emissions is a part of the BACT determination and implementation strategy.

C. Control Technologies/Practices

1. High Moisture Feeds Preservation and Stabilization

1.1 Pollutants controlled or mitigated, and expected range of control efficiencies

VOC: acetic acid, butyric acid, alcohols: goal--______% control

1.2 Where technology comes from

Best management practices available for animal industries. Research and extension literature and recommendations.

1.3 Description of technology or practice

Silage, haylage, high moisture grain (corn, milo, wheat, barley) harvest, storage systems, silage making practices employed to produce highly digestible feeds with nutrients in desired forms (i.e. minimize soluble N), and with proper practices to minimize undesirable volatiles (i.e. acetic if it volatilizes in the feeding system, butyric) and their emissions in preservation, storage and feeding.

a) Storage systems include:

1) Drive over piles
2) Bunker silos
3) Upright silos
4) Linear bag storage- i.e. Ag Bag etc.

b) Key parameters and controls:

1) Harvest maturity
2) Moisture
3) Chop length
4) Packing-density-air exclusion
5) Sealed covered storage
6) Use of fermentation controls-additives and other technologies as appropriate to achieve feed quality and emissions goals

c) Additives and controls:

1) Microbial inoculants to enhance stability, reduce acetic and butyric, reduce mold growth, enhance bunk shelf life etc.

Example assessment:

Silage bacterial inoculants

a. Function: To stimulate silage fermentation, reduce dry matter loss, decrease ensiling temperature, increase feed digestibility, improve forage surface stability, and increase lactate production
b. Level: 100,000 colony forming units (CFU) per gram of wet silage. Organisms include: I.e. Lactobacillus plantarum, L. acidophilus, Pediococcus acidilactici, P. pentacaceus, and Enterococcus faecium, among others.

~~c.Cost: $0.60 to $2.00 per treated ton of silage~~

~~d.Typical industry benefit to cost ratio: 3:1 (feed recovery) to 7:1 (milk improvement). Costs to achieve desired emissions reductions need assessment.~~

~~e.~~c. Feeding Strategy: Apply to wet silage (over 60 percent moisture); corn silage, haylage, and high moisture corn; low natural bacteria counts (first and last legume/grass silage and frost damaged corn silage); and under poor fermentation situations

1) Enzymes
    i. Cellulase and hemicellulases (i.e. xylanase) enzymes
2) Nutrients
    i. Minerals, energy sources
3) Fermentation extenders - i.e. more lactic, less acetic
    i. Limestone
    ii. Urea
    iii. Ammonia
4) Direct acidification
    i. Acetic, propionic
    ii. Mineral acids

1.4 Control Efficiency

The Control efficiency of this technology is not known at this time. However, it appears that emission reductions can be achieved based on the description of this technology. More data is needed in order to estimate the control efficiency.

1.5 Considerations regarding use of the technology or practice

- Many options for producing quality fermented feeds are available, but often not all are used.
- Covered sealed storage is essential in all systems
- Good feeding quality but low VOC emission fermented feed can be produced with all storage systems; management and technology use are the keys. Emissions will need documentation.
- Each storage system and feed to be preserved has unique issues which must be attended to-maturity, moisture, additives needed etc.

1.6 Cost

Costs are structure and technology specific and are well known for each storage system and the technologies available. Specific technologies need selection for the intended storage commodity and system.

1.7 Feasibility/Applicability at dairies

All storage systems are not universally applicable for all dairies, especially for large dairies where logistics preclude use of upright structures or Ag Bags except for special circumstances.

It is not known as to what extent the application of this technology will result in emission benefits. Therefore, prior to consideration of this technology, a comprehensive study should be undertaken which includes emissions reductions data.

1.8 Missing Data

Data can be assembled with some time and effort on likely and selected target VOC levels in silages preserved in alternative systems, technologies etc.

<u>However, it is unlikely that data will define all VOCs. Without knowing what percent the VFA is of the total VOCs it is impossible to interpret partial VOC data.</u>

Data are needed on volatilization of VOC with storage and handling of specific fermented feed production systems

1.9 Further Resources

Extension, industry practice literature

1.10 Recommendation

Since there is not much data available for emissions reduction with this technology, it should be placed in a "future evaluation" category. When more information becomes available, the applicability of this technology should be addressed at that time.

2. High Moisture Feeds: Stabilization in Ration Preparation and Feeding

2.1 Pollutants controlled or mitigated, and expected range of control efficiencies

VOC: acetic acid, butyric acid, alcohols: goal--______% control

2.2 Where technology comes from

Best management practices available for animal industries. Research and extension literature and recommendations. While there are no published recommendations that relate stabilization of high moisture feeds to VOC emissions, there are sound industry practices to enhance feed quality and reduce loss of feed volatiles for a base for these practices.

2.3 Description of technology or practice

Silage, haylage, high moisture grain (corn, milo, wheat, barley, wet byproducts (cannery wastes, corn gluten, brewers' grains), *a)* Storage system handling controls include:

1) Drive over piles
    i. Face management
    ii. Waste silage management
    iii. Cover management
2) Bunker silos
    i. Face management
    ii. Waste silage management
    iii. Cover management
3) Upright silos
    i. Unloading management
4) Linear bag storage- i.e. Ag Bag etc.
    i. Unloading management

b) Key parameters and controls:

1) Minimize exposed surface emissions
2) Minimize exposure time of removed silage/fermented feed
3) Minimize emissions in ration preparation-i.e. TMR mixing, temporary mixed ration storage and delivery
4) Minimize aerobic mold fermentation-heating and acetic production in removed fermented feeds, manufacturing, and in feed bunks/alleys
5) Minimize deterioration of wet commodities prior to feeding
6) Use aerobic mold control technologies to reduce respiration, heating and emission of volatiles in the feeds
7) Remove spoiled & waste feeds from feed alleys to prevent accelerated deterioration of newly fed rations

c) Additives and controls:

1) i.e. Calcium propionate to inhibit mold respiration and prevent heating and VOC emissions on TMR mixing and in the feed alley

2.4 Control Efficiency

The Control efficiency of these technologies are not known at this time. However, it appears that emission reductions can be achieved based on the description of this technology. More data is needed in order to estimate the control efficiency.

2.5 Considerations regarding use of the technology or practice

- Many options for handling quality fermented feeds are available, but often not all options and technologies appropriate for the unique situation are actually used.
- Good feeding quality but low VOC emission fermented feeds can be produced/handled with all storage systems; management and technology use are the keys. Minimizes fermentation end

products that volatilize in a specific feeding system is the goal, since any volatilized compound is not longer available to the cow, but may compromise the environment.
- Each storage system and feed to be preserved has unique issues on removal and feed preparation and handling which must be attended to and appropriate management and technology and additives used etc.

2.6 Cost

Costs are structure and technology specific and are well known for each storage system and ~~the~~ for technologies available for removal, feed preparation and handling. Costs/unit emission reduction are unknown.

2.7 Feasibility/Applicability at dairies

All storage systems are not universally applicable for all dairies, especially for large dairies where logistics preclude use of some structures except for special circumstances.

Feed removal, ration preparation and finished feed handling issues will also be dairy type-size specific.

It is not known as to what extent the application of this technology will result in emission benefits. Therefore, prior to consideration of this technology, a comprehensive study should be undertaken which includes emissions reductions data.

2.8 Missing Data

Data can be assembled on the efficacy of emission control technologies (such as calcium propionate) in feed manufacture and bunk/feed alley emissions

Data are needed on volatilization of VOC with removal, feed manufacturing and handling of fermented feeds from specific fermented feed production systems.

Available land in the production area dictates to some extent potential viable options for wet and dry feed storage.

2.9 Further Resources

Extension, industry practice literature

2.10 Recommendation

Since there is not much data available for emissions reduction with this technology, it should be placed in a “future evaluation” category. When more information becomes available, the applicability of this technology should be addressed at that time.

3. Nutritional Management: Feed Additives

3.1 Pollutants controlled or mitigated, and expected range of control efficiencies

VOC: ______% control

3.2 Where technology comes from

Research and extension literature and recommendations
Vendor technology information

3.3 Description of technology or practice

Management of cows to minimize digestive imbalance is critical and is the most effective method to minimize emissions. Feed additives are a group of feed ingredients that ~~can~~ may cause a desired animal response in a non-nutrient role such as pH shift, growth, or metabolic modifier. An improvement in animal productivity commonly results in an improvement in milk/unit feed and as a result, likely reduced emissions/unit milk produced. An improvement in normalization to steady state in rumen function is the goal, synchronizing production and absorption of metabolites including potential VOC (i.e. acetic). Further, enhanced digestion of structural components (i.e. fiber) leaves less material available for and/or needing later regurgitation in rumination, thus limiting opportunities for volatilization of any attached VOC. Examples of some mechanisms include:

- Stimulate rumen microbial synthesis of protein and/or alter volatile fatty acid (VFA) production
- Increase digestion in the digestive tract
- Stabilize rumen environment and pH

a) Examples of some categories of feed additives for dairy cows include:

1) Fermentation modifiers - Monensin (rumensin)

   i Function: Improve feed efficiency for lactating cow, reduce ketosis and displaced abomasums in transition cows by shifting rumen fermentation and microbial selection

   ii Feeding Strategy: Feed to dry cows (reduce metabolic disorders) and lactating cow (feed efficiency) while monitoring milk components to evaluate optimal levels of monensin.

2) Enzymes (fibrolytic)

i Function: Increase fiber digestibility by reducing fiber (cellulase and xylanase enzyemes) and DM intake

ii Feeding Strategy: Increase fiber digestibility, treated 12 hours before feeding, spray on product more effective when applied to dry diets, and may be diet specific

3) Buffers-alkalizers-flow agents Sodium bicarbonate/sodium sesquicarbonate (buffer)

i Function: Increase dry matter intake and stabilize rumen pH.

ii Feeding Strategy: Feed 120 days postpartum with diets that are high in corn silage (over 50%), wet rations (over 55% moisture), lower fiber ration (<19% ADF), little hay (<5 lb), finely chopped forage, pelleted grain, slug feeding, and heat stress conditions.

4) Microbial inoculants- **Example-**Aspergillus oryzae

i Function: Stimulate fiber-digesting bacteria, stabilize rumen pH, and reduce heat stress.

ii Feeding Strategy: High grain diets, low rumen pH conditions, and under heat stress (cows) and calves receiving a liquid diet

5) Probiotics, yeasts and chelators –

Bacterial direct-fed microbes

i Function: Produce metabolic compounds that destroy undesirable organism, provide enzymes improving nutrient availability, or detoxify harmful metabolites

ii Feeding Strategy: Feed to calves on liquid diet, transition cows, and during stress conditions

Yeast culture and yeast

iii Function: Stimulate fiber-digesting bacteria, stabilize rumen environment, and utilize lactic acid.

iv Feeding Strategy: Two weeks prepartum to ten weeks postpartum and during off-feed conditions and stress

Yucca extract

v Function: Decrease urea nitrogen in plasma and milk by binding ammonia to the glycofraction extract of Yucca shidigera plant improving nitrogen efficiency in ruminant animals.

vi Feeding strategy: To cows with high BUN and MUN levels

3.4 Control Efficiency

The Control efficiency of this technology is not known at this time. However, it appears that emission reductions can be achieved based on the description of this technology. More data is needed in order to estimate the control efficiency.

3.5 Considerations regarding use of the technology or practice

- Many feed additives are available, with differing functions, and most have some utility in some or many dairy enterprises. Current usage is dependent on cost effectiveness and technology application.
- Improving milk production/cow and per unit feed would be expected to impact emissions/unit milk, if not also/cow.
- Some additives will have a more direct effect on specific VOC than others- i.e. monensin reduces the fraction of acetic in the rumen for potential volatilization during rumination.
- Improving rumen function and digestive function is expected to reduce fermentable excreted nutrients in the waste, reducing downstream VOC generation potential.

3.6 Cost

Costs are technology specific and are well known for each of the technologies available. Some are documented previously in 3.3.

3.7 Feasibility/Applicability at dairies

All technologies mentioned find use at some dairies. Further reasons for use, such as emissions reductions if documented, will increase adoption. Some technologies may not have the potential of reducing emissions. ~~Need to only discuss technologies that have the potential of reducing emissions.~~

Since there is not much data available for emissions reduction with this technology, it should be placed in a “future evaluation” category. When more information becomes available, the applicability of this technology should be addressed at that time.

3.8 Missing Data

Data can be assembled on the efficacy of additives for intended functions in dairy productivity.

Data are needed on impacts on emissions/cow and emissions/unit milk for most technologies.

3.9 Further Resources

Extension, industry practice literature

3.10 Recommendation

Feed additives have a tremendous potential in the future to improve efficiencies of feed conversion to animal product. However, at this point there is insufficient information available and insufficient knowledge about the animal chemistry to determine if additives are effective at altering or reducing gaseous emissions from either the animal or the entire production system. Since there is not much data available for these technologies, they should be placed in a "future evaluation" category. When more information becomes available, the applicability of these technologies should be addressed at that time.

4. Nutritional Management: Protein Supply: Sources, Types, and Amounts

4.1 Pollutants controlled or mitigated, and expected range of control efficiencies

VOC, NH_3: _____%control

4.2 Where technology comes from

Research and extension literature and recommendations

4.3 Description of technology or practice

- Protein is derived from many sources, and has complex functions in dairy animals. Feeding management takes into account the types and rates and extent of availability in the cow for rumen function as well as for absorption as amino acids from the small intestine. Requirements differ with stage and level of lactation.

- Feedstuffs can be and commonly are selected based on protein profiles for criteria such as degradability, DIP, UIP etc. and when applied in a formulation system, rations are built accordingly.

- Some feed additives, such as yucca, specifically target rumen protein utilization.

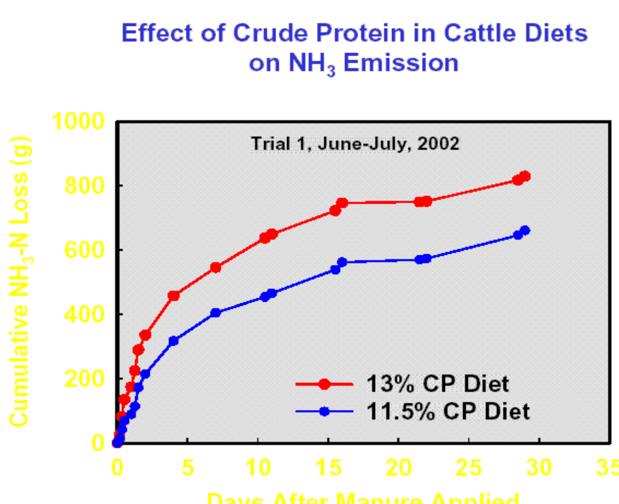
- Fine-tuning of protein feeding strategies is required to improve protein utilization and reduce waste emissions of VOC and NH_3.
  - This can be accomplished through "string feeding" or through more detailed nutritional management of targeted amino acid and carbohydrate availablity in the rumen or in the small intestine to best utilize feed nutrients to convert to animal product (milk).
  - Rumen undegradeable protein can be manipulated under some feeding regimes to target carbohydrate and amino acid ratios at specific locations in the digestive tract.
  - The National Research Council has previously had recommendations (1989) for feeding dairy animals.

Milk urea N (string or bulk tank sample) is an effective measure of herd protein optimization if milk urea N is above thresholds

Protein escaping the cow in the feces is a substantial source for fermentative VOC production in manure management systems. Nitrogen loss as urea in the urine is a major source of ammonia in waste management systems. Systems to optimize protein nutrition of dairy cows are complex and put in practice to variable degrees. Major opportunities exist to improve this.

4.4 Control Efficiency

The control efficiency of these technologies is not known at this time. It does appear that emission reductions can be achieved based on the description of these technologies. Also, the graph below shows that a significant amount of ammonia reductions can be achieved by reducing the amount of crude protein by a small percentage. However, how much protein reduction and what impacts protein reduction has on animal health or milk production have yet to be evaluated. Therefore, more data needs to be collected before a control efficiency can be estimated.



4.5 Considerations regarding use of the technology or practice

- To impact type of protein supplied, changes in silage preservation to reduce protein breakdown and soluble N, as well as in selection of feeds are required.
- While it is technically feasible to supply individual amino acids, cost effectiveness is another issue.
- Scientific understanding of limiting amino acids under a wide array of diets is missing.
- Diet formulation is not the same as feed consumption.
- It is unknown what changes in diet will ultimately accomplish regarding total facility emissions.
- Dietary manipulation can reduce N intake and theoretically reduce N excretion as well as alter composition of urinary excreta. However, this may not translate to changes in N emissions at the facility.
- Grouping cows by production strings (2-3 lactating, plus dry cows) and developing rations accordingly will improve overall protein optimization for the dairy enterprise and reduce protein in wastes. Not all dairies are currently set up to do this.
- Milk urea N (string or bulk tank sample) is an effective measure of herd protein optimization within certain bounds

4.6 Cost

Costs of feedstuff and protein sources are available on a site specific basis. Limiting of certain feedstuffs may increase costs. It is assumed that altering diets will result in increased costs. Cost per unit of N reduction are not known as the more detailed net system change in emissions is unknown. Costs associated with altering carbohydrate digestion and the consequences on subsequent VOC emissions are not known.

4.7 Feasibility/Applicability at dairies

Usually a consulting nutritionist/feed ingredient provider develops the rations for typical commercial dairies using a variety of computer driven ration formulation technologies to meet specific dairy objectives. Some consulting nutritionists already employ stringent protein considerations to target carbohydrate and protein availability in the rumen and post ruminally. All consultants could use this methodology.

Changing protein feedstuffs requires changes in feed storage and handling facilities, and not all strategies can be employed at all dairies.

More data is needed before these technologies can be considered feasible on dairies. However, at minimum, dairies should not overfeed protein to their cows based on the National Research Counsel (NRC) recommended nutrient requirements. Therefore, prior to consideration of this technology, a comprehensive study should be undertaken which includes emissions reductions data.

4.8 Missing Data

Data can be assembled on the efficacy of alternative protein management strategies for dairies as these relate to production and animal performance.

Data are needed on impacts of these strategies on VOC emissions/cow and emissions/unit milk for most protein strategies

4.9 Further Resources

Extension, research publications, industry practice literature. Many of these sources are available to familiarize the reader with NRC and other industry based recommendations and optimize cost per unit of production. However, limited information documents gaseous emissions such as ammonia or VOC either from the animal or the wastes.

4.10 Recommendation

Since there is not much data available for emissions reduction with this technology, it should be placed in a “future evaluation” category. When more information becomes available, the applicability of this technology should be addressed at that time. However, at minimum, dairies should not overfeed protein to their cows based on the National Research Counsel (NRC) recommended nutrient requirements

5. Nutritional Management: Structural carbohydrate (Fiber) Supply: Sources, Types, and Amounts

5.1 Pollutants controlled or mitigated, and expected range of control efficiencies

VOC, NH_3: _____%control

5.2 Where technology comes from

Research and extension literature and recommendations

5.3 Description of technology or practice

❖ High quality forages are a key component in dairy enterprises. The type, characteristics and availability of the fiber components supplied are key criteria.

- Corn silage and alfalfa are perhaps the most universal dairy forages in US production enterprises, and the ratio of the two forages produce specific implications for other nutritional management strategies such as types of protein supplementation feasible, maximum level of fat feeding, utility of additives etc.
- Animal diets are formulated to meet specific constraints for many parameters. Structural carbohydrate components(fiber) (cellulose, hemicellulose, lignin, and pectin) serve as energy sources to rumen microflora. Those not digested in the rumen are available for decomposition once excreted from the animal.
- The balancing of dietary fiber to optimize animal productivity and minimize excreted fiber is an evolving area of science.
- Fiber is derived from many sources, and has complex functions in dairy animals. Current feeding management takes into account the types and rates and extent of availability in the cow for rumen function. Requirements differ with stage and level of lactation.
- Feedstuffs can be and commonly are selected based on forage and feedstuff fiber profiles for criteria such as NDF, ADF, digestibility, etc. and when applied in a formulation system, rations are built accordingly.
- Fine-tuning of fiber feeding strategies is required to improve energy utilization and reduce waste emissions fermentable fiber that can produce VOC in the waste stream.
- Fermentable fiber escaping the cow in the feces is a substantial source for fermentative VOC production in manure management systems. Systems to optimize fiber nutrition of dairy cows are complex and put in practice to variable degrees.
- Some feed additive technologies as well as silage additive technologies (i.e. fibrolytic enzymes) target fiber utilization specifically, and inclusion of these technologies in rations would be expected to reduce fermentable fiber output in the waste, but also enhance productivity and perhaps emissions from the cow.

5.4 Control Efficiency

The Control efficiency of this technology is not known at this time. However, it appears that emission reductions can be achieved based on the description of this technology. More data is needed in order to estimate the control efficiency.

5.5 Considerations regarding use of the technology or practice

- To impact type of and availability of the fiber supplied, changes in selection and criteria for purchase of feeds are required.
- Systems to optimize fiber nutrition of dairy cows are complex and put in practice to variable degrees. Impact on emissions is unknown as with other technologies

- Grouping cows by production strings (2-3 lactating, plus dry cows) and developing rations accordingly will improve overall fiber utilization for the dairy enterprise and reduce available fiber in wastes. Not all dairies are currently set up to do this.

5.6 Cost

Costs of feedstuff are source specific and are known for given locations. Feed costs change based on availability, transportation costs, and weather conditions throughout the Midwest. There are no total-system data available to determine emission reductions from the entire animal system given specific dietary manipulations.

5.7 Feasibility/Applicability at dairies

Usually a consulting nutritionist/feed ingredient provider develops the rations for typical commercial dairies. It may not be possible to maintain herd performance and alter manure composition, without additional cost.

Changing fiber source feedstuffs requires changes in feed storage and handling facilities, and not all strategies can be employed at all dairies. The primary fiber in diets is alfalfa and corn silage or winter cereal silages, with usually a smaller fraction of dietary fiber coming from sources such as whole cottonseed and other available fiber byproducts.

It is not known as to what extent the application of this technology will result in emission benefits. Therefore, prior to consideration of this technology, a comprehensive study should be undertaken which includes emissions reductions data.

5.8 Missing Data

Data can be assembled on the efficacy of alternative forage and fiber management strategies for dairies as these relate to animal performance and productivity.

Data are needed on impacts of these strategies on VOC emissions/cow and emissions/unit milk for most feedstuff/fiber strategies

5.9 Further Resources

Extension, research publications, industry practice literature. Many of these sources are available to familiarize the reader with NRC and other industry based recommendations and optimize cost per unit of production. However, limited information documents gaseous emissions such as ammonia or VOC either from the animal or the wastes.

5.10 Recommendation

Since there is not much data available for emissions reduction with this technology, it should be placed in a “future evaluation” category. When more information becomes available, the applicability of this technology should be addressed at that time.

6. Nutritional Management: Non-fiber carbohydrate Supply

6.1 Pollutants controlled or mitigated, and expected range of control efficiencies

VOC, NH_3: _____%control

6.2 Where technology comes from

Research and extension literature and recommendations.

6.3 Description of technology or practice

- Processed feed grains, forages and feed byproducts supply Non-fiber carbohydrates, NFC, which are rapidly digested and include starch, sugars and pectin. NFC sources are a key component in dairy enterprises. The type, characteristics and availability of the NFC components supplied are key criteria.

- NFC is derived from many sources, and has complex functions in dairy animals. Grain processing and feeding management takes into account the types and rates and extent of availability in the cow for rumen function, and for lower gut absorption. Processing grain through steam flaking or dry rolling are examples. Requirements for animals differ with stage and level of lactation.

- Feedstuffs and processing are selected based on NFC profiles and for criteria such as rate of digestion, extent of digestion, energy value etc. and when applied in a formulation system, rations are built accordingly.

- Fine-tuning of non-fiber carbohydrate feeding strategies is required to improve energy utilization and may reduce waste emissions especially when diets high in fermentable carbohydrate-starch etc. are fed that can produce VOC in the waste stream. If more digestion occurs in the rumen there will be more gases created in the rumen and potentially emitted from the animal.

- Fermentable carbohydrate including starch as well as other plant carbohydrates escaping the cow in the feces ~~can~~ may be a substantial source for fermentative VOC production in manure management systems. Systems to optimize carbohydrate nutrition of dairy cows are complex and put in practice to variable degrees.

- ❖ Some feed additive technologies as well as silage additive technologies (i.e. starch enzymes) target carbohydrate utilization specifically, and inclusion of these technologies in rations would be expected to reduce fermentable carbohydrate output in the waste.

6.4 Control Efficiency

The Control efficiency of this technology is not known at this time. However, it appears that emission reductions can be achieved based on the description of this technology. More data is needed in order to estimate the control efficiency.

6.5 Considerations regarding use of the technology or practice

- o To impact type of and availability of the feed grain and other NFC sources supplied, changes in selection and criteria for purchase of and processing of feeds are required.

- o Grain storage and high moisture grain, precludes use of other processing strategies, and requires specific storage structures.

- o Grouping cows by production strings (2-3 lactating, plus dry cows) and developing rations with carbohydrate levels appropriate to specific production groups ~~is required~~may reduce carbohydrate in wastes. Not all dairies are currently set up to do this.

6.6 Cost

Costs are feedstuff and source specific and are known.

6.7 Feasibility/Applicability at dairies

Usually a consulting nutritionist/feed ingredient provider develops the rations for typical commercial dairies.

Changing feedstuffs such as grains and grain processing methods requires changes in feed storage and handling facilities, and not all strategies can be employed at all dairies.

It is not known as to what extent the application of this technology will result in emission benefits. Therefore, prior to consideration of this technology, a comprehensive study should be undertaken which includes emissions reductions data.

6.8 Missing Data

Data can be assembled on the efficacy of alternative NFC carbohydrate management strategies for dairies, although these data typically do not provide input regarding VOC emissions from the feed, the animal, or the manure stream

Data are needed on impacts of these strategies on VOC emissions/cow and emissions/unit milk for most feedstuff strategies

6.9 *Further Resources*

Extension, research publications, industry practice literature

6.10 *Recommendation*

Since there is not much data available for emissions reduction with this technology, it should be placed in a "future evaluation" category. When more information becomes available, the applicability of this technology should be addressed at that time.

7. Nutritional Management: Supplemental fats

7.1 *Pollutants controlled or mitigated, and expected range of control efficiencies*

VOC, _____%control

7.2 *Where technology comes from*

Research and extension literature and recommendations

7.3 *Description of technology or practice*

- ❖ Increased nutrient density of diets may result in less manure solids produced. Supplemental fats or feedstuffs high in oil content are commonly included in dairy diets. Inclusion rate depends on type of fat or oil used and other dietary ingredients present. Supplementing cows with fat ~~can~~ may have several beneficial effects. It usually increases the energy density of the diet as starch or fiber is replaced with fatty acids.

- ❖ Fats and oils of several types are used in dairy enterprises. The most commonly fed supplemental fats in dairy cow diets include whole cottonseeds, whole soybeans, rendered fats (tallows and yellow grease), and ruminally inert fats such as calcium salts of palm oil (e.g. Megalac). Processing is required for some seeds such as canola. Whole sunflower seeds are also fed where available.

7.4 *Control Efficiency*

The Control efficiency of this technology is not known at this time. However, it appears that emission reductions can be achieved based on the description of this technology. More data is needed in order to estimate the control efficiency.

7.5 Considerations regarding use of the technology or practice

- Changes in selection and criteria for purchase of and processing of feeds are required to impact type of and availability of the fat sources supplied,
- Fats ~~included~~ stored as liquids require specific storage structures and handling facilities.

- Grouping cows by production strings (2-3 lactating, plus dry cows) and developing rations accordingly will allow optimal fat inclusion/utilization for the dairy enterprise and reduce rumen acetic production and available carbohydrate excreted in wastes. Not all dairies are currently set up to do this.

7.6 Cost

Costs are feedstuff and fat source specific and are known.

7.7 Feasibility/Applicability at dairies

Usually a consulting nutritionist/feed ingredient provider develops the rations for typical commercial dairies.

Changing feedstuffs such as whole oilseeds or liquid fat inclusion requires changes in feed storage and handling facilities, and not all fat feeding strategies can be employed at all dairies.

It is not known as to what extent the application of this technology will result in emission benefits. Therefore, prior to consideration of this technology, a comprehensive study should be undertaken which includes emissions reductions data.

7.8 Missing Data

Data can be assembled on the efficacy of alternative fat supplementation under certain management strategies

Data are needed on impacts of these strategies on VOC emissions/cow and emissions/unit milk for most fat and whole oilseed feedstuff strategies

7.9 Further Resources

Extension, research publications, industry practice literature

7.10 Recommendation

Since there is not much data available for this technology, it should be placed in a “future evaluation” category. When more information becomes available, the applicability of this technology should be addressed at that time.

VIII. LIQUID MANURE MANAGEMENT

A. Description

The liquid manure management system consists of many components. These components can vary from dairy to dairy. However, a simple description of these systems include a solids separation system, such as a mechanical separator, settling basin, or weeping wall. These separation systems are further explained below. After separation, the liquid manure is sent to a lagoon or a storage pond for either treatment or storage. Some dairies may have multiple lagoons and storage ponds. The supernatant from the lagoon or storage pond is either applied to land for irrigation of crops and/or used to flush the concrete feeedlanes from the cow housing. Other systems that are a part of the liquid manure management system may include processing pits, which are explained in detail below.

Emissions from these systems are mainly generated by anaerobic digestion consisting of methane and CO2 as primary gases and VOC, ammonia, and hydrogen sulfide gases as secondary gases.

B. Control Technologies/Practices for Liquid Manure Management

1. Injection and/or spreading/incorporation of fresh manure (replaces flushing, separation and lagoons)

1.1 Pollutants targeted and expected range of control efficiency

VOC and NH_3. Reductions of ammonia are expected but cannot be quantified with available information. Unclear if VOC emissions are increased or decreased, however very small emissions following incorporation.

1.2 Where technology comes from

Currently in use on at least two dairies in California as a primary method of manure management. Also used in other livestock industries during application of manure whether fresh or stored. Injection is also used in the municipal waste treatment industry to dispose of biosolids (although the character of municipal biosolids should not be considered equivalent to dairy manure).

1.3 Description of technology or practice

Fresh manure is vacuumed or scraped daily or several times daily from concrete lanes in cattle housing. The manure (in a liquid/slurry form) is then injected (via injector equipment) into fallow cropland and/or spread onto cropland and later incorporated into the soil.

The technology impacts emissions in several ways although the overall system impacts are unclear:

- By <u>removing</u> fresh manure from the lanes on a regular basis, emissions from that manure are ***<u>relocated to</u>*** other portions of the dairy. In a standard California dairy, this is accomplished by regular flushing with water toward a series of solids separation and liquid storage basins.
- By substituting scraping/vacuuming for flushing and relocating the manure to alternate disposal (application to fields) the emissions are also ***<u>relocated from</u>*** the flush lanes, separation basins/separated solids piles and retentions ponds to the fields.
- The technology (or management practice) impacts emissions by incorporating manure into soil, thus presumably changing its character and moisture content and providing either a partial or complete layer separating the manure from the air. This can reduce the ability of the ambient air to carry away emissions through convection and evaporation. However it may also reduce exposure to oxygen, thus changing the character of biologic decomposition and resulting emissions. Some emissions such as ammonia have a high affinity for adsorption to soil particles and therefore their release to the air may be reduced.

1.4 Control efficiency

Extremely limited data is available to determine control efficiency and most available information points only to a narrative description of expected control efficiency impacts.

<u>Ammonia</u>
Based on current knowledge of soil and manure chemistry, reduction of atmospheric ammonia emissions is very likely. Ammonia is produced when urease in feces combines with urea in urine, and this ammonia is released to air when placed in conditions that allow it to volatilize. Immediate application to soil (within 1 day of excretion) is expected to reduce the opportunity for volatilization, compared to the flush system where there is an ongoing opportunity through the solids separation system, drying separated solids piles, and evaporation/volatilization from the retention pond, as well as additional volatilization during lane flushing and fertigation/irrigation using lagoon water. When applied to soil via injection or incorporation, ammonia is expected to adsorb to soil particles and remain in the soil until it is utilized by plants or otherwise breaks down into other nitrogen compounds. However, some DPAG members contend that there is insufficient data to support a quantification of this reduction compared to free-stall flush systems. Therefore, they recommend that the control efficiency for ammonia should only be

reported as falling within a range of between 0 and 100 percent, at this time.

Other DPAG members suggest that a control efficiency can be estimated using the following calculations:

Vacuuming and immediate injection instead of flushing does not necessarily relocate emissions from one area (settling basins, storage ponds, lagoons, etc from the flush) to another (manure application to land). Different conditions exist in both areas, the settling basins, storage ponds, and/or lagoons are anaerobic systems, which continuously emit by-products of anaerobic digestion, while land application of manure can consist of both aerobic and anaerobic conditions, hence creating less emissions. As discussed above, ammonia, when applied to soil via injection or incorporation, is expected to adsorb to soil particles and remain in the soil until utilized by plants or otherwise is broken down by soil microbes into other nitrogen compounds. Therefore, it can be assumed that by eliminating the settling basins, lagoons, and storage ponds, a complete source of emissions from the dairy can be eliminated.

By eliminating the liquid manure management system, the immediate control efficiency of vacuuming instead of flushing can be calculated as follows:

Total Dairy Emission Factor: 74 lbs/hd-yr
Liquid Manure Management System: 15.5 lbs/hd-yr[6]

Control efficiency$_{\text{Elimination of Liquid manure}}$ = 1- (74 lbs/hd-yr – 15.5 lbs/hd-yr / 74 lbs/hd-yr) = 20.9 **%**

There is an additional emissions reduction from vacuuming and immediately injecting the manure into the soil. Though emission reductions would be expected to be higher from manure injection than from manure incorporation, some DPAG members suggest that a similar control efficiency can be applied to this technology based on an emissions study at a Kern County dairy which evaluated the reductions of VOC and ammonia emissions from the immediate incorporation of manure through a discing process. The emissions reductions shown from that study are as follows:

58.3 % VOC
82% H2S
97.9 % ammonia

[6] Based on the District Draft Breakdown of Dairy Emission Factor document

In order to be somewhat conservative (see explanation under VOC calculation), the following control efficiencies will be applied (assuming 0-50%15% discounted reduction for each pollutant);

29 – 508 % VOC

41 - 7082 % H_2S

49 – 8397.9 % ammonia

Therefore, the emissions reduction from land application would be as follows:

Based on 49% CE

Emission Reduction$_{\text{immediate incorporation}}$ = 24.8 lbs/hd-yr x 830.49% = 20.612.2 lbs/hd-yr

Based on 97.9% CE

Emission Reduction$_{\text{immediate incorporation}}$ = 24.8 lbs/hd-yr x 0.979 = 24.3 lbs/hd-yr

CE$_{\text{immediate incorporation}}$ = 1 – (74 lbs/hd-yr – 20.6 lbs/hd-yr / 74 lbs/hd-yr) = 27.8%

Total dairy-wide emissions reductions can then be calculated as follows:

1 - ((74 lbs/hd-yr – 15.5 lbs/hd-yr – 20.612.2 lbs/hd-yr) ÷ 74 lbs.hd-yr) x 100 = **48.837.4%**

1 - ((74 lbs/hd-yr – 15.5 lbs/hd-yr – 24.3 lbs/hd-yr) ÷ 74 lbs.hd-yr) x 100 = **53.8%**

The above estimates isare based on the best available data at this time and is are expected to be refined with new research as it becomes available.

VOC

Some DPAG members maintain that since it is unclear, given the available information, whether incorporation or injection would reduce or increase VOC emissions compared to a baseline free-stall flush facility and that under these circumstances quantification of reduction or increases is not possible.

Like flushing, the act of vacuuming or scraping concrete feed lanes would remove manure from those areas, thus at minimum relocating VOC emissions from manure decomposition to other areas of the facility. Thus emissions in the cattle housing area may be comparable under either scenario; however the frequency of cleaning and the addition of water in one system might play a role in altering emissions. However it is unclear whether there would be any substantial differences.

Removal of the manure and spreading it on land, then incorporating, or injecting the manure, may change the overall fraction of volatile solids that end up being degraded under anaerobic conditions (compared to storage in the traditional flush system). That is, more (or less) of the manure may decompose under conditions that are more aerobic or partially aerobic, than in a more standard frees-tall flush system. If these “more aerobic” conditions reduce production of VOCs from manure decomposition (they would be expected to reduce methane production but not??? other non-methane hydrocarbons formed by different microbial processes), then this system might produce fewer VOCs. However, because anaerobic systems contain more methanogenic activity and may in fact preferentially convert carbon and hydrogen to methane instead of other VOCs, very anaerobic systems may produce fewer “reactive” VOCs than partially aerobic systems.

Another way of putting this: totally anaerobic and totally aerobic systems are expected to produce fewer (non-methane) VOCs. However it is very difficult to evaluate, given the lack of available data, which system (injection, incorporation or standard flush) would be more efficient at *avoiding the* production of VOCs.

While the overall production of VOC per unit of volatile solids in the compared systems is unclear, the “trapping efficiency” of either system is also difficult to evaluate. For example, neither system would be expected to trap methane. Methane is highly insoluble in water but also is highly stable and would not be expected to remain in the soil or react with soil particles.

However, other VOCs would be expected to have a wide variety of physical and chemical properties and their ability to be impacted by incorporation would vary accordingly. There is anecdotal evidence to suggest that soil incorporation would capture some fraction of the VOCs produced. This concept is based on several assumptions:

- Some fraction of odors includes VOCs (although odors and VOCs are not good surrogates for each other).
- Some fraction of VOCs are volatile fatty acids (VFAs). Some VFAs, such as acetic acid, have a high affinity to adsorb to soil particles – thus some fraction of emissions reduction might be assumed.
- At least one study indicates that a fraction of VOCs (C_3 to C_6 compounds) dropped to non-detects shortly after incorporation (approximately 1 day). While it is not clear whether the reduction was a result of incorporation itself or whether the reduction would have

occurred anyway, there appears to be a correlation. Based on the study, this last statement is false. The study showed through both pre-project and post-project measurements that there was actually a reduction.

Similarly the liquid system might in some cases inhibit emissions of VOC (or encourage them). For example, some VFAs such as acetic acid are hydrophilic. This may have the impact of retaining the VFAs in lagoon water, increasing their residence time and the likelihood they will be converted to methane by methanogens.

Despite the anecdotal evidence, it is not possible with the available evidence to determine whether a VOC reduction would occur in this system compared to a baseline (freestall flush). Therefore, control efficiency for VOC at this time can only be reported as a range, somewhere between 0 and 100 percent, with the possibility that emissions would actually increase.

Some DPAG members suggest that vacuuming and immediate injection instead of flushing does not necessarily relocate emissions from one area (settling basins, storage ponds, lagoons, etc from the flush) to another (manure application to land). Different conditions exist in all areas, the settling basins, storage ponds, and/or lagoons are anaerobic systems, which continuously emit by-products of anaerobic digestion (VOC, ammonia, H2S), while land application of manure is a combination of both aerobic and anaerobic conditions. Not every system in the liquid manure management system is designed to minimize VOC production and methane formation. Settling basins have a propensity of having incomplete anaerobic digestion, thereby generating emissions. Typical lagoon systems and storage ponds are also not designed accordingly (NRCS guidelines - anaerobic treatment lagoon) to minimize VOC production. Therefore, it can be assumed that by eliminating the settling basins, lagoons, and storage ponds, a complete source of emissions from the dairy can be eliminated.

By eliminating the liquid manure management system, the immediate control efficiency of vacuuming instead of flushing can be calculated as follows:

Total Dairy Emission Factor: 19.3 lbs/hd-yr
Liquid Manure Management System: 2.3 lbs/hd-yr[7]

Control efficiency$_{\text{Elimination of Liquid manure}}$ = 1- (19.3 lbs/hd-yr – 2.3 lbs/hd-yr / 19.3 lbs/hd-yr) = 11.9 %

[7] Based on the District Draft Breakdown of Dairy Emission Factor document

There is an additional emissions reduction from vacuuming and immediate injection of the manure into the soil. Though emission reductions would be expected to be higher from manure injection than from manure incorporation, a similar control efficiency can be applied to this technology based on an emissions study at a Kern County dairy which evaluated the reductions of VOC and ammonia emissions from the immediate incorporation of manure through a discing process (reference). The emissions reductions shown from that study are as follows:

58.3 % VOC
82% H2S
97.9 % ammonia

This study did not analyze all the VOC compounds at a dairy such as VFAs, phenols, and amines; however, both the pre-manure incorporation and post-manure incorporation tests were performed. It would be anticipated that similar reductions would have been achieved for the compounds not measured in the study. In spite of this, in order to be conservative, the following control efficiencies will be applied (assuming ~~15%~~0-50% discounted reduction for each pollutant);

29 - 58 % VOC

41 - 82% H_2S
49 – 97.9% ammonia~~50 % VOC~~
~~70 % H_2S~~
~~83 % ammonia~~

Therefore, the emissions reduction from land application would be as follows:

Based on 29% CE

Emission Reduction$_{\text{immediate incorporation}}$ = 3.7 lbs/hd-yr x ~~50%~~0.29 = 1.0~~8~~7~~5~~ lbs/hd-yr

Based on 58% CE
Emission Reduction$_{\text{immediate incorporation}}$ = 3.7 lbs/hd-yr x 0.58 = 2.15 lbs/hd-yr

~~CE$_{\text{immediate incorporation}}$ = 1 – (19.3 lbs/hd-yr – 1.85 lbs/hd-yr / 19.3 lbs/hd-yr) = 9.6 %~~

Total dairy-wide emissions reductions can then be calculated as follows:

1 - ((19.3 lbs/hd-yr – 2.3 lbs/hd-yr – 1.0785 lbs/hd-yr) ÷ 19.3 lbs.hd-yr) x 100 = **21.517.5%**

1 - ((19.3 lbs/hd-yr – 2.3 lbs/hd-yr – 2.15 lbs/hd-yr) ÷ 19.3 lbs.hd-yr) x 100 = **23.1%**

The above estimates isare based on the best available data at this time and areis expected to be refined with new research as it becomes available.

1.5 Considerations

It appears very likely that land application and incorporation will produce less methane than a conventional lagoon system. This is evidenced by what we know about the process necessary to create methane (moisture and oxygen deprivation combined with presence of methanogens and a feedstock containing carbon and hydrogen). Clearly lagoon conditions would be more favorable than soil application, where it is far more likely that soil and feedstock would dry out, inhibiting methanogenic activity during the dry season. Whether this is a “pro” on balance will depend on what metabolites are formed instead of methane as the manure feedstock decomposes, and whether those metabolites are captured in the soil in its capacity to function as a “biofilter.”

Incorporation and injection would almost certainly reduce atmospheric emissions of ammonia, particularly when the incorporation is complete and rapid (less so when the manure is allowed to dry partially or fully before incorporation although doing so may provide other benefits). It also may eliminate or reduce the reliance on lagoons and thus eliminate some costs related to lagoons as well as separation systems (settling basins, weeping walls, mechanical separators and screens or combinations of these technologies). This system may reduce water storage needs and thus reduce risk related to wastewater storage. It may also reduce water quality concerns and management issues (but only those water quality concerns related to lagoons and settling basins).

Scraped or vacuumed manure can also be directly taken into a plug flow digester considering fresh manure is already at the ideal moisture content for plug flow digester(s).

On most dairies this system will not be feasible to fully replace a free-stall flush lagoon system. Success of incorporation/injection as a *primary* liquid manure management strategy requires available land year-round for application of manure. Whether or not sufficient land is available involves consideration of several factors:

- Are general climate conditions arid enough to guarantee ability to move heavy equipment over cropland during all or most of the year? If not, where and how will manure be stored until it can be applied?
- Is there sufficient land available such that at all times some land is fallow or has a crop that won't be harmed by application of manure?
- Do climate and other conditions support growing crops year-round to allow uptake of the manure nutrients by plants in a timely manner?
- Does incorporation of manure into the soil change nutrient management plans in a way that would require more land/crop activity to achieve a nutrient balance due to reduced losses of ammonia to volatilization?

It is clear that for most dairies currently operating in California, it would be challenging to implement this system as a primary method of liquid manure management. This could potentially be addressed by allowing for manure storage during the wet season; however, this would increase costs by essentially requiring the dairy producer to keep up two primary manure management systems. And it would still be only a temporary solution, requiring that sufficient land was available to allow "catch up" application following the wet season.

Land application/injection of fresh manure also may preserve a higher percentage of the manure nitrogen than application of manure that has been aged or otherwise treated. Thus, risk to groundwater (due to increased input of nitrogen into the soil) may increase and require additional management, which may also increase costs.

This system will require capital costs for purchasing equipment to collect and apply manure, as well as ongoing fuel and maintenance costs for the equipment, and labor costs to operate the equipment on a daily basis. This may compare unfavorably to flushing, which has a low amount of associated labor costs. However, maintenance and energy costs also accrue to equipment used in a flush system, such as pumps and solids separators.

There may also be some offsets of pollution creation to be traded for pollution reduction. Running additional equipment (scrapers, vacuums, injectors) will involve burning fuel, usually diesel, which will result in some emissions of pollutants such as nitric oxides and particulates. In comparison, most flush lane water is moved by electric pumps that essentially have no emissions.

1.6 Cost

We were unable to locate comprehensive cost data for this technology, partly because it has not been widely implemented as a control measure.

Few dairy farmers are utilizing this method and so a range of costs is not available.

Factors to consider include sharply increased labor costs to accomplish daily manure collection with equipment compared to the less labor-intensive method of flushing. This may also result in increased fuel costs and will result in increased equipment costs, including specialized equipment that may have no other productive use on the facility (such as vacuuming and injection equipment). There may be partially offsetting labor and energy savings in reduced needs to maintain lagoons, separation basins or mechanical separators.

In one case study, a California dairy producer reported capital costs for equipment of about $156,000 including a vacuum truck to remove manure from lanes and a dedicated tractor; this amounts to about $36 per cow. In addition, the same producer reported labor, fuel and equipment maintenance/depreciation costs totaling $267,000 annually, or about $61 per cow. It is clear, however, that a comparative cost analysis might include additional factors, such as additional land application area if needed, redundant manure storage systems, etc.

For example, this method of manure recycling would be likely to require less use of water and might therefore reduce lagoon capacity needs. However, because adequate fallow cropland (or otherwise available land) would be needed at all times, the cost could include sufficient land acquisition, potentially more than needed with a standard flush-lagoon system.

This method may increase the amount of available nitrogen (in the ammonia form) to crops by reducing the opportunity for ammonia to volatilize prior to manure application. This could reduce fertilizer costs. At the same time, this may also affect the producer's ability to manage for groundwater quality protection, resulting in additional costs to realize that protection.

1.7 Feasibility at dairies

Ammonia

In general, land application and injection is technologically feasible for reduction of ammonia, but some DPAG members believe there is no data to support a quantification of the reduction of those emissions, while others do. This technology/practice may not be technologically feasible in all cases. For example, a dairy without sufficient year-round access to land may not be able to implement this technology. Land application/injection should always undergo a site-specific evaluation to determine whether groundwater quality can be protected given the climate, cropping patterns, soil and hydrology. This technology is only feasible if it can be determined that the groundwater quality would be protected given the site-specific conditions.

VOC

Some DPAG members believe there is presently not enough information to determine whether VOC emissions are reduced or increased using this system compared to a baseline freestall flush dairy. Therefore it is unclear if land application/injection is technologically feasible based on the available information. Additional data will substantiate whether VOC reductions occur. Some DPAG members believe that emissions reductions can be estimated as shown in section 1.4. However, as above, a site-specific evaluation to ensure groundwater protection would be needed. An alternate to land application can be the use of a plug flow digester, which will reduce emissions and will generate a very useful end-product — digested manure — with many of the nutrients intact for use during land application by keeping much of the nitrogen in a solid form, hence increasing the economic benefits to the dairymen.

1.8 Missing data

Data is needed to quantify ammonia reductions, particularly compared to a baseline free-stall flush model. Data is also needed to determine whether a representative profile of *dairy* VOC emissions[8] (as defined by the District) are reduced, again, compared to a baseline. In both cases, it would be helpful to determine whether injection is more or less helpful than application to the soil surface followed by incorporation. There is evidence that suggests complete incorporation via injection is more effective for odor management immediately after application[9], and may help to use the soil as a filter for ammonia and VOC emissions. However, there is also reason to believe that this would slow the drying of manure and potentially create anaerobic or partially anaerobic conditions – which could lead to groundwater quality management (increased nitrogen) challenges and a different emissions profile, e.g. higher methane production and potentially higher VOC production. This potential conflict should be evaluated and addressed. In the case where manure is applied to soil and incorporated later, it also makes sense to determine an appropriate amount of time (or range of times) between application and incorporation for best overall effect.

Risks to water quality using this approach must be more thoroughly evaluated to allow for development of Best Management Practices to protect groundwater quality and to support decisions related to crop nutrient management. More data is needed related to equipment options available, e.g. costs, availability and agronomic issues related to

[8] The Borba Bakersfield study quantifies VOC emissions using EPA Method 18, which does not include volatile fatty acids (VFAs). Thus it provides only a partial data set to support emissions reductions.

[9] Livestock and Poultry Environmental Stewardship Curriculum, Lesson 44, Module E, page 8.

application to crops. For example, dairy producers will need to be advised as to problems and advantages related to various types of equipment, how to avoid damage to crops, and cropping strategies that support year-round availability of land for manure application while still ensuring timely planting of the ground to allow uptake of soil nutrients before they build up in soil and cause groundwater concerns. Additional information on proper manure collection methods is needed (e.g. optimum timing and frequency for manure collection and an evaluation of equipment available, costs, pros and cons).

1.9 Other resources

Agnew, Joy, Hubert Landry, Claude Laguë, Martin Roberge, and Conrad Iskra, 2004. Prototype Precision Applicator for Solid and Semisolid Livestock manure. American Society of Agricultural and Biological Engineers Annual Meeting, Paper number 041116, 2004, Ottawa, Canada, August 1-4, 2004.

Alberta Agriculture, Food and Rural Development, Technical Services Division, September 2005. Liquid Manure Injection Systems: Performance Evaluation.
http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex10096

Alberta Agriculture, Food and Rural Development, Technical Services Division, September 2005. Performance Evaluation of Five Liquid Manure Injection Systems. 26pp.
http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex10096/$FILE/743-1_report.pdf

Laguë, C., H. Landry, and M. Roberge, 2005 . Engineering of land application systems for livestock manure: A review., CANADIAN BIOSYSTEMS ENGINEERING Volume 47
http://www.engr.usask.ca/societies/csae/protectedpapers/c0349.pdf

Livestock and Poultry Environmental Stewardship Program - Curriculum Lessons

20. Planning and Evaluation of Manure Storage
21. Sizing Manure Storage, Typical Nutrient Characteristics
22. Open Lot Runoff Management Options
23. Manure Storage Construction and Safety, New Facility Considerations
24. Operation and Maintenance of Manure Storage Facilities
25. Manure Treatment Options
30. Soil Utilization of Manure
31. Manure Utilization Plans
32. Land Application Best Management Practices
33. Selecting Land Application Sites
36. Land Application Equipment

43. Emission Control Strategies for Manure Storage Facilities
44. Liquid Manure Odor Control Techniques

http://www.lpes.org/les_plans.html

Department of Agriculture and Agri-Food Canada, ManureNet
http://res2.agr.ca/initiatives/manurenet/

Tessier, Sylvio, May 2001. Manure Handling Strategies for Minimising Environmental Impacts. Animal Industry Branch, Manitoba Agriculture and Food.
http://www.gov.mb.ca/agriculture/livestock/pork/swine/bab10s08.html

Borba Bakersfield Study, on file, San Joaquin Valley Air Pollution Control District. Also personal communication.

See also discussion on injection versus incorporation in the Land/Crop Application Section of Dairy BACT.

1.10 Recommendation

- Not achieved in practice as a primary method of manure management
- May not be technologically feasible in all cases given land availability, climate, etc.
- Should be eligible for consideration on a site-specific basis for technological feasibility and cost effectiveness
- Should not be a permit condition unless it can be demonstrated that water quality will not be adversely impacted
- Possibly deem this technology Alternate Basic Equipment or Achieved in Practice if it can be ensured that dairies have enough cropland prior to the construction of their dairy.

2. Frequency/timing/manner of flushing

2.1 Pollutants targeted and expected range of control efficiency.

VOC & NH_3; reductions possible but not quantifiable. Possibility exists that this would increase emissions.

2.2 Where technology comes from

Research on ammonia and VOC emissions

2.3 Description of technology or practice

This practice is based on the theory that manipulating the way feed lanes are flushed will have an impact on air emissions. The major factors considered are:

- Frequency of flushing (times per day)
- Timing (how soon after manure is deposited, timing the flush based on factors intended to reduce emissions)
- Source of flush water (is the water coming from a source that contains ammonia and VOCs and thus may actually produce emissions, or is it intentionally drawn from the cleanest possible source)

2.4 Control efficiency

Some DPAG members indicate that there is some evidence from California dairy research (Dr. Charles Krauter's studies of Merced and Kings dairies, 2004) indicating that more intensive manure management reduces some VOC emissions (as measured using EPA Method TO-15 with upwind and downwind sample canisters and modeling). However, the utility of this research is somewhat limited as it measured dairies operating under different conditions in different geographical areas and it is unclear which if any management practices (as opposed to engineering designs, etc.) played a role in the emissions. Nevertheless this is a promising assumption that merits further investigation.

Any VOCs formed from decomposing manure in flush lanes necessarily requires that manure as a feedstock; it thus stands to reason that frequent removal of the manure would reduce residence time of the manure in the flush lanes and at least potentially reduce emissions in that area (although it may increase or spike overall emissions in the flush lanes due to increased manure disturbance in the lanes during flushing).

Oosthoek and Kroodsma (1990) noted a threefold reduction in ammonia emission rate by flushing the concrete floor of a freestall barn.[10] While, "rapid drying is the key to odor control"[11] manure deposited in the flush lanes remains wet given the routine flush intervals employed in a typical San Joaquin Valley dairy. This suggests that increasing the number of flushes, could therefore lead to a decrease in emissions.

The possibility of no overall reduction of emissions or trading a reduction in one emissions unit for an increase in another emission unit must be considered. We also should not assume a linear relationship (increased

[10] "Air Quality Research and Technology Transfer White Paper and Recommendations for Concentrated Animal Feeding Operations," USDA Agricultural Air Quality Task Force, July 2000, p. 43.

[11] Ibid., page 43.

frequency = reduced emissions) as there in fact may be an optimal frequency whereby increasing or decreasing frequency would both increase emissions.

Certainly the choice of the source water can have an impact on odors, and this may offer some insight into the prospect of reducing other emissions. This could include using rinse water that has not yet been transported to a lagoon, water drawn intentionally from the portion of a lagoon or lagoon system where the water is determined to have the lowest level of dissolved solids (that is, is the most diluted) and/or has experienced the longest available treatment time. Cheng et al (1999) observed sequential decreases in odor from a) raw flushed swine wastewater, b) primary lagoon effluent and c) secondary lagoon effluent.[12] Odor was reduced by a factor of approximately 4.

However, no known work has demonstrated VOC or ammonia reductions under similar circumstances. Odors should not be used as a direct surrogate for either VOC or ammonia emissions.

No data are available to support whether reductions might be expected based on timing of the flush. By at least one theory, timing flush to remove manure after the majority of manure is deposited (e.g. shortly after feeding) would reduce the amount of time manure resides in the flush lanes, removing it from the area. It is not clear if this merely relocates emissions to another area of the dairy or if it would result in an increase or decrease.

Of the practices described above the one most likely to result in an emissions reduction is the choice of cleaner source water. Quantifying that reduction is not possible with the current data for either VOC or ammonia, and so control efficiency is estimated at between 0 and 100 percent.

Flush timing and flush frequency are less certain in their outcome and may increase emissions. However, it is clear that both of these practices could impact emissions and merit further investigation.

In summary and given the limited data, control efficiency cannot be estimated accurately; therefore, for current purposes control efficiency is estimated at between 0 and 100 percent with the possibility that changing flush frequency may actually increase emissions.

Some DPAG members believe that the best available data should be used to estimate a control efficiency.

[12] Ibid., page 45.

It is unambiguous that if manure has less probability of being degraded/decomposed in the feed-lanes, fewer emissions would be expected. The following assumptions can be made towards estimating a control efficiency:

- The bulk of the emissions will occur in the last few hours prior to flush, since it takes some time for decomposition and anaerobic conditions to subsist. However, to be conservative a linear approach will be taken which will most likely underestimate the emissions reductions.
- Emissions from the feed-lane will be considered negligible from the very fresh excreta, (first few hours after excretion)
- The emissions from the flush lanes based on two flushes is approximately 4.1 lbs/hd-yr[13]
- There may be an increase in emissions from increase in flushing from a typical dairy lagoon/storage pond water
- Flushing with cleaner source water such as flush from the secondary lagoon would result in additional emission reductions.
- No increase in emissions from the storage pond/treatment lagoon is expected, since the same amount of manure is sent to the lagoon, regardless of how many flushes take place.
- Manure deposited in the flush lanes typically always remain in a wet condition and normally does not dry between flushes. By removing this manure more frequently, decomposition of manure would be minimized, thereby reducing emissions.

The following control efficiencies based on the increase in removal can be estimated:

Control efficiency estimation based on three flushes:

It is acknowledged, that there are emissions from flushing itself. However, emissions from the flush would be decreased if flushed from a secondary lagoon (two-cell system). The calculation below will estimate emissions from this type of system. A typical flush usually lasts about 15 minutes. Three flushes would equate to a total of 45 minutes of flush in one day. Due to the low-level of Volatile Solids (VS) in the flush, emissions are expected to be small; therefore, emissions from that time period can be subtracted linearly from the 4.1 lbs/hd-yr emissions factor as follows:

[13] Refer to document emailed by Dave Warner entitled "Breakdown of Dairy VOC Emission Factor into Permit Units. Enteric emissions of 8.3 lbs/hd-yr should be subtracted from the total 12.4 lbs/hd-yr from cow housing

4.1 lbs/hd-yr ÷ 24 hours x 45 minutes/60 minutes = 0.13 lbs/hd-yr from the flush itself.

The remaining emission factor of 3.97 lbs/hd-yr occurs from the manure decomposition from the flush lanes. This factor will be broken up by each hour as follows:

3.97 lbs/hd-yr ÷ 24 hours = 0.165 lbs/hd-yr

The increase in flushing by one time a day, from 2-3 reduces the time manure decomposition takes place by a total of 8 hours. Therefore, instead of having the manure sit there for a total of 12 hours/day, by going to 3 flushes, four potentially crucial decomposition hours (last four hours of each flush period) are eliminated. The other 12-hour period will also benefit from a 4-hour reduction of manure decomposition, hence making the total hours of VOC reduction to 8.

Therefore, the emissions reductions from the 8 hours is as follows:

8 hrs x 0.165 lbs/hd-yr = 1.32 lbs/hd-yr

The emissions left over in the system would be equal to:

4.1 lbs/hd-yr – 1.32 lbs/hd-yr = 2.78 lbs/hd-yr

Therefore, the control efficiency for increasing the flush by 1 time is calculated as follows:

CE = 1 – (2.78 lbs/hd-yr ÷ 4.1 lbs/hd-yr) = 32.2%

Control efficiency estimation based on Four flushes:

As stated above, a typical flush usually lasts about 15 minutes. Four flushes would equate to a total of one hour of flush time in one day; therefore, emissions from that time period can be subtracted from the 4.1 lbs/hd-yr emissions factor as follows:

4.1 lbs/hd-yr ÷ 24 hours x 60 minutes/60 minutes = 0.171 lbs/hd-yr from the flush itself.

The remaining emission factor of 3.9 lbs/hd-yr occurs from the manure decomposition from the flush lanes. This factor will be broken up hourly as follows:

3.9 lbs/hd-yr ÷ 24 hours = 0.163 lbs/hd-yr

The increase in flushing by two times a day, from 2-4 reduces the time manure decomposition takes place by 12 hours. Therefore, the emissions reductions from the 12 hours is as follows:

12 hrs x 0.163 lbs/hd-yr = 1.956 lbs/hd-yr

The emissions left over in the system would be equal to:

4.1 lbs/hd-yr – 1.956 lbs/hd-yr = 2.144 lbs/hd-yr

Therefore, the control efficiency for increasing the flush by 2 times is calculated as follows:

CE: 1 – (2.144 lbs/hd-yr ÷ 4.1 lbs/hd-yr) = 47.7%

The above estimates are based on the best available data at this time and are expected to be refined with new research as it becomes available.

2.5 Considerations Regarding Use of the Technology or Practice

The chief advantage of changing flush frequency or timing is the ease of implementation. More frequent flushing would not require an overhaul or major change in management practice.

The chief advantage to changing the source of flush water is that, if a cleaner source of flush water is available, it can be done without increasing water use and should require only a minimal change in overall management.

Increasing flush frequency may increase energy use on the dairy (e.g. more electricity use for pumps). Increasing flush frequency may also be limited by practical considerations to times when cattle are absent from the freestall barn lanes (e.g. during milking). Attempting to flush during other times may be detrimental to animal health and safety. There are dairies that flush while cows are in the free-stalls

Changing the source of flush water may require installation of additional plumbing infrastructure (this is for existing dairies only). It necessitates that a cleaner source than the primary lagoon is available. If fresh water is used as part of this strategy it will increase overall water use by the dairy, not only increasing costs but also potentially causing challenges to proper water quality management, including allowing enough additional storage for winter storm events.

Assuming that this approach could be demonstrated to achieve emissions reductions, water is increasingly becoming a limited resource in California and especially in the San Joaquin Valley. This could have implications both in terms of resource availability and economics.

2.6 Cost

Cost is difficult to estimate. Changing the flush frequency or timing may be a minimal cost so long as major changes in cattle management are not triggered. Costs will vary depending primarily on the need for additional engineering and infrastructure as well as increased energy needs.

2.7 Feasibility at dairies

Some DPAG members contend that there is insufficient data to determine whether this technology will result in emissions reductions, therefore it is not yet possible to determine its feasibility. If emissions reductions can be shown, however, it does appear that the above strategies could be integrated feasibly into an operating dairy. There is no reason to believe at this time that they would trigger exorbitant costs.

Other DPAG members believe that there is enough information to estimate emission reductions and due to the ease of employment of such a technology, this technology would be considered feasible.

2.8 Missing data

The most important missing data is a comparison of standard flushing to a proposed optimum flush schedule in which both emissions of VOC and ammonia are studied. In addition, data comparing emissions from flushes where different source water is used would assist in determining control efficiency.

2.9 Further resources

"Monitoring and Modeling of Reactive Organic Gases at California Dairies," Krauter, Goorahoo, Goodrich, Beene, available at ftp://ftp.arb.ca.gov/carbis/ag/agadvisory/krauter05jan26.pdf

"Air Quality Research and Technology Transfer White Paper and Recommendations for Concentrated Animal Feeding Operation," Sweeten et al (USDA Agricultural Air Quality Task Force, July 2000).

2.10 Recommendation

Some in the DPAG hold the position that:

- Not achieved in practice until it can be determined that it will not increase emissions
- Should be further examined by the District when additional data available.

Others in DPAG hold that:

- Frequent flushing may be considered Achieved in Practice

3. Anaerobic Treatment Lagoon designed according to NRCS Guideline (two cell system: Mechanical separator – anaerobic treatment lagoon – Storage Pond – Flush from storage Pond)

3.1 Pollutants targeted and expected to range of control efficiencies

VOCs, NH_3; reductions expected in both cases but not quantifiable (0 to 100 percent).

3.2 Where technology comes from

NRCS guidelines, research.

3.3 Description of technology or practice

An anaerobic treatment lagoon is a lagoon that is designed to ensure enough treatment volume (water) to facilitate preferential, full decomposition of dissolved manure solids to methane rather than intermediate metabolites (VOCs).

The National Resource Conservation Service (NRCS) outlines design specifications for waste treatment lagoons (both open and covered). NRCS Interim Practice Standards No. 359 - Waste Treatment Lagoon requires the following criteria for anaerobic treatment lagoons:

- 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.

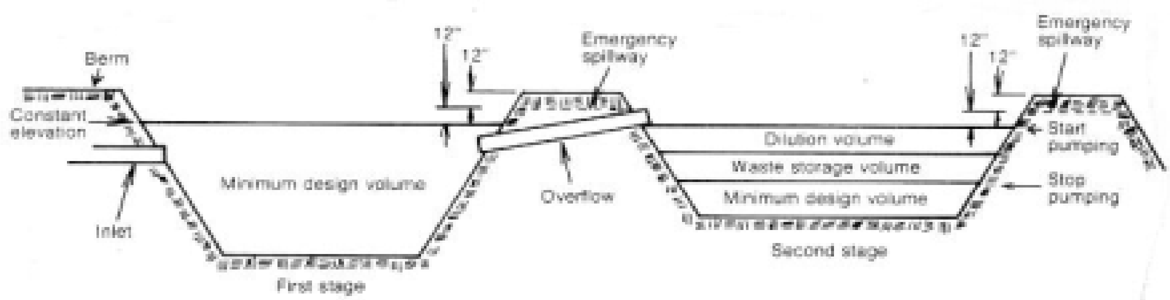
- The operating depth of the lagoon shall be 12 feet or greater. Maximizing the depth of the lagoon minimizes the surface area, which in turn minimizes the cover size and cost. Increasing the lagoon depth has the following advantages:

- Minimizes surface area in contact with the atmosphere, thus reducing surface available to convection, evaporation
- 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.

The NRCS guideline suggests that this system consist of two cells, a treatment lagoon (primary lagoon) and a storage pond (secondary lagoon). The first stage of the lagoon system is the biological treatment stage and is designed with a constant liquid level to stabilize the anaerobic digestion. The effluent from the first stage overflows into a second lagoon designed for liquid storage capacity. Effluent from the second lagoon is used in the flush lanes and for the irrigation of cropland.

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[14]:



3.4 Control efficiency

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.

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

The secondary lagoon is also thought to have odor benefits and potentially other emissions reductions if it is used as the source water for irrigation and lane flushing.[15]

However, some DPAG members believe there are no data to support a quantification or control efficiency for ammonia or VOC. There are reasons to believe that both would be reduced although it is unclear how significant the expected reductions would be. In the case of ammonia, volatilization of ammonia to the atmosphere from lagoons is considered in part to be a function of the total surface area of the retention pond; therefore, reducing the surface area might be expected to reduce ammonia emissions.

In the case of VOCs, the entire point of the anaerobic treatment lagoon system is to more efficiently convert carbon, oxygen and hydrogen in the decomposing manure more efficiently into methane (CH_4) and carbon dioxide (CO_2). Thus it may be expected that the design will increase production of methane and preferentially convert decomposing manure feedstock to methane, reducing correspondingly the production of VOCs that also would require carbon, hydrogen and in some cases oxygen. An active methanogenic population may in fact consume VOCs that are in solution in the liquid phase and convert them to methane.

However, some DPAG members believe that while a reduction in VOC and ammonia production can be expected, it is not possible to estimate with the available data what the reduction would be. Therefore control efficiency for both ammonia and VOC is estimated at between 0 and 100 percent.

Some DPAG members believe that a control efficiency can be estimated from this type of system. Two methods can be used in estimating the emission reductions as follows:

1. Comparing the residence time of anaerobic treatment lagoon systems to standard lagoons at dairies
2. Compare the amount of Volatile Solids removed from both anaerobic treatment lagoons and standard lagoons to derive a control efficiency

However, based on all that is known from this system and all its benefits, an ultra conservative control efficiency of 25% can be applied at this time.

3.5 Considerations regarding use of this technology or practice

The largest potential advantage to this system is that it may reduce VOCs and ammonia at a lower cost than comparable strategies such as

[15] Ibid. page 45.

covered lagoons and tank digesters. This system allows dairy producers to continue to utilize the advantages of the freestall flush system and may in fact improve the overall efficiency and emissions throughout that system. For this reason, it would be one of the more straightforward measures to incorporate into a dairy design. The availability of published design schematics also provides support to consulting engineers.

Unlike a covered lagoon, tank digester or most other available alternatives, this technology would not require dairy producers to make a major, significant change in daily manure management practices and as such, it should not risk major unforeseen consequences, such as risks to groundwater quality, changes in crop management or expensive maintenance problems.

Cost may also provide an advantage over other systems. While this system of sequential lagoons would be more expensive to design and build and in some cases may require more land, ongoing maintenance costs and labor should be comparable to standard manure management practices in place today.

From an air quality perspective, the largest disadvantage is the uncertainty as to whether this system provides appreciable reductions in either VOC or ammonia. In comparison to digesters, where the idea is to capture and combust emissions of VOC, this system purports to reduce those emissions in the first place. Without measured data to support this contention it is impossible to evaluate control efficiency.

From an engineering and design perspective, the optimum depth for lagoons may not be feasible on all dairies, particularly in areas with shallow groundwater. In those cases, extra measures to protect groundwater may be required and these could dramatically increase costs associated with lagoon construction.

The design specifications have the general effect of increasing the total lagoon volume to ensure stable treatment volume. Engineers report that this increase can add 50 percent or more to the design size of a lagoon and correspondingly higher costs for construction.

3.6 Cost

At this time we do not have definitive cost data but this is expected to increase lagoon construction cost by about 50 percent or more. In some cases, where especially difficult hydrology or soil conditions are specific to the site, costs may be significantly higher.

3.7 Feasibility at dairies

This technology may be feasibly integrated into a dairy design and would be expected to have positive impacts on odors, VOC and ammonia. However, data will be necessary to determine whether VOC and ammonia reductions are significant enough to support a finding that this is feasible for control of those pollutants.

3.8 Missing data

A study of an anaerobic treatment lagoon system designed to NRCS standards compared to a more standard flush system would help determine whether this system delivers actual reductions of VOC and ammonia.

Additional case studies are needed to accurately determine the construction and ongoing operating costs of anaerobic treatment lagoons.

3.9 Further Resources

NRCS guidelines.

3.10 Recommendation

- Some DPAG members consider this as not yet achieved in practice
- Technologically feasible but cost-effectiveness analysis not possible at this time without control efficiency
- Should be further examined when control efficiency data is available
- Other DPAG members believe that anaerobic treatment lagoons designed according to the NRCS Guideline should be considered as Achieved in Practice.

4. Follow NRCS Guidance for Aerobic Lagoons (very shallow)

4.1 Pollutants targeted and expected range of control efficiency

VOC, NH_3. Reductions not quantifiable with available information; possible that emissions might increase.

4.2 Where technology comes from

USDA/NRCS code 359, municipal waste treatment industry, private vendors

4.3 Description of technology or practice

Aerobic lagoons are described in USDA-NRCS Conservation Practice Standard Code 359. Aerobic lagoons are also described by reference in American Society of Agricultural Engineers literature.

Aerobic lagoons are shallow to allow enough aeration of water to cause aerobic bacteria to thrive. According to NRCS code 359, the lagoons must maintain a minimum depth of 2 feet and a maximum depth of 5 feet. There must also be a minimum surface area per unit of loading rate (Biological Oxygen Demand or BOD) that can be calculated.

According to ASAE[16], "aeration can be used to control *odor* [emphasis added] generation by preventing anaerobic decomposition. Two basic aerobic treatments are complete mixed aeration in a treatment vessel and extended surface aeration in a manure storage or treatment lagoon." According to the same document, "supplying oxygen to satisfy one third to one half of the biochemical oxygen demand can reduce odor generation while minimizing energy costs."

In general, the goal is biological oxidation, which converts the organic matter in the manure to carbon dioxide, water, and microbe cells. Instead of mechanical aeration, this practice purportedly requires that the lagoons be designed shallow in order to naturally keep the lagoons aerobic.

4.4 Control efficiency

We were unable to locate any data to support a conclusion that aerobic lagoons reduce emissions of VOCs or ammonia. Most of the available literature pertains broadly to odors, which are not suitable as a surrogate for either ammonia or VOCs.

Therefore, control efficiency is expected to be between 0 and 100 percent with the possibility that emissions of either ammonia or VOCs or both may increase.

4.5 Considerations regarding use of this technology or practice

If this could be made to work it could provide a positive emissions profile characterized by emissions of carbon dioxide and low odors. If VOC and/or ammonia reductions can be demonstrated without creating methane emissions, this may provide an attractive alternative.

The most serious concerns are related to surface area needed. Given that the pond can be no more than 5 feet deep and no less than 2 feet deep, management of treatment depth will be critical. A pond of this depth will require at least four times the land area of an anaerobic lagoon 12 feet in depth, and up to 10 times the land area when flexibility issues are taken into consideration. Given the narrow band of depth for proper treatment, managing for flood control may be problematic and this type of a lagoon might be more vulnerable to storm-water events. This could

[16] ASAE EP373.9 July 2005 from ASAE Standards 2005.

raise land acquisition costs, and costs associated with design, construction and management of this system, which currently is not in wide use on dairies.

From an air quality perspective, the most problematic issue is the lack of evidence as to whether this would reduce the target emissions. In the absence of data, detailed schematics, etc., it is difficult to even evaluate whether a specific design would be effective, particularly for VOC or ammonia reduction. It is also unclear if a "passive aeration" system as described here would be effective year-round, what type of maintenance it would require, etc.

4.6 Cost

We were unable to locate any cost data for this type of system. Cost is expected to be significantly higher than anaerobic lagoons given the added management challenges and land area needed.

4.7 Feasibility at dairies

There is not enough information on emissions reductions to determine technological feasibility at this time. If reductions are demonstrated, then cost data will be needed to determine economic feasibility.

4.8 Missing data

Cost data for an aerobic lagoon is needed to allow an evaluation of cost effectiveness in the future. Also, an emissions study is needed to determine if this method will reduce emissions of ammonia, VOCs or other pollutants. Some of this information may be available within the municipal waste treatment industry.

4.9 Further resources

Conservation Practice Standard Code 359-1, USDA-NRCS.

Alabama Guide Sheet No. AL 359, USDA-NRCS.

ASAE EP379.3 July 2005, "Control of Manure Odors"

ASAE S292.5 February 2004, "Uniform Terminology for Rural Waste Management"

ANSI/ASAE EP403.3 February 2004, "Design of Anaerobic Lagoons for Animal Waste Management"

"Odor, The Issue for the New Decade," USDA-NRCS and the National Water Management Center, http://wmc.ar.nrcs.usda.gov/technical/WQ/odor.html

“Air Quality Research and Technology Transfer White Paper and Recommendations for Concentrated Animal Feeding Operations,” USDA Agricultural Air Quality Task Force, July 2000, p. 45.

4.10 Recommendation

Not achieved in practice
Not yet technologically feasible but may be if data can show reductions of VOC, ammonia or both.

5. Covered Lagoon with 95% VOC control of captured biogas (IC engine w/catalyst or equivalent)

5.1 Pollutants targeted and expected range

VOC and H_2S; Control efficiency up to 95 percent for VOCs with some qualifications. Hydrogen sulfide emission reductions are expected but not quantifiable with available data.

5.2 Where technology comes from

In use at several California dairy facilities, see also U.S. EPA AgStar site (http://www.epa.gov/agstar/).

5.3 Description of technology or practice

Anaerobic digestion is a biochemical degradation process that converts complex organic material, such as animal manure, into methane, carbon dioxide and small amounts of VOC and other byproducts. An anaerobic digester is a device that promotes the decomposition of manure or “digestion” of the organics in manure to simple organics and gaseous biogas products. Manure is regularly put into the digester after which the microbes break down the manure into biogas and a digested solid.

Unlike tank digesters, where manure is collected without flushing, this technology gathers manure through a system similar to normal free-stall flushing – that is, manure is flushed from concrete lanes to a system that separates large solids (fibrous materials) out for separate drying/processing. The liquid effluent, which includes dissolved manure solids, is then processed in the covered lagoon. Efficient capture of the biogas requires the full enclosure of a lagoon/treatment lagoon by a relatively airtight cover, usually made of durable plastic. The biogas is generally filtered and then combusted in an internal combustion engine, boiler or other approved combustion device engineered to ensure 95 percent control of VOC, such as an IC engine with catalyst or equivalent.

5.4 Control efficiency

As defined above, control efficiency of this technology for VOCs is expected to be 95 percent or above, with some qualifications. First, this type of digester is only capable of capturing emissions from the covered lagoon itself. Thus, any emissions of VOC or hydrogen sulfide from other portions of the dairy are not controlled, nor are emissions that occur prior to manure being placed in the digester. Covered lagoon digesters also require solids separation prior to manure flowing to the lagoon; thus, emissions from separated solids are not captured. Nor are emissions from liquid effluent after it leaves the digester for land application captured.

With the above limitations taken into account, it is assumed that virtually all of the biogas created in the anaerobic environment of a covered lagoon would indeed be captured and controlled. Assuming that all VOCs (or virtually all of them) are destroyed during combustion, then control efficiency of 95% of the portion of VOCs emitted from the covered lagoon should be achievable.

5.5 Considerations regarding use of this technology or practice

From an air quality perspective, the primary advantage is assurance that whatever VOCs are produced in the covered lagoon will be eliminated through combustion. Therefore this system gives us some certainty that we could expect a reduction rather than an increase in emissions. It also suggests that – if we can indeed expect combustion to destroy most or all VOCs – that we can expect excellent control efficiency.

While there are significant costs associated with covered-lagoon digesters, these are one of the few proposed technologies that may offer a partially offsetting revenue stream for a dairy of an appropriate size for this technology. The technology allows capture and combustion of methane, enough of which is produced that it can allow the dairy producer to generate electricity or run a boiler, in turn potentially saving energy costs. However, the energy is usually generated around the clock and surpluses cannot be stored; therefore the dairy producer is dependent on government regulators and electric utilities to determine prices paid for excess electricity generated.

Compared to other types of digesters, covered lagoons allow a dairy to operate in an otherwise similar manner to a standard freestall flush system, that is, using water to flush lanes within the barn. This may, for example, save labor costs associated with daily manure collection as can be expected with some types of tank digesters.

The largest disadvantages with this system are capital and maintenance costs. Covered lagoon digesters require significant investment and management and remain fairly rare in the United States. Over 50

digesters of varying types are currently installed in the US[17] and a total of at least 21 digesters will soon be installed in California.[18]
Because covered lagoons are often designed to maximize anaerobic digestion by maintaining a stable treatment volume and loading rate, they may already be significantly reducing problematic VOCs prior to combustion (see anaerobic treatment lagoons section above). Thus the control efficiency of this system may not be significantly greater than an anaerobic treatment lagoon although the capital costs are significantly higher.

The liquid effluent from digesters is a subject of some concern to water quality regulators. So far there is little information to determine the amount of nitrogen (in ammonia and other forms) in the effluent and how that compares with effluent from a standard lagoon. There is a concern that the nitrogen sequestered during anaerobic digestion could be rapidly released to air when the effluent is applied to land.

Combustion of VOC gases will produce some amount of offsetting pollutants such as nitric oxide (NOx) compounds. Any emissions control necessary to control these pollutants will add to the cost of the technology.

If this type of digester is not properly operated and maintained, reactive and green house gases can escape from the under the lagoon cover, with adverse impacts on both local air quality and the world's climate.

5.6 Cost

According to Western United Resource Development Inc., which administered the recent government incentive program known as the Dairy Power Production Program (DPPP) for building dairy digesters in California, the cost of a covered lagoon digester can range from about

[17] http://www.epa.gov/agstar/accomplish.html
http://www.epa.gov/agstar/pdf/2002digest.pdf

[18] Under California's Dairy Power Production Program (DPPP) five dairies have begun generating power within the last year, and 9 others are due to come online before the end of 2005. The projects have an estimated generating capacity of 3.5 MW and operational systems are running at 82% capacity (California Biomass Collaborative Quarterly NEWSLETTER Vol. 2 No. 1 Winter 2005.
http://biomass.ucdavis.edu/pages/newsletters/BiomassW05124.pdf, Western United Resource Development, Inc., JUNE 2003. Dairy Power Production Program. Update.
http://www.wurdco.com/Annual%20Report%20Aug.%202003.pdf, Western United Resource Development, Inc., California Dairy Power Production Program Backgrounder.
http://www.wurdco.com/DPPPbackgrounder.htm). According to the US-EPA AgSTAR program prior to the DPPP there were already 7 digesters producing power in California (http://www.epa.gov/agstar/operation/bystate.html). The DPPP has since been extended by the passage and signing of AB728 which allows for up to 50MW of generation from dairy digester projects if they become operational before the end of 2009 (http://www.leginfo.ca.gov/cgi-bin/postquery?bill_number=ab_728&sess=CUR&house=B&author=negrete_mcleod).

$500,000 to $2 million. The majority of the capital costs are associated with installing a thick but flexible and durable plastic cover on the lagoon, which can be several acres in size, and with installing stationary engines to combust the biogas (with proper pre-cleansing technology for the gas and emissions controls on the exhaust).

Some of these costs are offset by the dairy's ability to utilize the energy generated by the engines, particularly in the case of large dairies that include cheese manufacturing facilities, etc. However, in many cases far more electricity is generated than can be utilized by the dairy and it is difficult to recover costs on the extra power by selling it to the power-grid. However, over time, these costs can be realized.

Every digester built to date has been done so with substantial government assistance; in California most digesters today were built with 50% cost matches from the government as part of the DPPP (manure digesters have been seen as a possible alternative to fossil fuels since the 1970s but have only recently been considered as a potential control for regional air pollutants).

Economic feasibility of digesters to date has depended heavily on government cost shares and incentive programs as wells as some cost recovery through net metering which allows additional savings on utility bills for participating dairy producers. The government cost-share and incentive programs in some cases were temporary or have sunset dates in legislation; these factors should be taken into account when determining economic feasibility.

5.7 Feasibility at dairies

Covered lagoon digesters can be feasibly integrated into a commercial dairy design and can be expected to reduce any VOC emissions coming directly from the lagoon. Economic feasibility must be determined on a site-specific basis.

5.8 Missing data

The most important set of missing data is a characterization of VOCs and hydrogen sulfide in the covered lagoon headspace compared to emissions of VOCs and other pollutants in the exhaust from the combustion source. Ideally, this before and after comparison would also look at emissions before the lagoon is covered, as covering itself may cause important changes.

The fate of nitrogen compounds after the digestate has been removed from the covered lagoon reactor needs to be determined/monitored. There is a very real possibility that the anaerobic conditions will lead to the sequestration of nitrogen in the digestate, which could rapidly volatilize when any component (whether that be the liquid or solid fraction) of the digestate is removed from the reactor and exposed to air.

Additional cost data will also be helpful in determining the economic feasibility of this system, including available subsidies, a more thorough understanding of utility costs/benefits and a better long-term understanding of the life and costs of maintaining lagoon covers.

5.9 Further resources

EPA Ag Star Program.
Inland Empire Utilities Agency.
Western United Resource Development, Inc.

5.10 Recommendation

- Some DPAG members consider this approach as not being achieved in practice at this time due to high failure rate, short track record, and heavy dependence on government subsidies and temporary utility rate incentives
- Technologically feasible for VOC reduction.
- Not technologically feasible for H2S given current available data.
- The fate of nitrogen compounds needs to be determined.
- The District should perform a generic cost-effectiveness analysis to determine whether this technology is reasonable to consider in future dairy proposals.
- Other DPAG members believe this technology should be considered Achieved in Practice BACT

6. Plug-flow, complete mix or other types of enclosed Anaerobic Digester

6.1 Pollutants targeted and expected range of control efficiency

VOC, NH_3. Control efficiency up to 95 percent for VOCs with some qualifications. Hydrogen sulfide emission reductions are expected but not quantifiable with available data.

6.2 Where technology comes from

Farm-based anaerobic digesters have been used in the United States since the 1970s. Since then, anaerobic digesters have been used on farms throughout the United States and around the world. They are most commonly used at dairy and swine operations because the manure is more suited for farm-based energy conversion (Lusk, 1998).

6.3 Description of technology or practice

Anaerobic digestion is the decomposition of manure in an oxygen-free (anaerobic) environment. Anaerobic digesters work in much the same way as an animal's digestive tract; microorganisms breakdown or digest the manure. One of the last phases of digestion is the conversion of the manure into biogas by methane forming bacteria. Biogas is a combination of methane, carbon dioxide, nitrogen, hydrogen, carbon monoxide, oxygen, and hydrogen sulfide. Between 55 and 70 percent of the biogas in methane, and the remainder consists mostly of carbon dioxide. The methane in biogas is the same compound that makes up the bulk of the chemical constituents found in natural gas, and after scrubbing to remove contaminants it can be used to fuel internal combustion engines that run generators that produce electricity.

The on-farm digester system typically involves an animal facility where manure is produced; a manure-handling system to transport the manure to and from the digester; a reactor tank; where anaerobic digestion occurs; and an apparatus for the collection, pretreatment, and use of biogas.

There are several types of digesters, which are made for specific types of manure management situations. The complete mix digester (also known as a complete stir tank reactor or CSTR) and plug-flow digester (PFD) are the most common types of enclosed on-farm digesters.

All manure biogas digesters operate on the same basic principles – enhancing conversion of manure solids to methane gas by creating and maintaining an oxygen-starved (anaerobic) environment conducive to methanogens, which are anaerobic microbes that create methane. While the engineering of different systems varies, all tank digesters share common features from an air quality perspective. This is true whether the digester is located on one farm or is regional in nature and serves multiple facilities (also referred to as a centralized or cooperative facility).

Unlike the covered lagoon digesters described above, tank digesters require that manure be collected in a fresh, uncontaminated (moist with no sand or dirt) state. Therefore it is generally not collected by flushing, but by scraping or vacuuming. The manure is placed in an enclosed tank, above or below ground, and methane and presumably some VOCs gas off. These are collected and combusted to create heat or electricity or both. Thus the pollution control effectiveness in terms of VOCs is dependent not on the specific type of digester used but mostly on the type of IC engine or boiler used to combust the gas. It will also be necessary to consider that biogas contains many natural contaminants and pre-scrubbing of gas may be needed in order to both avoid engine failure and minimize the emissions associated with combustion of the gas; this should be considered in feasibility and cost analyses.

Co-digestion (adding food wastes and other organic wastes to the manure waste stream) is also an option that may enhance economic feasibility by increasing the efficiency of gas production in the digester and thus the total amount of energy produced. However, this can also change the character of the effluent from the digester and it should be considered in the overall analysis.

Importantly, digesters do not convert a large percentage of the manure mass into biogas; in fact it is a tiny fraction of the total mass of the manure. This statement is disputed. Therefore, emissions from the effluent after digestion should be considered as well as proper management of the effluent to protect water quality, etc. ALTERNATIVE PARAGRAPH: Depending on the type of digester (plug flow vs CSTR), the quality of the manure feedstock, and whether codigestion is used or not, varying amounts of the organic solids (known as volatile organic solids) can be converted into biogas. The type of materials used for codigestion can also influence the efficiency with which the solids are converted to gas. Typically more of the solids will be converted into gas in a CSTR when compared to a PFD, and more solids will be converted into gas when they are codigested than when manure alone is used. The duration (hydraulic retention time) during which the newly introduced manure – and additional organic solids in the case of codigestion – are allowed to digest can also be critical to the gas quality and yield. This has potential consequences for the quantity and type of emissions produced by the effluent after digestion and this should be considered in determining the proper management of the effluent to protect water quality, etc. As previously mentioned (5.5 and 5.8 above) the fate of nitrogen compounds needs to be addressed.

6.4 Control efficiency

Also refer to section 5.4 for a discussion of the use of covered lagoons.

Control efficiency of this technology for VOCs is expected to be 95 percent or above, with some qualifications. First, this type of digester is only capable of capturing emissions from manure decomposition after the manure is placed inside the digester. Thus, any emissions of VOC or hydrogen sulfide from other portions of the dairy are not controlled, nor are emissions that occur prior to manure being placed in the digester. Tank digesters do not require solids separation prior to manure being placed in the tank; this may reduce overall emissions compared to a covered lagoon digester by reducing the number of open-air treatment steps. Digesters do produce a liquid effluent that may have some emissions upon leaving the digester. This liquid can be processed through a solids separator and is often applied to land in either a liquid or solid form. Again, the fate of the nitrogen compounds must be accounted for at this stage of handling and application.

With the above limitations taken into account, it is assumed that virtually all of the biogas created in the anaerobic environment of an enclosed tank would indeed be captured and controlled. Assuming that all VOCs (or virtually all of them) are destroyed during combustion, then control efficiency of 95% of the portion of VOCs emitted from the covered lagoon should be achievable.

6.5 Considerations regarding this technology or practice

From an air quality perspective, tank digesters may be more efficient than covered lagoon digesters at reducing emissions because they eliminate the need to flush and separate solids before digestion. The use of these types of digesters also assures that the VOCs produced are captured in the reactor's headspace and can be eliminated through combustion, thus providing some certainty that there will be a reduction in emissions and thereby providing excellent control efficiency. Depending on the dairy, the use of this type of digester could offset the costs associated with daily manure collection on a flush dairy, but could require more labor and expense to operate, including daily labor and equipment to remove manure in optimum condition and in order to place it in the tank in a timely manner, and to monitor the digester. There are also likely to be offsetting emissions from equipment used to gather the manure.

For the most part, anaerobic digesters require high-level management time, and when farmers do not have the skill or time to manage the digester the systems tend to fail. Farmers are often reluctant to use digesters, because the operation and maintenance costs are too high compared to the financial returns from the energy production. Another reason for digester failure is that producers select systems that are not compatible with their type of manure handling method and the layout of their farm. Poor design and installation also contribute to the failure of digesters.

There may be offsetting savings compared to lagoon digesters in initial lower construction costs and scale.

One of the largest technological problems for anaerobic digesters is sand clogging the digester. If dairy farms are conducive to sand collection (through sand bedding or corrals) their anaerobic digesters have a high probability of failing.

Over 50 digesters of varying types are currently installed in the US[19] and a total of at least 21 digesters will soon be installed in California.[20]

These types of digesters can work well in combination with vacuumed or scrape systems.

6.6 Cost

Also refer to section 5.6 for a discussion of costs.

Digesters have high start-up costs. A study of anaerobic digesters used by dairy farmers in Michigan indicated that a typical payback period for farmers with anaerobic digesters is at least 7 to 10 years. However, a recently published document by the California Energy Commission indicated a payback of 3- 7 years. ALTERNATIVE LANGUAGE: Digesters have high start-up costs. A recent report published by the California Energy Commission indicated that the intial return on investment for anaerobic digesters could be paid back over a 3-7 year period while a Michigan study indicated that a payback period would take at least 7 to 10 years. Most farmers are not able to make these long-term payments, especially when energy costs are small compared to total operational costs. For farmers in Michigan to consider purchasing digester the price of energy would have to triple (Rozdilsky, 1997). According to an article published in Westbioenergy, the annual maintenance cost of a digester installed on a 400 dairy cow operation in California was estimated at 8% of the capital construction costs, or $16,000 for a $200,000 anaerobic digester.

For more cost information, refer to *A Manual for Developing Biogas Systems at Commercial Farms in the United States (Roos and Moser. 1997).* Additional economic information is available in a report by Lusk,

[19] http://www.epa.gov/agstar/accomplish.html
http://www.epa.gov/agstar/pdf/2002digest.pdf

[20] Under California's Dairy Power Production Program (DPPP) five dairies have begun generating power within the last year ~~[Blakes Landing Dairy (Marin), Castelanelli Bros. Dairy (San Joaquin), Gallo Cattle Company (Merced), Koetsier Dairy (Tulare), and Meadowbrook Dairy (San Bernardino)]~~ and 9 others are due to come online before the end of 2005. The projects have an estimated generating capacity of 3.5 MW and operational systems are running at 82% capacity (California Biomass Collaborative Quarterly NEWSLETTER Vol. 2 No. 1 Winter 2005. http://biomass.ucdavis.edu/pages/newsletters/BiomassW05124.pdf, Western United Resource Development, Inc., JUNE 2003. Dairy Power Production Program. Update. http://www.wurdco.com/Annual%20Report%20Aug.%202003.pdf, Western United Resource Development, Inc., California Dairy Power Production Program Backgrounder. http://www.wurdco.com/DPPPbackgrounder.htm). According to the US-EPA AgSTAR program prior to the DPPP there were already 7 digesters producing power in California (http://www.epa.gov/agstar/operation/bystate.html). The DPPP has since been extended by the passage and signing of AB728 which allows for up to 50MW of generation from dairy digester projects if they become operational before the end of 2009 (http://www.leginfo.ca.gov/cgi-bin/postquery?bill_number=ab_728&sess=CUR&house=B&author=negrete_mcleod).

entitled *Methane Recovery from Animal Manures: The Current Opportunities Casebook.*

Digesters in general are one of the few proposed technologies that offer opportunities for the offsetting of costs and for revenue recovery. The technology allows capture and combustion of methane, enough of which is produced that it can allow the dairy producer to generate electricity or run a boiler, in turn potentially saving energy costs. There is also the potential for excess electricity to be sold back to the power-grid.

The perception among the farming community that anaerobic digesters fail is one of the largest social barriers to acceptance of the technology (Rozdilsky, 1997). Through personal communication or word-of-month, many farmers know of some farm with an abandoned digester. The perception has resulted in limited support from the agricultural community (Roos and Moser, 1997).

6.7 Feasibility at dairies

Digesters are clearly technologically feasible for reducing whatever fraction of VOCs are produced in the tank. Economic feasibility for the system in general, particularly without government subsidies, has not yet been established. Economic feasibility for actual VOC reductions does not appear likely unless additional technological improvements are made available or government funding is taken into account.

6.8 Missing data

Additional information is needed to assess control effectiveness and operating costs. See also the discussion on daily manure collection labors costs under "incorporation/injection" and also the similar discussion on control effectiveness under "covered lagoons."

The fate of nitrogen compounds after the digestate has been removed from the covered lagoon reactor needs to be determined/monitored. There is a very real possibility that the anaerobic conditions will lead to the sequestration of nitrogen in the digestate, which could rapidly volatilize when any component (whether that be the liquid or solid fraction) of the digestate is removed from the reactor and exposed to air.

6.9 Further Resources

Lusk, P. 1998. Methane Recovery from Animal Manures: The current Opportunities Casebook. National Renewable Energy Laboratory, Golden, CO.

Roos, K.F., and M.A. Moser. 1997. A Manual for Developing Biogas Systems at Commercial Farms in the United States. AgStar Handbook.

U.S. Environmental Production Agency, Washington D.C. EPA-430-B-97-015.

Rozdilsky, J.L. 1997. Farm-based Anaerobic Digestion in Michigan: History, Current Status, and Future Outlook. Michigan Biomass Energy Program, Lansing, Michigan.
http://eimisweb.cis.state.mi.us/biomas/anaerobic.pdf

USEPA 1997 Plug Flow/Complete-Mix digesters. AgStar Technical Series. U.S. Environmental Protection Agency, Washington, D.C.

Westbioenergy. 2000. A 16-year Success Story…Making Bucks and Electricity from Dairy Cow Waste.

6.10 Recommendation

- Some DPAG members consider this technological approach to not be achieved in practice at this time due to high failure rate, short track record, and heavy dependence on government subsidies and temporary utility rate incentives
- Technologically feasible for VOC reduction.
- Not technologically feasible for H2S given current available data.
- The District should perform a generic cost-effectiveness analysis to determine whether this technology is reasonable to consider in future dairy proposals.
- Other DPAG members believe that anaerobic digesters are Achieved in Practice.

7. Microaerobic Biological Nutrient Management Process

7.1 Pollutants targeted and expected range of control efficiencies

VOC, NH_3, H_2S; vendor data suggests very low emissions for the process itself but does not include information to quantify actual or overall reductions from the process effluent and/or solid residuals that remain on the dairy.

7.2 Where technology comes from

1) The United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) issued new National Conservation Practice Standards for biological treatment systems, which qualifies the Microaerobic Biological Nutrient Management Process under the Amendments for the Treatment of Agricultural Waste (Code 591), Liquid/Solid Waste Separation Facility (Code 632) and Waste Treatment (Code 629) which is a new standard intended to address the installation of alternative animal waste treatment systems and processes (see Appendix C).

2) The SCAQMD issued a letter on February 1, 2005 which states that a specific Microaerobic Biological Nutrient Management Process qualifies under SCAQMD new Rule #1127 EMISSION REDUCTIONS FROM LIVESTOCK WASTE

3) Information on a specific process can be found at http://www.biontech.com/index.html. The web site includes emission and other process data.

7.3 Description of technology or practice

Manure and recycled wastewater, with or without milking parlor wastewater, is captured in a contact chamber which is mixed to maintain solids in suspension. The waste is then processed to remove coarse solids using a static screen or other mechanical solids separator. The liquid fraction is then discharged into a two-stage bioreactor that includes an anaerobic treatment zone and a micro-aerobic treatment zone. In the second stage, soluble P is converted to particulate organic form via its uptake into microbial biomass. Organic nitrogen and ammonia are converted to nitrate then to N_2 gas via nitrification/denitrification processes, or taken up as microbial biomass. The process water is recycled for flushing the barns or is added back to the contact chamber. The process-water also can be discharged to a storage lagoon for use as irrigation/fertilizer, or polished via fine screening or centrifugation to remove additional solids. The solid fraction is used as bedding or may be composted for use as an organic soil amendment. The complete system is purportedly designed to reduce the nutrient load (nitrogen and phosphorus) and air emissions (ammonia, reactive organic gases, methane, hydrogen sulfide, and odors). A specific Microaerobic Biological Nutrient Management Process has produced data that indicates it also “substantially reduces pathogen numbers in the waste-stream.” All claims are from data produced by the vendor and as such, would benefit from additional independent verification.

7.4 Control efficiency

If a Microaerobic Biological Nutrient Management Process replaces a current dairy process, such as lagoon, then its emission data, after proper review, can be compared to emissions from the replaced process unit. If the Microaerobic Biological Nutrient Management Process is an addition to the current dairy processes, it will be a separate permit unit whose emissions will need to be quantified. However, the control potential for this technology, when used in this manner, is that it will reduce emissions in either its liquid effluent, solid residuals, or both. The degree of control efficiency, in this case overall control efficiency for the impacted processes, will depend on how the Microaerobic Biological

Nutrient Management Process is used on the dairy (e.g., process water returned to flush lanes, sent to separator and/or lagoon, etc.)

Data from independent laboratory analysis which was subjected to independent peer review, show very low levels of emissions; 0.08 lb VOC/cow-yr, 0.2 lb NH_3/cow-yr, 0.56 lb H_2S/cow-yr, 0.017 lb NO_X/cow-yr, 38.47 lb CH_4 /cow-yr, coming from a specific Microaerobic Biological Nutrient Management Process bioreactor which has a hydraulic retention time of over 20 days. No data has been provided on emissions coming from processes receiving the treated effluent from the Microaerobic Biological Nutrient Management Process (storage lagoons, residual solids, further treatment, land application).

Before and after studies are not available for total dairy facility emissions impact (or the impact on specific downstream processes), the Microaerobic Biological Nutrient Management Process, or any other atmospheric emissions control technology. However, if the removal efficiency of atmospheric emission precursors as reported for the Microaerobic Biological Nutrient Management Process is repeatable, it would be reasonably expected that emission reductions would occur and, for at least some compounds, greater than for the application of anaerobic digestion. The quantification of those reductions could be determined either by downstream testing with and without the process (which would be expensive and time-consuming) or by alternative analyses characterizing the downstream effluent in terms of nutrients (nitrogen and carbon in particular), compared to untreated effluent and determining the impact of such a change on air emissions.

Vendor has provided the following control efficiencies for this technology. The measured values are highlighted. The remaining values were estimated by numerous calculations, which can be found in attachment xxx (BION report).

Emissions Data provide by vendor from each emissions point			
Unit #	Emission Point	NH_3	VOC
1	Manure Basin	0.000225	0.00015
2	Milk House Basin	0.000075	0.00005
3	Anaerobic Digestion	0	0.0803
4	Contact Chamber	0.00087	0.000579
5	Coarse Solids	0.00039	0.00016
6	Anaerobic Zone	0.12	0.0303
7	Microaerobic Zone	0.075[21]	0.0499
8	Fine Solids	0.00039	0.00016
9	Secondary Lagoon	13.44[22]	0.206

[21] It appears that this value is not correct based on BION's proposal – Need to verify

Total Liquid Manure Management		**13.64**	**0.368**
Baseline[23]		15.7	2.7
10	Land Application	0.4084	2.38
Total Land Application		**0.4084**	**2.38**
Baseline[23]		29.1	5.0

Based on the above table, the control efficiency for liquid manure management and land application is as follows:

Vendor Control efficiency		
	NH_3 (%)	VOC (%)
Liquid manure Management	13.1	86.4
Land Application	98.6	52.4

The following values have been re-calculated to conservatively estimate control efficiencies for both VOC and ammonia emissions using the following conservative assumption.

Assumptions:
In order to be very conservative in estimating a control efficiency, wherever no value was actually measured, and where there is no other reasonable way to estimate emissions, the worst-case value will be assumed based on the measured value from the microaerobic zone of 0.0499 lbs for VOC and 0.23 lbs for NH_3

Re-calculated Emissions Data from each emissions point				
Unit #	Emission Points	My NH3	VOC	Basis
1	Manure Basin	0.23	0.0499	No actual measurement, worst-case values used
2	Milk House Basin	0.23	0.0499	No actual measurement, worst-case values used
3	Anaerobic Digestion	0.23	0.0803	No actual measurement, worst-case value used. For VOC identical calculation used as used by vendor
4	Contact Chamber	0.23	0.0499	No actual measurement, worst-case values used
5	Coarse Solids	0.01	0.0100	Negligible emissions assumed since material will be largely solids
6	Anaerobic Zone	0.37	0.0499	No actual measurement,

[22] Baseline emissions used to calculate this value were fairly higher that Districts baseline
[23] Districts Draft Breakdown of Emission Factor Report

				However, vendor calculation used
7	Microaerobic Zone	0.23	0.0499	Measured values
8	Fine Solids	0.01	0.0100	Negligible emissions assumed since, material will be largely solids
9	Secondary Lagoon	3.77	0.206	Identical method used to estimate emissions from vendor. However, baseline emissions for ammonia were quite different
Total Liquid Manure Management		**5.31**	**0.556**	
Baseline[23]		15.7	2.7	
10	Land Application	6.99	2.38	Identical method used to estimate emissions from vendor for VOCs. For NH_3, Assuming only 24% of Nitrogen is available in the secondary lagoon (per applicant), then only 24% of emissions would be potentially generated from land application. (29.1 x 0.24 = 6.99)
Total Land Application		**6.99**	**2.38**	
Baseline[23]		29.1	5.0	

Based on the above table, the control efficiency for liquid manure management and land application is as follows:

Re-calculated Conservative Control Efficiency		
	NH_3 (%)	VOC (%)
Liquid manure Management	66.2	79.4
Land Application	76	52.4

7.5 Considerations regarding use of this technology

In addition to potentially mitigating criteria pollutants (VOC, NO_X), NH_3 and H_2S, and greenhouse gases (CH_4), this system has the advantage of also potentially providing a method for improving the water quality characteristics of the effluent. Emission reductions have been partially demonstrated, however, they have not been demonstrated from the entire process stream associated with this technology.

The technology's application as a high rate process has not been widely used at present and is poorly understood in the dairy community; lack of independent verification of capital and operating costs and overall emissions reductions and lack of wide adoption are all obstacles to adoption.

Only one vendor (BION) appears to be offering this technology at this time, compared to other technologies such as digestion, which have multiple providers in the commercial market. This lends to the perception that the process remains experimental, although the vendor indicates that several systems are running on dairies and hog farms. However, this perception may change as additional data become available.

Unlike digesters, which generate electricity, this technology uses electricity (unless combined with a digester). The Microaerobic Biological Nutrient Management Process can act as a technology platform and, as such, include an anaerobic digester upstream (for energy recovery) and a solids processing facility downstream (to recover bedding, fertilizer or other beneficial solids use), according to one vendor. This could affect overall emission reductions on the farm, as well as total cost.

7.6 Costs

According to the vendor, there are over 20 “first-generation” Microaerobic/Anoxic Biological Waste Treatment Systems on large dairies and hog farms, all of which were paid for by the owner (without government subsidies). The largest dairy is 3,700 cows and the oldest operating system is over 10 years old. For the current generation technology, there is an economy of scale, so, for a retrofit to an existing dairy in the Southwest, the capital costs range from $850 per cow for dairies of 1,000 cows to $600 for 2,000 cows, $500 for 4,000 cows to $450 per cow for 10,000 cows, again according to the vendor.

<u>Capital costs are sensitive to:</u>
Climate (i.e. Temperature & Precipitation)
Site conditions (i.e. Depth of water table & ledge)
% Solids input (i.e. flush (3%) vs. scrape (14%)

<u>Operating costs are sensitive to:</u>
Energy costs impacted by Temperature & Precipitation
Cost of electricity - projected to be largest individual operating cost exclusive of debt service and will range from $25 and $75 per cow per year.

The capital costs for a 10,000 – 15,000 cow facility in a warm climate that also integrates anaerobic digestion and solids processing ranges from $1,200 to $1,900 per cow. With the costs of servicing the debt and with the operating costs, these systems would cost somewhere between

$140 and $200 per cow per year without government subsidy and before considering any revenue streams.

The costs are offset by whatever grants or subsidies might be enjoyed. The Microaerobic Biological Nutrient Management Process is now approved for grants under the USDA NRCS EQIP program under the National Conservation Practice Standards for biological treatment systems. The EQIP program provides direct farm support in the form of grants to cost share up to 75% of qualified conservation practices, not to exceed $450,000 to any individual dairy during the term of the Farm Bill.

According to the vendor, potential revenue streams to offset costs from a Microaerobic Biological Nutrient Management Process integrated with anaerobic digestion and solids processing includes the sale of energy, recycle for bedding, and high N & P organic fertilizer, Greenhouse Gas Carbon credits and, if approved, emission reduction and nutrient credits.

All cost-related claims are from a technology vendor and as such would benefit from independent, third-party verification.

7.7 Feasibility at Dairies

A Microaerobic Biological Nutrient Management Process can be feasibly integrated into a commercial dairy design and can be expected to reduce any VOC, NH_3, H_2S, emissions coming from the facility, according to the vendor.

However, testing to date has generally been limited to _the digester-system itself and has not been comprehensive in terms of evaluating emissions changes with and without the system, particularly in evaluating its impact on whole-dairy or downstream process emissions. Evaluating only one link in the manure management chain is not sufficient to determine emissions reductions along the entire chain, and if it is added to the dairy (as opposed to replacing a dairy process), it is an emissions unit itself (see 7.4).

Some DPAG members believe that to a certain extent, emissions reductions have been demonstrated, although more work will need to be performed to fully quantify the precise reductions, therefore, this technology should be considered technologically feasible

7.8 Missing data

There is a relatively large amount of performance and emissions data for the process. However, there is no independent analysis of downstream processes or overall (whole-dairy) impact on emissions. There has been no independent analysis of the system costs. In the case the Microaerobic Biological Nutrient Management Process does not replace an existing dairy process, but is added to the dairy processes, … additional work is needed on the impact of the process on the emissions of its liquid effluent and solid residuals before emission reductions can be determined. The claims can be evaluated through source testing…

7.9 Further Resources

Detailed reports with spreadsheets of the data on the emissions to air and releases to water of a 1,250 cow flush lane dairy are available at www.biontech.com/technology.

7.10 Recommendation

- Although emissions data for the process are available, emissions reductions have not been demonstrated where the process is added to the dairy, rather than replacing an existing dairy process.
- The technology has been used at some dairies, notably in the Southwest.
- Merits reconsideration by the Air District when additional data are available

8. Gasification

8.1 Pollutants targeted and expected range of control efficiency

VOC, NH_3. Emissions reductions of VOC are expected but not yet quantifiable. Impact on ammonia is unknown.

8.2 Where technology comes from

Various private industry claims; some studies of other industries (poultry manure and brewery waste); may not yet be commercially available for dairies. Pilot scale protocol, however, scheduled to be "tested" in several locations over the next couple of months, including a pilot project in Chino, California.

8.3 Description of technology or practice

More than one company is researching and attempting to commercialize gasification technology that would allow manure effluent to be combusted at very high temperatures under oxygen-starved conditions. This produces a gas mixture known as syngas (synthetic gas) that can then be combusted to produce heat that can be used directly or to generate electricity. It also produces ash, which may offer other advantages or challenges related to waste disposal. Has not been proven in a "real world" scenario with dairy manure. Gasification technology generally requires a "dry" feedstock. Liquid waste would probably have to go through a pre-treatment drying device. The Dairy Technology Feasibility Assessment Panel is assessing gasification and is expected to report on its feasibility in the future.

8.4 Control efficiency

Not enough is known about the method of manure collection to assess control efficiency. It is not yet clear even whether this technology would utilize “liquid manure,” “slurry,” “semi-solid” manure or solid manure as a feedstock. Additional research is needed.

Because of the very high temperatures utilized in this process, it is expected that VOC emissions from the feedstock and any ash produced as a result would be virtually eliminated. Assuming that the proper control is placed at the exhaust and based on the control efficiency applied to similar control technologies, the control efficiency of this technology would be expected to be greater than 95%.

8.5 Considerations regarding use of this technology or practice

Potential advantages with this technology include energy generation, reduction of effluent volume and creation of new options for waste management and salts. These will require a complete investigation to prevent unintended consequences to water quality, agronomics, etc.; for example, users of this technology will need a plan for disposing of ash from this system.

This system remains in the experimental stage and does not appear to be commercially available to the dairy industry. A comparison of before-and-after emissions on an example dairy would be helpful to determine whether this technology has a positive environmental profile for air and water quality. A discussion of effluent/ash disposal plans is essential to a full evaluation. It is not yet clear if this technology works with dairy manure although at least one company reported a successful test with poultry litter.

8.6 Cost

Costs are unknown at this time. It appears that this remains in the experimental stage and is not yet commercially available.

8.7 Feasibility

Feasibility of this technology cannot be determined with the available information.

8.8 Missing data

The most important information needed is whether dairy manure can be utilized as a feedstock for gasification on an ongoing basis. Some feedstocks do not work in this type of technology. If dairy manure can be utilized a full investigation of costs and how such a system would be integrated into a dairy is needed.

8.9 Further resources

Coaltec, Inc.
Agricultural Waste Solutions

8.10 Recommendation

Not technologically feasible
Revisit as technology develops and/or additional information becomes available

9. Natural Crust Manure Storage Cover

9.1 Pollutants targeted and expected range of control

Reduction in VOC & NH_3 are targeted. Control efficiency for ammonia is expected to be about 75 percent. Control efficiency for VOC is unknown but a reduction is expected under certain circumstances (see below).

9.2 Where technology comes from

Research from various universities. On farm-practice within the swine and dairy industry. This technology is reviewed for two separate components of the manure handling system (1) the storage pond, and (2) the settling basin.

9.3 Description of technology or practice

A manure crust will form if a large amount of solids are added to a liquid manure storage unit. Such a crust serves as a biological cover and has been shown to reduce ammonia emissions from dairy storages by 75%. A significant crust will form on shallow settling basins used for solids separation purposes. In this use the crust provides a biological cover/filter as the settling basins dry.

9.4 Control efficiency

Control efficiency for storage ponds is unknown and it is possible and even likely that in many cases increasing solids loading (purposely overloading) storage ponds would increase emissions of odors, VOCs and other pollutants.

However, creating a crust on a settling basin that is designed not to hold water but to de-water solids is expected to reduce emissions as the surface crusts. Ammonia emissions reductions of up to 75 percent would be expected. VOC emission reductions would also be expected but it is not yet possible to quantify these.

9.5 Considerations regarding use of technology or practice

- Not a standard practice in the industry for storage ponds because of manure waste application needs.

- But it is a frequent occurrence in settling basins and may have application to reduce emissions from these areas of the manure treatment system.
- Impacts to emissions are not yet known.
- It may require changes in manure management for some dairies.
- It is unclear if managing manure differently in storage ponds (not separation basins) would increase or decrease VOC emissions.
- This practice is relatively easy to implement, particularly for separation basins.
- Additional costs may incur on the distribution of manure waste from the storage facility.
- Is being practiced on some dairies in California. These dairies are typically flush dairies with limited solid separation.
- Numerous studies have been done regarding reductions in ammonia, more data is needed on VOCs.
- While the possibility exists that these surface crusts could provide a large surface area upon which a biofilm could grow and develop — thereby providing an opportunity for syntrophy and metabiosis to occur — it is not clear to what extent this would permanently reduce emissions of reactive and green house gases (such as N_20 and methane), and to what extent the surface crust is merely acting as a cap that traps any gases and which may allow for their sequestration and further rapid release upon exposure to air. If the emissions reductions are permanent and real, the mechanism by which this management practice works and the efficiency with which it works under different loading and climatic conditions should be rigorously investigated.
- There is a danger that this management practice could provide reproductive habitat for mosquitoes. Given the large size of many of the lagoons/storage ponds it could prove very difficult to treat the affected areas. Assuming that any reductions through the use of surface crusts are real, the potential exists for any control strategy directed at mosquitoes to disrupt the microbial dynamics that are being depended upon which could consequently have unknown impacts on the system's ability to continue to reduce emissions.
- Recently at the American Society of Agronomy Annual Meetings in Salt Lake City, UT. a researcher from The Danish Institute of Agricultural Sciences made a presentation entitled "Methane Oxidation in Slurry Storages: a New Greenhouse Gas Mitigation Option?" The hypothesis of Soren O. Petersen et al. was that the natural surface crust on stored slurry could act as a sink for (methane) CH_4 by supporting bacteria that oxidized the $CH_{4.}$ After in depth investigation he was able to document for the first time CH_4 oxidation in natural and artificial slurry storage crust. Evidently previous to the meeting in Salt Lake City the work was published in the Journal of Environmental Quality earlier this year.

During the presentation Petersen brought up the possibility of other compounds being oxidized aside from CH_4.

- Further review of current literature has shown that indeed CH_4 oxidizing bacteria or methanotrophic bacteria do oxidize other compounds. This process is called cometabolism, cooxidation, or fortuitous metabolism. There has been much work in the realm of environmental remediation utilizing methanotrophs, usually remediating soil or water contamination by (trichloroethylene) TCE, a commonly used solvent. In a report to the U.S. Department of Energy (Methanotrophic Bacteria:Use in Bioremediation) the author reports that methanotrophs are ubiquitous in the environment and are able to cometabolize compounds such as aromatics, aliphatics, and alkanes. Methanotrophic bacteria are able to breakdown these compounds with enzymes called nonspecific oxygenases. Because these oxygenases are nonspecific, they not only oxidize available CH_4 but additional compounds as well (Hanson and Hanson, 1996).
- What methanotrophs need to survive is an aerobic environment and CH_4 for an energy or carbon source. Through a review of current available literature it seems likely that a natural crust surface on California dairy lagoons would provide this environment and may act as a mitigation technique for the reduction of VOC emissions from lagoons. The type of storage facilities in current operation in the state that would best suit this option would be described as a settling pond, or a settling basin. These settling basins are most commonly located on a facility downstream or in place of the mechanical solids separation unit and upstream of the storage pond. Usually these settling basins are built in a manner making them long and narrow, allowing the effluent to flow through them for settling of solids before eventual deposition into the storage pond. Usually these crusts develop naturally but for a storage pond situation artificial crusts can be made by adding straw or lecca pebbles to the lagoon surface (Petersen et al., 2005). Natural crusts are also known to abate (ammonia) NH_3 when formed over stored slurry (Misselbrook et al., 2005).
- The research group at CSU, Fresno is familiar with this design as an operating version is located on one of our current test facilities. There are also plans to evaluate this possible mitigation strategy in a current ARB funded project.

9.6 Cost

Additional costs may incur on the distribution of manure waste from the storage facility. These costs are unknown. Costs of managing settling basins to crust over may be minimal on some dairies. There will be costs associated with mosquito control measures.

9.7 Feasibility/Applicability at dairies

It is feasible to integrate this practice into at least some dairy operations and this is being practiced on some dairies in California. These dairies are typically flush dairies with limited solid separation. This practice is feasible for reducing ammonia emissions. It is not yet known whether this would feasibly reduce VOC emissions.

9.8 Missing data

A better characterization of how this practice would be implemented on dairies in general will support a more thorough evaluation of its feasibility and impact on overall emissions. An emissions study of two comparable systems, e.g. a basin that has a crust and a comparable basin without a crust will help to determine whether this practice has an impact on VOC emissions. Numerous studies have been done regarding reductions in ammonia, more data is needed on VOCs.

9.9 Further Resources

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Westinghouse Savanna River Co.
U.S. Dept. of Energy contract. No. DE-AC09-96sr18500
Web access: http://sti.srs.gov/fulltext/ms2001058/ms2001058.html

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Misselbrook, T.H., S.K.E. Brookman, K.A. Smith, T. Cumby, A.G. Williams, and D.F. McCroy. 2005. Crusting of stored dairy slurry to abate ammonia emissions: pilot-scale studies.
J. Environ. Qual. 34:411-419.

Petersen, S.O., B. Amon, and A. Gattinger. 2005. Methane Oxidation in Slurry Storage Surface
Crusts. J. Environ. Qual. 34:455-461.

University of Minnesota, Biosystems and Agricultural Engineering
Clemson University
University Of Nebraska
Several dairy farms in California

9.10 Recommendation

- Achieved in practice under certain conditions (settling basins as primary method for solids separation and for reducing ammonia)
- Unable to determine technological feasibility at this time for VOCs.
- Not recommended for storage ponds as will be a violation of mosquito abatement rules

10. Phototrophic Lagoon Processing

10.1 Pollutants Targeted and Expected Range of Control Efficiencies

Odor: 70 – 90% control
VOC: Expected to parallel odor reduction *(70-90%) based on published research on purple phototrophic lagoons where VOC emission reduction paralleled odor reduction*
NH_3: 50-80% control
H_2S: 70-90% control

10.2 Where Technology Comes From

Current industry innovative practice technology in place on California dairies. Technology is currently in place as engineered natural phototrophic “red water” lagoon systems on California dairies. This innovative practice is simply a controlled systematic application of a process that naturally occurs widely in dilute anaerobic ponds and in animal waste lagoons on livestock enterprises across the US.


Examples of naturally occurring phototrophic swine and dairy lagoons are pictured above

10.3 Description of Technology or Practice

This technology seeks to take advantage of a naturally occurring phenomenon where municipal and animal waste lagoons as well as natural lagoons and estuaries, strata in lakes etc have turned either purple, pink, or rose in color. This phenomenon is now known to be caused by assemblages of phototrophic bacteria known as the purple sulfur and purple non-sulfur bacteria. Blooms of these bacteria occur opportunistically when conditions provide the appropriate dilute nutrient loading in combination with the right temperatures, lighting conditions and limited oxygen availability that are required for these bacteria to become dominant. In nature these blooms (as the name suggests) are transitory. In order for these types of algal blooms to be maintained in a municipal waste-water treatment or farm context the conditions must be continuously and properly maintained in order for the bloom to be sustained indefinitely (thus they are no longer a “bloom”).

In order to encourage and maintain the development of these bacterial species assemblages in farm lagoons year-round, the proposed practice is to use sequential pond systems (ie. up to 3 ponds: for processing, sequestration, and polishing/flush) involving several types of mechanical circulation, mixing and fresh water dilution that continually mixes the lagoon liquids and solids to ensure that the phototrophs are exposed to sufficient sunlight several times/day. It is proposed that most of the systems will include fresh water (irrigation water) dilution to achieve the necessary dilute conditions and translucency. Most systems will also include mechanical solids/liquids separation to remove excess solids for composting. This has two advantages: 1) it removes the excess carbon found in the solids and which can inhibit the desired beneficial nitrification/denitrification process that occurs in these lagoons, and 2) excess solids contributes to turbidity and thus would inhibit the phototrophs.

The agricultural community has met with some success in taking advantage of these purple-pink-rose bacterial communities in treating the waste-water from swine and dairy operations in order to reduce the odors produced by the lagoon water associated with their operations. Research indicates that these microbes and their associated syntrophs metabolize sulfur and nitrogen containing compounds as well as various long chain organic compounds, many of which could be a potential source of problematic VOCs of concern with regards to air quality in the San Joaquin Valley. Indeed there is some research which indicates that these systems can reduce VOC emissions, at least at swine operations. Given this research and the understanding that these assemblages of organisms metabolize VOCs, nitrogen, and sulfur compounds[24[1]] it has been proposed that the engineered lagoon systems described above may not only reduce odors, they may also be important in reducing the emissions of H2S, reactive nitrogen compounds and VOCs (since these could theoretically all be metabolized to S°, SO_4, N_2, CO_2, and H_20).
Example Dairy Phototrophic Lagoon System for Odor Control, at CA Dairy studied by USDA-ARS, and USDA-NRCS-Conservation Innovation Grant Project through California Dairy Campaign.

[24[1]] Indeed these species assemblages take advantage of a complex interplay that involves the use of carbon compounds as energy sources for heterotrophs, and various carbon, sulfur, and nitrogen compounds as both electron donors and acceptors

10.4 Control Efficiency

While these lagoon systems have shown some promise in reducing odors associated with CAFOs, their ability to reduce the emissions of VOCs and other reactive air emissions at California dairies awaits the results of new sampling and analytical lab research protocols that are being developed and evaluated in California. The reduction of odors in combination with the understanding that the bacterial species assemblages found in these lagoons metabolize all of the classes of compounds of concern to the Air District does not mean that odor reduction can be used as a valid surrogate for the significant reductions in VOCs and other compounds. The control efficiency of these lagoon systems awaits further evaluation.

10.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- This technology offers promise in reducing emissions through all phases of liquids handling—flushing, liquid/solid separation, lagoons, field application
- This technology offers additional benefits in clean fiber for composting, cleaner freestall alleys, cleaner cows contributing to herd health
- This technology eliminates stagnant water lagoon mosquito habitat, and typical lagoon crust habitat for flies, rats, snakes and other vermin
- Cleaner flush alleys and better solids removal further reduces fly habitat

b) Cons

- This technology works best in the spring, summer, and fall

- This technology requires a nearby land base for irrigated fertigation liquids, as do all farm process of nutrients.
- The requirement of dilute lagoon conditions could require a greater use of water than is already typically the case in the Valley's flush dairies. This raises a resource concern for the future. The blending of nutrient water with fresh water usually done in the pipe line system, Here in it blended in the lagoon rather than the pipe line. Same water usage different process
- This technology requires multiple lagoons and lagoon capacity. However, there have been numerous retrofits using existing infrastructure W/O addition of lagoons
- This technology requires cycling irrigation water through the system for dilution
- Some electrical energy will be required in typical applications
- Techniques necessary to test and validate possible VOC reductions are just now in development, and are being developed here in California.

Lagoons with PSB may follow a diurnal trend with PSB oxidizing sulfide to other sulfur compounds during the day, and SRB (sulfur reducing bacteria) dominating during the evening and reducing sulfate to sulfide. The oxidative state of sulfur compounds impacts on the processing on nitrogen compounds. When sulfide is absent or in low concentration, nitrate can be converted to ammonia. The presence of sulfate encourages denitrification of nitrate. While denitrification is ongoing methanogenesis is inhibited, the redox potential goes up with the increase in nitrite levels with a consequent reduction in sulfide levels.

Percheron, G., N. Bernet, and R Moleta. 1999. Interactions between methanogenic and nitrate reducing bacteria during anaerobic digestion of an industrial sulfate rich wastewater. FEMS Microbiology Ecology 29:341-350.

10.6 Cost

Pond mixing and circulation units are currently marketed by several US and International vendors, primarily for odor control, so costs are well known. For odor control, typically 1 unit moving millions of gallons of liquid/day is placed for every 50 to 100 lactating cows (or equivalents), and this may cost $ 200/cow installed and operating. Costs of additional lagoons, and mechanical separators, if not already present, would be additional. Operating costs are very low with typical industry electric rates (i.e. $ .02/cow/day). With the value of fertigation plant liquids alone, payback is typically 2 years or less. Thus, the economics are feasible. Costs/unit of emission reduction await direct emission reduction measurements on California dairies.

Cost per cow is in a range of 3000 – 10,000 per unit divided by application 50 - 100 -150 animal units = cost per cow

10.7 Feasibility at Dairies

- This technology offers promise but needs on-site verification of emissions reductions
- Irrigated fields close to the dairy for land application are required
- Modifications of dairy liquids processing systems are required- usually involving lagoons, capacity and cycling a portion of the normally used irrigation water through the system for dilution

10.8 Missing Data

- VOC emissions measurements at dairies with this technology
- Odor emissions measurements at dairies with this technology Dr Ron Sheffield Univ of Idaho has this info.
- NH_3 emissions measurements at dairies with this technology
- H_2S emissions measurements at dairies with this technology

How the cost of such a system would scale with dairy size ? this info is available on a cost per cow.

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Web-based refs

http://www.lpes.org/Lessons/Lesson43/43_4_Biological_Processes.pdf. LESSON 43 Emissions Control Strategies for Manure Storage Facilities

www.iowadnr.com/air/afo/files/finalaforeport.pdf. Animal Feeding Operations Technical Workgroup Report On: Air Emissions Characterization, Dispersion Modeling, and

Best Management Practices Prepared by: The Iowa Department of Natural Resources

Animal Feeding Operations Technical Workgroup 12/15/04.

Industry Resources, Vendors, Current Research in Progress

Pond mixing equipment:

Aerobicizer
Blue Frog
CIRCUL8 Systems
Little River Pond Mills-Sunset Solar
Solar Bee
Vortatec

Mechanical Separators:

Incline mechanical: Albers
Horizontal-sidehill: Numerous vendors

Research in Progress:

USDA-ARS-Albany, CA: Phototroph microbial kinetics and organics processing

USDA-NRCS-CIG: Lagoon Innovation Technology; Lagoon liquids processing and liquids applications; CDC managed project

10.10 Recommendation

- *Some DPAG members believe the technology is achieved in practice (where irrigation dilution water is available);*
- *Other DPAG members do consider the technology to be achieved in practice*
- *Actual emissions reductions need verification for application*

11. Complete Aeration (Dissolved Oxygen > 2.0 mg/l)

11.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC: 95%
NH_3: 95%

H_2S: 95%

11.2 Where Technology Comes From

Experiments on wastewater aeration started in England as early as 1882. These experiments involving aeration and aerated filter wastewater treatment continued in U.S. until the activated sludge process was developed in April of 1914. Large-scale aerobic treatment of wastewater has been practiced in the United States for decades. Technological advances have spurred the use of small-scale individual aerobic treatment systems by increasing efficiency and making the systems more affordable. Partial aeration for odor control and to promote nitrification of ammonia is currently used in agricultural liquid waste lagoons, including dairy and swine lagoons. Complete aeration systems are currently used in waste treatment facilities.

11.3 Description of Technology or Practice

The purpose of aeration is to maintain a sufficient concentration of dissolved oxygen to enable aerobic digestion to occur. Aerobic digestion is the decomposition of organic compounds by microbes in an oxygen-rich environment. The microbes reduce the organic compounds in the waste to carbon dioxide, water, nitrates, sulfates, and biomass (sludge). Aeration of liquid manure streams is accomplished by mechanically forcing air into the liquid. According to Dr Ruihang Zhang of UC Davis, complete aeration can be achieved with a Dissolved Oxygen rating of > 2.0 mg/l. Aerators, which are currently used on dairies have a DO which is significantly lower than 2.0 mg/l.

11.4 Control Efficiency

The control efficiency for complete aeration is not precisely known but if a sufficient dissolved oxygen concentration can be maintained, the control efficiency could be assumed to be near 100% since complete aerobic digestion would convert ammonia into nitrates, H_2S into sulfates, and the carbon of VOCs into CO_2.

11.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- Negligible amounts of VOC and H_2S emissions are created from completely aerobic lagoons.
- Aerobic digestion minimizes the amount of ammonia (NH_3) produced, resulting in nitrate and organic forms of nitrogen instead.
- Aerobic digestion generally does not produce methane, a greenhouse gas.
- Aerated lagoons result in relatively odor-free end products.

- Aerobic systems are able to achieve superior liquid effluent quality.
- Mechanically aerated lagoons have relatively small surface area requirements when compared to naturally aerobic lagoons

b) Cons

- Aerobic treatment is generally more expensive than anaerobic treatment because of the cost of aeration equipment and the equipment power requirements.
- Aerobic treatment can produce several times the amount of biomass (sludge) than produced by anaerobic digestion.

This approach may be suitable for a centralized or cooperative approach.

11.6 Cost

After initial installation, the most significant cost would be for the energy needed to run the aerators. There would also be costs for maintenance. The economics of such a system would suggest that it would benefit from the use of a centralized or cooperative approach..

11.7 Feasibility at Dairies

This technology would be considered feasible at dairies. However, the detailed cost effectiveness of this system needs to be performed prior to its application.

11.8 Missing Data

How the costs of such a system would scale with dairy size.

11.9 Further Resources

Dr. Ruihang Zhang – UC Davis
Al Vargas - CDFA

11.10 Recommendation

This technology should be considered technologically feasible and the District should perform a cost-effective analysis for this technology.

C. ~~Technologies Placed on the Sidelines~~ Other Technologies

1. Flushwater injection systems

Determination: Flush water cannot be injected. This only works with fresh manure; therefore this technology should not be considered.

2. Lagoon Elimination or Reduction

Determination: This is not a control strategy by itself. Another management strategy in place of the lagoon must be evaluated, e.g. covered lagoon or tank digester, injection to crops, etc.; these alternate strategies are evaluated in section VIII.B.1 of the report.

3. Speed of transit to processing pond (VOC)

Determination: We were unable to find any information to suggest this is substantially different than flush frequency, which is included in section IV.B.4 and VIII.B.2 of the report. This was determined therefore to be either duplicative or irrelevant.

4. Flush and Irrigation Management – low VOC flush and low VOC irrigation effluent

Determination: We were unable to find any information to suggest this is substantially different than “manner of flushing/flush water source,” which is included in section VIII.B.2 of the report. This was determined therefore to be either duplicative or irrelevant.

ii Aeration Systems

1. The O_2 Solution ™ -

Determination: This technology was evaluated in the Dairy Technology Feasibility Assessment Panel Draft Report, which is not available to the public and is in draft form. Without sufficient information we cannot make a finding that this technology has potential as defined in APR 1305.

2. AMTS - Advance Microbial Treatment System -

Determination: This technology was evaluated in the Dairy Technology Feasibility Assessment Panel Draft Report, which is not available to the public and is in draft form. Without sufficient information we cannot make a finding that this technology has potential as defined in APR 1305.

3. Water Reclamation System -

Determination: This technology was evaluated in the Dairy Technology Feasibility Assessment Panel Draft Report, which is not available to the public and is in draft form. Without sufficient information we cannot make a finding that technology has potential as defined in APR 1305.

4. Aeration and Wet Combustion

Determination: This technology was evaluated in the Dairy Technology Feasibility Assessment Panel Draft Report, which is not available to the public and is in draft form. Without sufficient information we cannot make a finding that this technology has potential as defined in APR 1305.

iii Anaerobic Digesters

1. Covered Lagoon Vented to a Biofilter

Determination: No information exists to suggest that lagoon biofilters can be evaluated for technological feasibility. The Draft Dairy BACT document of April 27, 2004 is cited as a source but does not contain any information other than vendor claims and phone numbers; in most cases VOC controls are not cited. However, we also note that even in the draft the District did not find that these were technologically feasible and we are unaware of any information to change that determination. If additional information becomes available this can be re-evaluated.

Biofilters are a proven technology for reducing VOC, ammonia, and hydrogen sulfide gases, therefore, this technology is technologically feasible. However, the cost of such a system including covering the lagoon may make this technology not cost effective.

2. Bio-Cap ML

Determination: This technology was evaluated in the Dairy Technology Feasibility Assessment Panel Draft Report, which is not available to the public and is in draft form. Without sufficient information we cannot make a finding that this technology has potential as defined in APR 1305. In addition, see #10 above as this appears to be a biofilter.

3. Complete Mix Anaerobic Digester

Note: This was combined into the general entry for tank-style anaerobic digesters in the report; the workgroup determined that this did not merit a separate evaluation.

4. Biogas Technology - continuous stirred tank reactor (CSTR) using steel tank technology, gas mixing and external heat exchange.

Note: This was combined into the general entry for tank-style anaerobic digesters in the report; the workgroup determined that this did not merit a separate evaluation.

5. Renewable EnergyWorks (REW) – Mixed plug digester –IC Engine, Supplemented with other organic matter from food industry – digested solids are composted.

Note: This was combined into the general entry for tank-style anaerobic digesters in the report; the workgroup determined that this did not merit a separate evaluation. We noted in that entry, however, that potential differences in emissions and effluent need to be considered in the event that a food waste stream is added to manure.

6. Cow Complex – Centralized digester, WWTP

Note: This was combined into the general entry for tank-style anaerobic digesters in the report; the workgroup determined that this did not merit a separate evaluation.

iv Multiple Technologies

1. Everstech ET Process

Determination: This technology was evaluated in the Dairy Technology Feasibility Assessment Panel Draft Report, which is not available to the public and is in draft form. Without sufficient information we cannot make a finding that this technology has potential as defined in APR 1305.

2. Manure Separation and Treatment

Determination: This technology was evaluated in the Dairy Technology Feasibility Assessment Panel Draft Report, which is not available to the public and is in draft form. Without sufficient information we cannot make a finding that this technology has potential as defined in APR 1305. Even when information becomes available, this may be more appropriate for consideration under solids separation depending on the details. However, manure various manure separation technologies are evaluated under section V.A.i.

3. Nitrification/Denitrification

Determination: This technology was evaluated in the Dairy Technology Feasibility Assessment Panel Draft Report, which is not available to the public and is in draft form. Without sufficient information we cannot make a finding that this technology has potential as defined in APR 1305.

4. System for Converting Animal Wastes to Energy and Useful By-Products

Determination: If this is in fact a gasification technology it is discussed in general terms in Attachment A. If it is another technology or there are important facts distinguishing this from other technologies, those facts may be analyzed as they become available.

5. OrTec Biocatalyst (NH_3 & H_2S)- The technology consists of a "biocatalyst" additive that is used to enhance the digestion of

organic matter in manure-handling systems including anaerobic digesters.

Determination: This technology was evaluated in the Dairy Technology Feasibility Assessment Panel Draft Report, which is not available to the public and is in draft form. Without sufficient information we cannot make a finding that this technology has potential as defined in APR 1305.

6. Flex-Microturbine

Determination: This technology was evaluated in the Dairy Technology Feasibility Assessment Panel Draft Report, which is not available to the public and is in draft form. Without sufficient information we cannot make a finding that this technology has potential as defined in APR 1305.

7. Pyromex-Pyrolysis-Hydrolysis Ultrahigh Temperature

Determination: This appears to be a technology that requires dry manure to work and thus we recommend reclassification. This technology was evaluated in the Dairy Technology Feasibility Assessment Panel Draft Report, which is not available to the public and is in draft form. Without sufficient information we cannot make a finding that this technology has potential as defined in APR 1305.

8. Management Practices for Lagoon to Promote Red Lagoon (demonstrate bacteriochlorophyll concentrations equal to or greater than 40 nmol/mL)

Determination: Given that almost no information exists to support addition of any type of biological agents (microbes, chemicals, etc.) to lagoons as an emission reduction method, we recommend that biologicals/additives be a) condensed to a single category and b) re-evaluated as new information becomes available.

9. Octaform PVC Lined Concrete Tanks with CIRCUL8 System

Determination: This technology was evaluated in the Dairy Technology Feasibility Assessment Panel Draft Report, which is not available to the public and is in draft form. Without sufficient information we cannot make a finding that this technology has potential as defined in APR 1305.

10. Rapid Pyrolysis

Determination: This technology was evaluated in the Dairy Technology Feasibility Assessment Panel Draft Report, which is not available to the public and is in draft form. Without sufficient information we cannot make a finding that this technology has potential as defined in APR 1305.

11. Pro-Act Microbial Manure Munching Microbes

Determination: Given that almost no information exists to support addition of any type of biological agents (microbes, chemicals, etc.) to lagoons as an emission single category and b) re-evaluated as new information becomes available.

12. ReCiprocating Wetlands

Determination: This appears to be primarily a nitrogen removal technology. This technology was evaluated in the Dairy Technology Feasibility Assessment Panel Draft Report, which is not available to the public and is in draft form. Without sufficient information we cannot make a finding that this technology has potential as defined in APR 1305.

13. Waste Technology Transfer (WTT bio crude oil from organic waste)

Determination: This appears to be a technology geared at treatment of solid, not liquid manure. Also, This technology was evaluated in the Dairy Technology Feasibility Assessment Panel Draft Report, which is not available to the public and is in draft form. Without sufficient information we cannot make a finding that this technology has potential as defined in APR 1305.

14. Microbe injections for lagoon treatment

Determination: Given that almost no information exists to support addition of any type of biological agents (microbes, chemicals, etc.) to lagoons as an emission reduction method, we recommend that biologicals/additives be a) condensed to a single category and b) re-evaluated as new information becomes available. We would also note that the description cited was attribute only to the South Coast Air Quality Management District web site as follows: **http://www.aqmd.gov/rules/support.html#r1127** . We recommend that future references are more specific to speed looking up the supported information, e.g., Tetra-Tech Report with title, date, page number, section number and extracted text. Our review of this information shows that SCAQMD actually determined there was no evidence to support this technology as having potential to reduce emissions. That should have either removed it from this list, or should have been noted along with the entry.

15. Root guard-subsurface irrigation using flush water

Determination: References were listed but they in no way support the contention that this would reduce VOC emissions. Thus, we cannot make a finding that this technology has “potential” to reduce emissions. We would again recommend better and more detailed references with page numbers, sections, and extracted text. Finally, this technology is note related to liquid manure management but only use of irrigation water. It should be reclassified and its applicability to dairy feed crops determined (as opposed to tree and vine crops) before further consideration.

http://www.greenmediaonline.com/ij/1999/0699/699inws.asp
http://www.geoflow.com/wastewater/nitrate.htm
http://www.geoflow.com/wastewater/sdi.htm
http://www.nal.usda.gov/wqic/Bibliographies/dairy2.html

16. Verdegaal-Sulfuric acid treatment for lagoons

Determination: This technology does not claim to reduce emissions of VOCs from lagoons. It does not quantify ammonia reductions from lagoons. Given that the primary driver is the desire to reduce VOC emissions, more information is needed to determine this technology's impact on VOC emissions.
workhttp://cati.csufresno.edu/update/index.asp?isquery=True&selectedarticle=56

17. Photoremediation for lagoons

Determination: We believe the term that is intended here is actually phytoremediation. The cited references do not appear to support a contention that VOCs would be reduced; however, this may be useful to remove certain water quality contaminants. This can be re-evaluated if more information is made available.

18. Biocatalyst-Adding Trace Metals to the Lagoon to Enhance Biological Growth (VOC)

Determination: The contention that this would reduce VOCs is not supported in the only cited reference. Either a more specific reference is needed or additional information before this can be reconsidered.

19. Addition of Potassium Permanganate to the Lagoons

Determination: The workgroup deemed that the cited references were not worth the time to research given that they were a) not provided in written form, b) attempting to locate these references would require substantial time and c) the references are so old that it is extremely unlikely they would have anything useful to say about VOCs and particularly animal waste VOCs, given that these topics are only now beginning to be understood.

Potassium permanganate has been shown to temporarily reduce ammonia emissions if applied regularly to manure flush water under laboratory conditions. However, this laboratory study does not appeared to have examined impacts of potassium to groundwater nor whether VOCs were reduced or increased. This may be a topic for further research but cannot be determined to have VOC potential until additional information is available.

20. Algae Cropping in the Lagoon (VOC)

Determination: No reference information whatsoever was submitted to support inclusion of this on the list, not even a basic description.

21. Chemical Binding of Nitrogen and Desiccants

Determination: No reference information was submitted whatsoever other than the phone number and email of a purported vendor. This is not enough information to support a finding of "potential" for reduction of VOCs. This may be re-evaluated if additional information becomes available.

~~See Attachment 2 or these technologies can be placed in this section~~

~~IX. PROCESSING PITS~~ MOVED TO SOLIDS SEPARATION SECTION

~~A. Description~~

~~The processing pit is an emission unit, which serves the following purposes:~~

1. ~~Temporarily holds and stores fresh flush water from the milking parlor~~
2. ~~Contents within the processing pit are used to flush the concrete feedlanes. This flush water including the waste in the feedlanes is returned to the processing pit and is recycled during each flush.~~
3. ~~Once the volume exceeds the preset levels in the processing pit, pumps and agitators are turned on. The agitators mix the contents in the processing pit so that solids do not settle and the pumps take the contents to the separator to remove the fibrous content prior to the lagoon.~~

~~This processing pit replaces the standard method of flushing which involves flushing the concrete feedlanes from the lagoon or secondary lagoon (storage pond).~~

~~B. Control Technologies for Processing Pits~~

~~1. Flushing from Secondary lagoon - Elimination of Processing Pit~~

~~1.1 Pollutants Targeted and Expected Range of Control Efficiencies~~

~~VOC and NH_3~~

~~1.2 Where Technology Comes From~~

~~Engineering Judgment~~

1.3 Description of Technology or Practice

A processing pit is an additional emission unit to a dairy system which has recently been adopted on new dairies. The basic function of a processing pit is to temporarily store flush water so that it can be used to flush the concrete feedlanes, however, in the process, this system has the potential of increasing overall emissions from a dairy. First, unlike flushing from the storage pond, where manure has gone through a treatment system through the primary lagoon, no treatment takes place prior to flushing the concrete feedlanes from the processing pit. Second, unlike the storage pond, where the solids content is well below 1% (fairly clear water), the processing pit contains about 1.5 to 2.5% solids and recycles the flushed manure back and forth to the flush lanes, basically flushing with unclean manure water. Third, when the preset volume in the pit is exceeded, pumps turn on and the contents in the pit are stirred, potentially releasing significant emissions into the air. Fourth, solids in this system, have the potential of settling to the bottom of the pit, creating anaerobic conditions which promote unwanted emissions (VOC, H_2S, NH_3).

This system can easily be replaced by utilizing the standard method currently in place on many existing dairies, which involves flushing the concrete feedlanes from the secondary lagoon. By flushing from the secondary lagoon, cleaner flush water is introduced into the concrete feedlanes. This is due in prime to the pre-treatment of that flush water by the primary anaerobic treatment lagoon, which has digested a significant amount of Volatile Solids (VS) from the manure. In addition to the emission reductions obtained from flushing, a new potential source of emissions, the processing pit, is eliminated, without affecting the dairymen's manure management.

1.4 Control Efficiency

The control efficiency of the elimination of the processing pit is not exactly known but can be assumed to be as high as a 100% since a similar practice (flushing from the storage lagoon) can be employed without any of the emissions concerns outlined for processing pit in section 1.3.

1.5 Considerations Regarding Use of the Technology or Practice

Some DPAG members believe that this type of system should not be considered on new dairies due to the potential emissions generated from it.

a) Pros

- This system potentially decreases the amount of fresh water required at a dairy.

- The energy costs to operate pumps is lower from a processing pit when compared to flushing from the lagoon.
- Separator pumping time is greatly reduced. Since flush water is recycled from the processing pit to increase manure concentration, the separator pump only runs when the pit has reached a preset level. Generally you can see a 30% to 50% reduction in separator pumping time.

b)Cons

- A processing pit is an additional emission source at a dairy
- There is a potential for an increase in emissions from each flush due to the higher manure solids content in the flush and the fact that the manure has had no treatment prior to each flush

1.6Cost

The cost of this system is not known but can be obtained by vendors of this technology

1.7Feasibility at Dairies

The current standard of washing or cleaning the concrete feedlanes appears to have lower emissions than a processing pit, while serving the same purpose. Therefore, the application of processing pits at a dairy should not be considered any further.

1.8Missing Data

Emissions data from both the processing pit itself and from the flush is needed.

1.9Further Resources

US Farm Systems

1.10Recommendation

Due to the potential of emissions generated from the processing pits when compared to the standard method, it is recommended that that application of processing pits on dairies be discontinued or eliminated. Since the standard method (flush from the storage lagoon) for cleaning flush lanes is utilized at many dairies, this technology/practice should be considered Achieved in Practice.

2.Cover Processing Pit and vent biogas to biofilter

2.1Pollutants Targeted and Expected Range of Control Efficiencies

VOC and NH_3

2.2Where Technology Comes From

Engineering Judgment and technology transfer

2.3Description of Technology or Practice

A processing pit is an additional emission unit to a dairy system which has recently been adopted on new dairies. The basic function of a processing pit is to temporarily store flush water so that it can be used to flush the concrete feedlanes, however, in the process, this system has the potential of increasing overall emissions from a dairy as explained in section 1.

In order to reduce emissions from the processing pit, a cover can be applied, and the biogas generated can be sent to a biolfilter which is capable of reducing emissions of greater than 80%. Refer to section xxx for a discussion on biofliters.

2.4Control Efficiency

Biofilters have been shown and proven to have control efficiencies greater than 80%. According to the SCAQMD Rule 1133.2 final staff report (page 18) Technology Assessment Report, a well designed, well operated, and well-maintained biofilter is capable of achieving 80% destruction efficiency for VOC and NH_3. Therefore, a 80% control efficiency will be applied to the emissions generated directly off of the processing pit.

The cover alone will not be sufficient in reducing any other emissions associated with the use of a processing pit such as those emissions generated from the flush water from the processing pit. As mentioned in section 1.3, emissions would be greater due to the increase in solids content of the flush water and lack of pretreatment. Therefore, a further control technology or practice will need to be applied to reduce those emissions.

2.5Considerations Regarding Use of the Technology or Practice

a)Pros

- Processing pits potentially decreases the amount of fresh water required at a dairy.
- The energy costs to operate pumps is lower from a processing pit when compared to flushing from the lagoon.
- Separator pumping time is reduced. Since flush water is recycled from the processing pit to increase manure concentration, the separator pump only runs when the pit has reached a preset level.

- 80% reduction in emissions can be obtained from the emissions generated off of the processing pit.

b) Cons

- A processing pit is an additional emission source at a dairy
- There is a potential for an increase in emissions from each flush due to the higher manure solids content in the flush and the fact that the manure has had no treatment prior to each flush. This process will remain uncontrolled even with a cover over the processing pit.

2.6 Cost

The cost of adding a cover and venting the gas to a biofilter is not known but can be compared to similar industries where the use of covers and biofilters have been used.

2.7 Feasibility at Dairies

This technology would be considered feasible at dairies. However, the detailed cost effectiveness of this system needs to be performed prior to its application.

2.8 Missing Data

Emissions data from both the processing pit itself and from the flush is needed.

2.9 Further Resources

2.10 Recommendation

This technology should be considered technologically feasible and the District should perform a cost-effective analysis for this technology.

X. IX. SOLID MANURE MANAGEMENT

A. Control Technologies/Practices for Solid Manure

i SOLIDS REMOVAL /SEPARATION

Solid liquid separation partitions some of the solids fraction of the liquid stream into its own stream. Separated solids may be further processed for transport off farm or for on farm use as bedding, soil amendment, fertilizer or feed. . Drying is a standard practice to reduce the moisture content (usually between 70–85%) prior to transport and final use. Storage, handling, and spreading techniques for both liquid and solid manure are required if the solids are separated. Higher investments for equipment must be made for operation and maintenance, and more management skills are needed. (http://www.lpes.org/Lessons/Lesson43/43_3_Solid_Liquid_Separation.pdf)

Separation process technologies include *gravity separation* (sedimentation pits, ponds, basins, or compartments) *mechanical separation* (screens, centrifuges, hydrocyclones, and presses), ~~and~~ *flocculation or precipitation separation* (chemical additions are used to help precipitate particulate and colloidal materials)[25], and processing pits. Separation is typically used in the dairy industry to remove larger, more dense particles from the liquid stream.

Mechanical separators may use a combination of screens and presses to separate the more liquid and more solid fractions of the manure. Efficiency of total or volatile solids separation is a function of the screen opening and average particle size. Bedding can be a large contributor to total solids. Efficiency of solid separation can range from less than 5% of total solids (single screen with influent coming from a retention/storage pond or lagoon) to less than 50% (two screens of differing sizes used in sequence between the animal housing and the retention/storage pond or lagoon). Some separators are able to produce solids that are about 70 percent moisture as a result of additional dewatering accomplished by presser roller or other advanced dewatering technology.

1. Mechanical separation

1.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC; possibly NH_3

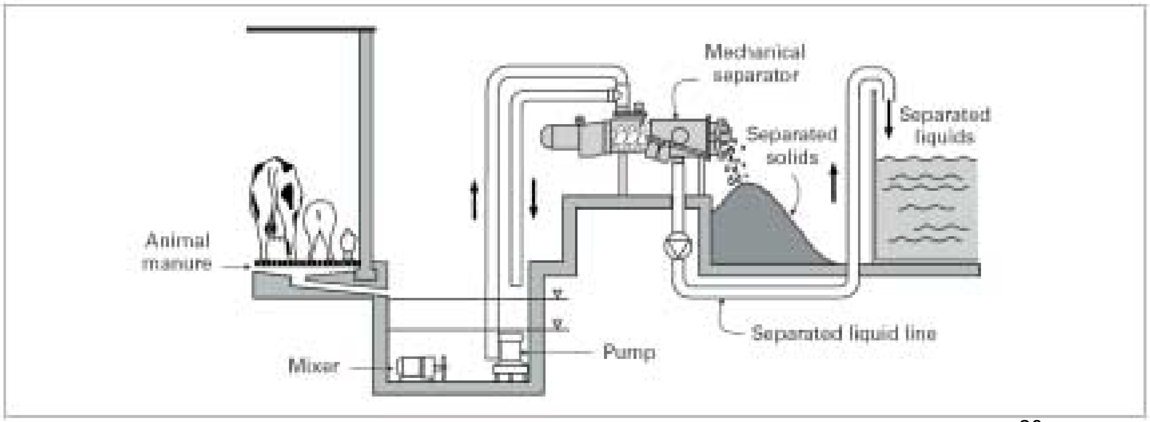
1.2 Where technology comes from

Engineering Judgment and existing dairies

1.3 Description of "technology"

The purpose of mechanical separation is to remove the fibrous and more dense materials prior to the liquid manure entering the lagoon.

[25] http://www.climatetechnology.gov/library/2003/tech-options/tech-options-4-2-2.pdf
http://www.bee.cornell.edu/extension/manure/solids_separation.htm



(Basic arrangement for mechanical solid-liquid separation system[26])

By removing the most fibrous material from the liquid stream prior to entering the pond, it is hypothesized that the amount of intermediate metabolites released during digestion in the pond may be reduced. Removal of the fibrous material allows for more complete digestion in the pond potentially resulting in lower emissions.

1.4 Control Efficiency

The control efficiency of mechanical separators is not known at this time. Actual emission changes must be considered speculative at this time.

Separation systems in general have the potential of reducing emissions from the lagoon system by allowing for more complete digestion to take place through the removal of indigestible solids. In addition, some within the group believe that there is a potential of further overall emissions reduction by utilizing a mechanical separator rather than settling basins or weeping walls.

To create an estimated control efficiency for mechanical separators, the following assumptions are made by some DPAG members:

- Mechanical separators generate separated solids with a manure moisture content between 75-85%. These separated solids piles are removed on a weekly to monthly basis and are further dried generally within a month or so during the warm summer months. Therefore, the total time separated solids are kept in a high moisture state is between 5 weeks to 8 weeks.

- Settling basins generate a slurry type manure with a manure moisture content of greater than approximately 92%. The slurry in this system resides within the basin from three months to a year.

[26] Livestock and Poultry Environmental Stewardship (LPES) Curriculum. Lesson 43: “Emissions Control Strategies for Manure Storage Facilities” (October 31, 2005) http://www.lpes.org/Lessons/Lesson43/43_3_Solid_Liquid_Separation.pdf

Once the settling basin is off-line, the contents of the settling basin are allowed to dry, which may take several more months. Therefore, the total time the contents of the settling basin are kept in a high moisture state is between 6 months to 15 months.

- The more time manure is kept in higher moisture state, the more emissions are generated

In order to calculate a CE from the mechanical separator, similar moisture contents will be assumed from both systems. Therefore the CE can be calculated as follows:

1.25 months (mechanical separator) / 6 months (settling basins) = 21 %

Therefore, the CE of mechanical separation systems compared to settling basins is estimated to be about 79%.

It is worthwhile to note that numerous members within the group believe the above calculations to be of little utility based on the lack of actual emissions reduction data available and the assumptions used for the biological function of settling basins that are used as the comparison media.

1.5 Considerations regarding use of the technology or practice

Mechanical separators require maintenance and repair. There are certain times during the year when these function less optimally due to changes in lagoon activity. Changes in bedding material can effect efficiency of separation. Changes in diet (feedstuffs) resulting in manure composition changes can alter efficiency of separation. Separator design will determine frequency of solids handling to remove or merely relocate recently separated solids.

a) Pros

- Mechanical separators produce separated solids that may be spread and quickly dried during the dry, summer months of the year.
- Separated solids can be used for bedding or applied to land
- Double screen separators or dual screen separators can potentially have higher solids removal efficiency

b) Cons

- Increased pumping and handling costs
- Increased potential stripping of ammonia from the liquid stream as it is pumped over the screens.

- Potential regular (daily or weekly) need to handle solids (use of heavy equipment and labor). May result in multiple handling of solids before ultimate use.
- The technology may have a relatively large footprint especially when solids are removed and handled to promote drying.

1.6 Cost

Solids separation expenses include the costs of the equipment and some additional utilities. The additional utility costs are incurred in pumping liquid through or over mechanical separators. Temporary storage structures (sumps) may be necessary to store material prior to pumping. Pumps of 3 to 30 HP are typically used. The initial fixed costs of mechanical separation are about $135 per dairy cow.[27]

1.7 Feasibility/Applicability at dairies

Mechanical separation is used on dairies. A survey in the 1990s indicated that a relatively small percent of dairies were actually using mechanical separators even though they appeared to be located on many dairies (they were there but not being used).

1.8 Missing Data

Data are needed to justify the concept that separation of solids reduces emissions. Such data should be obtained from a facility where the lagoon treatment capacity meets treatment technology requirements.

1.9 Further Resources

Meyer, D., J.P. Harner III, W. Powers, and E. Tooman. 2003. Manure technologies for today and tomorrow. Western Dairy Management Conference. March, Reno, NV.

The Dias Double Screen Solid-Liquid Separator:
http://www.suscon.org/dairies/ndesc.asp
http://www.patentstorm.us/patents/6892891.html
United States Patent 6892891. Manure management system using sloped screen separator Issued on May 17, 2005. Richard A. Dias Application No. 10291080 filed on 2002-11-08

1.10 Recommendation

Since many dairies utilize mechanical separation at their dairies for the separation of solids prior to their lagoon/storage pond, this technology should be considered Achieved in Practice BACT.

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[27] Iowa Odor Control Demonstration Project:
http://www.extension.iastate.edu/Publications/PM1754I.pdf (October 31, 2005)

2. Settling Basin Separation

2.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC; possibly NH_3

2.2 Where technology comes from

Field/biological judgment

2.3 Description of "technology"

The purpose of settling basin separation is to remove the fibrous materials prior to the liquid manure entering the lagoon. By removing the most fibrous material from the liquid stream prior to entering the pond, it is anticipated that the amount of intermediate metabolites released during digestion in the pond may be reduced. Removal of the fibrous material allows for more complete digestion in the pond and lower emissions.

2.4 Control Efficiency

The control efficiency of settling basins is not known at this time. Separation systems in general have the potential of reducing emissions from the lagoon system by allowing for more complete digestion to take place through the removal of indigestible solids. Settling basins dewater predominantly through draining. Some evaporation can occur (depending on weather) creating a biofilter (crust) over the top of the basin.

Some members of the DPAG believe that the use of settling basins would potentially result in more overall emissions when compared to mechanical separators based on the information included in the section above. However, other members believe that settling basins include a naturally- formed bulking agent biofilter (extremely fibrous solid manure) preventing emissions from the basin itself and that settling basins still hold utility for overall emission reductions through the removal of indigestible solids prior to the storage pond.

2.5 Considerations regarding use of the technology or practice

Gravity separation through settling pits, basins, or ponds exists in California. Infrastructure is present to utilize gravity and reduced flow of material to allow settling. The technology may have a relatively large footprint especially when solids are removed and handled to promote drying.

a) Pros

Large percentage of solids removal can be obtained from settling basins.

These systems are usually low-cost to operate.

b) Cons

Settling basins may require a large foot-print at dairies.
These systems are potentially a significant emissions sources.

2.6 Cost

Cost for these systems is not available but is usually a standard cost incurred on dairies.

2.7 Feasibility/Applicability at dairies

Numerous types of settling basins exist at dairies. Design and management affect the efficiency of separation. In some instances these are equal to mechanical separation. In other instances, these remove more solids from a liquid stream.

2.8 Missing Data

No data available to define reduction in VOC emitted from retention/storage pond or lagoon with or without the technology. Additionally, there is no information on any source emissions.

2.9 Further Resources

Meyer, D., J.P. Harner III, W. Powers, and E. Tooman. 2003. Manure technologies for today and tomorrow. Western Dairy Management Conference. March, Reno, NV.

2.10 Recommendation

Some within the DPAG membership believe that since settling basins have the potential of generating emissions that their use should be limited in future dairies. However, others within the group feel that these should be considered Achieved in Practice, that they be utilized in combination with other appropriate technologies and that further research on actual emissions increase/reductions be prioritized.

3. Weeping Wall Separation

Weeping Wall Basin

3.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC; possibly NH_3

3.2 Where technology comes from

Field/biological judgment

3.3 *Description of "technology"*

The purpose of weeping wall separation is to remove the fibrous materials prior to the liquid manure entering the lagoon and enhance the dewatering surface when compared to any other separation pit, basin, or pond. By removing the most fibrous material from the liquid stream prior to entering the pond, it is anticipated that the amount of intermediate metabolites released during digestion in the pond will be reduced. Removal of the fibrous material allows for more complete digestion in the pond and lower emissions. With weeping walls the effluent is allowed to weep through the slots between boards or screens while the solids are retained. Liquid manure enters the structure and slowly moves through the solids in the structure to dewater at a face. Solids from the structure can be hauled directly out of the structure if farming practices permit or they can be dried for future use. Weeping wall systems can remove 60% of the solids in manure..[28]

3.4 *Control Efficiency*

The control efficiency of weeping walls are not known at this time. Separation systems in general have the potential of reducing emissions from the lagoon system by allowing for more complete digestion to take place through the removal of indigestible solids.

Some members within the DPAG believe that the use of weeping walls would potentially result in more overall emissions when compared to mechanical separators based on the weeping wall operation and the potential to create conditions where incomplete anaerobic digestion is promoted. Others within the group disagree with these assumptions.

3.5 *Considerations regarding use of the technology or practice*

a) Pros

Large percentage of solids removal can be obtained from weeping walls.
These systems are usually low cost to operate.

b) Cons

These systems are potentially a significant emissions sources.

3.6 *Cost*

For a basin providing 120 days of storage, capital costs range from $200 to $250 per cow[29].

~~4.~~[28] http://www.suscon.org/news/ndesc_report/Capturing%20Nutrients.pdf
~~5.~~[29] http://www.suscon.org/dairies

3.7 Feasibility/Applicability at dairies

Currently used in some San Joaquin Valley Dairies.

3.8 Missing Data

Quantifiable emissions reductions. Effectiveness of technique in reducing VOC emissions compared to mechanical separation, regular settling ponds, or other manure management practices.

3.9 Further Resources

Sustainable Conservation www.suscon.org
Meyer, D., J.P. Harner, E.E. Tooman, C. Collar. 2004. Evaluation of weeping wall efficiency of solid liquid separation. Applied engineering in Ag 20: 349-354.

3.10 Recommendation

Some members within the group feel that weeping walls should be limited in their use based on their potential of generating emissions during the dewatering and drying phase. However, others within the group recommend that weeping walls be considered Achieved in Practice, that they be used in combination with other appropriate technologies and that further research be a priority. Weeping walls are noted as the most consistent solids removal system. Much of the material removed is fibrous material, the potential emissions from the weeping wall are anticipated to be similar to those from a double screen separator.

4. Dewatering Systems (reduce moisture content of separated solids (dehydrator, roller ,screw press or similar)

4.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC & NH_3

4.2 Where technology comes from

Engineering Judgment

4.3 Description of "technology"

The moisture content of separated solids off of the mechanical separator could be as high as 85%. Wetter materials are more subject to anaerobic degradation. By reducing the moisture content it is assumed that anaerobic degradation will be reduced and emissions may be reduced. The moisture can be reduced by various systems, such as a screw press, dehydrator, etc.

4.4 Control Efficiency

The control efficiency of this type of system is not known, however, one can be estimated based on the assumption that fewer emissions are generated when there is less moisture in manure, in this case, separated solids.

Due to many types of de-watering systems available, moisture content of the separated solids can be brought down from 85% - 60%. Reduction in the moisture content would minimize the amount of leachate created from the pile; it would facilitate the drying process, taking far less time for the pile to be come dryer; it would also minimize the amount and rate of anaerobic digestion that would take place in the pile. Further drying of the separated solids can increase the control efficiency, by increasing the frequency of removal of separated solids, keep in less than two-inch layer, then harrowed to enhance drying and further maintain aerobic conditions. This option is mentioned as a side note. Further analysis would be required.

4.5 Considerations regarding use of the technology or practice

Dewatering technologies (other than solar) require significant energy inputs, operation of additional equipment, and potentially additional use of diesel powered equipment (tractors). However, some of these costs can potentially be offset by having to move less manure by volume.

a) Pros

- Costs to move separated solids is reduced due to less moisture content
- Anaerobic conditions are decreased due to less moisture content
- Leachate off of separated solids pile is reduced, hence reducing potential emissions.
- Less time required later to dry separated solids

b) Cons

- Increase in capital costs and energy costs for de-watering system
- Additional maintenance required
- Additional manure handling is required
- Potential equipment failure & lapse in effectiveness

4.6 Cost

Initial cost of equipment and maintenance and repair costs must be considered. Many of the roller presses have moving parts that require regular attention. However, some of these costs can be offset by having to move 20% less manure by volume.

4.7 Feasibility/Applicability at dairies

Presser roller technology is used intermittently at some dairies outside of California. Therefore, this technology is considered feasible on dairies.

4.8 Missing Data

No data available to document emissions reduction from various moisture reduction schemes.

4.9 Further Resources

http://www.vincentcorp.com/
Vincent KP-6L Solids Separator Test Results Using the University of Tennessee Testing Protocol:
http://wastemgmt.ag.utk.edu/ExtensionProjects/VINCENT%20KP-6L%20REPORTa.pdf
Press Technology (www.presstechnology.com)
Vincent Crop (www.vincetcorp.com)
http://www.goodnature.com/

4.10 Recommendation

Since this technology is installed at many existing dairies outside of California, it should be potentially evaluated as Achieved in Practice BACT.

5. Centrifuge Solid Separation

5.1 Pollutants Targeted and Expected Range of Control Efficiencies

Potentially VOC, NH3

5.2 Where technology comes from

Installations on dairy facilities in other parts of the nation.

5.3 Description of technology or practice

Centrifuges are horizontal or vertical cylinders continuously turned at high velocities. Centrifugal force presses solids onto the inside wall of the cylinder. An auger, which turns slightly faster than the cylinder, removes the cake.

5.4 Control Efficiency

The control efficiency of this type of system is not known, however, one can be estimated based on the assumption that fewer emissions are generated when there is less moisture in manure, in this case, separated solids.

Due to many types of de-watering systems available, moisture content of the separated solids can be brought down from 85% - 60%. Centrifuge solid separation may result in moisture percentage reductions greater than 25%, however, more information is needed to determine exact percentage of reductions. Reduction in the moisture content would minimize the amount of leachate created from the pile; it would facilitate the drying process, taking far less time for the pile to be come dryer; it would also minimize the amount and rate of anaerobic digestion that would take place in the pile. Further drying of the separated solids can increase the control efficiency, by increasing the frequency of removal of separated solids, keep in less than two-inch layer, then harrowed to enhance drying and further maintain aerobic conditions. This option is mentioned as a side note. Further analysis would be required.

5.5 Considerations regarding use of the technology or practice

The equipment requires routine maintenance and cleaning. Manure particle size and density has a greater effect on separation efficiency for this type of separator system.

a) Pros

- Costs to move separated solids is reduced due to less moisture content
- Anaerobic conditions are decreased due to less moisture content
- Leachate off of separated solids pile is reduced, hence reducing potential emissions.
- Less time required later to dry separated solids

b) Cons

- Increase in capital costs and energy costs for de-watering system
- Additional maintenance required

5.6 Cost

Costs associated with a centrifuge are high. Expensive polymers are needed for flocculation.

5.7 Feasibility/Applicability at dairies

A sump to temporarily hold liquid manure may be necessary to maintain flow through a centrifuge at relatively low rates. It may difficulty to process large quantities of liquid manure with the use of a centrifuge. Varying use of this technology has proven problematic on dairy facilities because of its constant maintenance. This technology would be considered feasible at dairies. However, the detailed cost effectiveness of this system needs to be performed prior to its application.

5.8 Missing Data

Additional emission research is needed.

5.9 Further Resources

US Centrifuge (www.uscentrifuge.com)
http://www.accentmanufacturing.com/

5.10 Recommendation

This technology should be considered technologically feasible and the District should perform a cost-effective analysis for this technology.

6. Tangential Flow Separator Waste Treatment System

6.1 Pollutants Targeted and Expected Range of Control Efficiencies

By keeping the pH above 7, reducing nutrient (nitrogen and phosphorous) and organic loadings, the QED Tangential Flow Separator Waste Treatment System is able to control odor. In particular, air emissions (resulting in odors) are moderated by reduction of VOC, Mercaptans, particulates, H_2S and NH_3.

6.2 Where technology comes from

Farm Pilot Project Coordination Funded Project presented at Water and Environment Federation Conference on Animal Waste Processing. A second generation QED system is to be installed at the DPS Dairy in Florida under FPPC funding.

A full operating system is installed at the McArthur Dairy located in the Okeechobee Basin, Florida.

6.3 Control Efficiency

The Control efficiency of this technology is not known at this time. However, it appears that significant emissions reductions can be obtained based on the description of this technology. More data are needed in order to estimate a control efficiency.

6.4 Description of "technology"

The QED system is a combination of physical, mechanical (patented) separation and chemical flocculation that removes nutrients (>95% P removal, up to 80% N removal) and fine solids (including organic-nitrogen), resulting in a treated liquid and solid manure which has concentrated nutrients that can be composted and moved off-farm. QED is also investigating other value-added options for the solids such as renewable energy applications or peat substitution.

The system is designed with the farmer in mind and to be used by farmers. It is designed to utilize the absolute minimum of chemicals (e.g., ferric sulfate, lime and polymer) to make operating costs minimal.

The system makes use of an innovative dewatering system that produces product of approximately 30% solids which are easily transportable (and treated water). The system moderates pH and reduces organic matter loading to lagoons, which will reduce VOC and H2S emissions. A biological treatment system for ammonia removal can also be added if necessary.

6.5 Considerations regarding use of the technology or practice

I will add something, but feel free to add.

a) Pros

b) Cons

6.6 Cost

The costs from this technology are not available, but may be obtained from the vendor.

6.7 Feasibility at Dairies

This technology is feasible at dairies. However, the detailed cost effectiveness of this system needs to be performed prior to its application. No information is known regarding emissions control.

6.8 Missing Data

Cost data and emissions data are needed.

6.9 Further Resources

www.qedocctech.com
Contact: Neil Beckingham 407 399 3118 (Orlando, Florida)

6.10 Recommendation

Since there are not much data available for this technology, it should be placed in a “future evaluation” category. However, this technology appears to be promising in reducing emissions and should be further evaluated.

7. Removal frequency of separated solids

7.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC

7.2 Where technology comes from

Engineering Judgment

7.3 Description of “technology”

As solids lay in a static pile, with moisture content of greater than 60%-85%, conditions are created which are conducive to anaerobic decomposition. The temperature inside the pile can easily exceed 50 degrees F and reach as high as 150 degrees F, creating VOC, ammonia, and possible H_2S emissions by the anaerobic bacteria. Therefore, to prevent the occurrence of these conditions, the pile(s) should be moved frequently and dried out as soon as possible as weather permits.

7.4 Control Efficiency

No control efficiency is known from the removal of separated solids pile.

In order to achieve efficiencies, the removal of separated solids must be combined with another practice to ensure that the pile when removed does not revert to anaerobic conditions, such as immediate or rapid drying.

7.5 Considerations regarding use of the technology or practice

a) Pros

- Significant reductions of emissions along with odor reductions can be obtained
- Easy to incorporate into dairy manure management

b) Cons

- Must be combined with another control or practice (not really a con depending on the type of control)
- Additional costs occur due to increase handling and hauling of the separated solids.
- If separated solids are removed on a more frequent basis, it is more difficult to relocate because of higher moisture content.

7.6 Cost

There are labor costs including tractor equipment costs to move separated solids piles that may be already incurred at existing dairies.

According to a socio-economic report prepared by SCAQMD, an increase in solids removal does impact costs.

7.7 Feasibility at Dairies

This control technology/practice is feasible at dairies since this practice is currently utilized at dairies. However, this practice in combination with another drying technology is not currently being utilized at dairies.

7.8 Missing Data

Data on emissions reductions

7.9 Further Resources

None found

7.10 Recommendation

Since many dairies already remove their separated solids off of the mechanical separator very frequently, the removal of separated solids on a weekly basis will be considered Achieved in Practice BACT.

8. Removal frequency of settling basin solids

8.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC

8.2 Where technology comes from

Engineering Judgment

8.3 Description of "technology"

Settling basins collect a significant amount of solids during its operation. Usually, a settling basin is not taken off-line (temporary shut-off and manure flush routed to alternate settling basin(s)) until it is full of solids. The contents of a settling basin are usually referred to as a slurry, meaning that the moisture content is usually higher than 92% or so. Basins are dewatered usually during a 4 week period following initial loading. After this period, material is hauled out, thin bed dried, and then piled for subsequent use as bedding or for land application. Emissions during this stage are unknown. Reducing the drying time from two months to two weeks or even one month will result in significant reductions. This analysis will evaluate drying time of settling basins to under two weeks.

8.4 Control Efficiency

There is no control efficiency known for this technology, however one can be estimated. The control efficiency estimated below will only be based on reductions obtained from the drying process.

It will be assumed that reducing the amount of time the contents of the settling basin are kept in anaerobic conditions will result in emission reductions. By reducing the drying process from 2 months to two weeks and using a linear emissions reduction approach, will result in the following estimated control efficiency:

CE = 1 – (2 weeks / 8 weeks) x 100% = 75%

Since emissions from this system would be front-loaded (mostly occurring from the beginning and slowly decreasing as time goes do to the manure drying), 75% reductions of emissions would be considered a reasonable CE, however, a 50% CE will be conservatively applied at this time.

8.5 Considerations regarding use of the technology or practice

a) Pros

Some members within the group anticipate that fewer settling ponds would be needed with reduced drying time. However, others within the group feel that this is an incorrect assumption based on the fact that the number of settling basins built is typically determined by loading time.

b) Cons

Increased labor and equipment costs

8.6 Cost

Costs for reducing the time it takes to dry settling basin contents are not known, as this practice is not widely used on dairies.

8.7 Feasibility/Applicability at dairies

The feasibility of this technology needs to be further evaluated. Although there may be techniques that can be used to enhance the drying process, the techniques need to be refined and properly defined.

8.8 Missing Data

Emissions and CE data

8.9 Further Resources

<u>None found</u>

8.10 Recommendation

General practices need to be created and/or properly defined in order to achieve drier manure from the settling basins in a more rapid fashion.

Since there are not many data available for this technology, it should be placed in a “future evaluation” category. However, this technology appears to be promising in reducing emissions and should be further evaluated.

9. Baleen Filters

9.1 Pollutants Targeted and Expected Range of Control Efficiencies

Potentially VOC

9.2 Where technology comes from

http://www.baleenfilters.com/

9.3 Description of “technology”

The technology is described as offering two distinct treatment approaches: 1) "Primary Filtration” to remove visible and/or suspended substances greater than 100-microns or as precursor to higher-order tertiary filtration technologies, and 2) “Secondary Filtration” with biochemical assistance to remove particles greater than 25-microns. Filter system uses a static screen that can be purchaced with different settings. The trade off is that removal of finer material reduces the feed rate.

9.4 Control Efficiency

The control efficiency of this technology is not known at this time. A more detailed analysis of this technology is required before a control efficiency can be applied.

9.5 Considerations regarding use of the technology or practice

Solids removed by technology must still be handled. Remaining liquid would contain salts and have little nutritive value. This material may well be classified as a waste with minimal fertilizer value.

a) Pros

b) Cons

9.6 Cost

unknown

9.7 Feasibility/Applicability at dairies

Technology has not been applied to dairy systems or liquid dairy manure. Theoretical basis.

9.8 Missing Data

It is not known what the emissions reductions would be if this technology was utilized.

It has not identified if manure can be utilized (with its large particles) in these filters.

9.9 Further Resources

http://www.baleenfilters.com/

9.10 Recommendation

Since there are not much data available for this technology, it should be placed in a “future evaluation” category. However, this technology appears to be promising in reducing emissions and should be further evaluated.

10. Integrated Separations Solutions – Advanced Separation System

10.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC & NH_3

10.2 Where technology comes from

Dairy Technology Feasibility Assessment Panel Draft Report

10.3 Description of “technology”

The basic premise is to remove the nutrients from the liquid manure in the most cost effective method, and thus reducing the cost of handling the waste. A series of filtration/separation techniques is used to remove non-dissolved nutrients in the water.   The concentrated nutrients can be removed with lower transportation costs.

10.4 Control Efficiency

The control efficiency of this technology is not known at this time. However, it appears that significant emissions reductions can be obtained based on the description of this technology. Similar or higher emissions reductions may be achieved compared to de-watering systems. More data are needed in order to estimate a control efficiency.

10.5 Considerations regarding use of the technology or practice

It is unclear if the effluent from this technology would be acceptable anywhere.

a) Pros

b) Cons

It is unknown how manure used as bedding plus manure generated fresh will interact with the technology.

10.6 Cost

Unknown.

10.7 Feasibility/Applicability at dairies

This has not been tested/demonstrated on dairies. However, this technology is considered feasible at dairies. Prior to application, the detailed cost effectiveness of this system needs to be performed including a CE determination.

10.8 Missing Data

Data are needed to document effectiveness and emissions reductions.

10.9 Further Resources

http://www.isepsol.com/

10.10 Recommendation

Since there are not many data available for this technology, it should be placed in a "future evaluation" category. However, this technology appears to be promising in reducing emissions and should be further evaluated.

11. Flushing from Secondary lagoon - Elimination of Processing Pit

11.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC and NH_3

11.2 Where Technology Comes From

Engineering Judgment

11.3 Description of Technology or Practice

The processing pit is an emission unit, which serves the following purposes:

1. Temporarily holds and stores fresh flush water from the milking parlor. Some systems may serve a dual purpose and allow soil and other mineral particles present in the manure or tracked into the parlor to settle out of the flush water to prevent contamination of the separation screens and the lagoon piping system.

2. Contents within the processing pit are used to flush the concrete feedlanes. This flush water including the waste in the feedlanes is returned to the processing pit and is recycled during each flush.
3. Once the volume exceeds the preset levels in the processing pit, pumps and agitators are turned on. The agitators mix the contents in the processing pit so that solids do not settle and the pumps take the contents to the separator to remove the fibrous content prior to the lagoon.
4. The processing pit (which can also act as a sand trap) is constructed in a manner that allows it to be emptied by the separator screen pump so that the sand and soil can be removed easily by a scraper or loader. If that is not done, the heavy, mineral sediment will accumulate and be picked up by the screen pump causing problems as it passes through the separation and lagoon system.
5. Some DPAG members believe that the processing pit increases the solids separation efficiency by concentrating more solids in the processing pit and consequently removing more solids in the mechanical separators. The rationale for the use of this pit water for flushing is the assumption that the higher solids content increases viscosity that will pick up and carry manure from the flush lanes more efficiently, providing a cleaner lane after flushing.

This processing pit can replaces the standard method of flushing which involves flushing the concrete feedlanes from the lagoon or secondary lagoon (storage pond).

A processing pit is an additional emission unit to a dairy system which has recently been adopted on new dairies. Some DPAG members believe Tthis system has the potential of increasing overall emissions from a dairy for the reasons listed below:.

1. First, uUnlike flushing from the storage pond, where manure has undergone through a treatment system through the primary lagoon, no treatment takes place prior to flushing the concrete feedlanes from the processing pit.
2. Second, uUnlike the storage pond, where the solids content is well below 1% (fairly clear water), the processing pit contains about 1.5 to 2.5% solids and recycles the flushed manure back and forth to the flush lanes, basicallyessentially flushing with unclean manure water.
3. Third, wWhen the preset volume in the pit is exceeded, pumps turn on and the contents in the pit are stirred, potentially releasing significant emissions into the air.
4. Fourth, sSolids in this system, have the potential of settling to the bottom of the pit, creating anaerobic conditions which promote unwanted emissions (VOC, H_2S, NH_3).

This system can easily be replaced by utilizing the standard method currently in place on many existing dairies, which involves flushing the concrete feedlanes from the secondary lagoon. By flushing from the secondary lagoon, cleaner flush water is introduced into the concrete feedlanes. This is due in prime to the pre-treatment of that flush water by the primary anaerobic treatment lagoon, which has digested a significant amount of Volatile Solids (VS) from the manure. In addition to the emission reductions obtained from flushing, a new potential source of emissions, the processing pit, is eliminated, without affecting the dairymen's manure management.

Some DPAG members contend that there is no data to support a claim that there would be an increase in emissions from the processing pit. These members believe the emissions to be the contrary for the following reasons:

1. Residence time of the manure in the processing pit is very short, inhibiting anaerobic digestion and therefore, not generating any emissions
2. Due to the freshness of the manure in the processing pit, no emissions would be generated when contents of the processing pit are used to flush the concrete feedlanes
3. Due to the combination of a short residence time, stirring, and removal of solids over a mechanical separator through pumps, solids are not expected to settle to the bottom of the pit. By continuously removing these solids and keeping these solids suspended, anaerobic conditions will not exist.
4. If there are some solids including sand which happen to settle, the processing pit is designed with a concrete slope, where a front-end loader can easily remove that material.
5. Due to the mixing of the material in the processing pit, anaerobic zones or hotspots are eliminated.

Based on the above, it can be assumed that the processing pit itself does not pose a new emissions threat to a dairy and does not have the potential to emit anymore from flushing than the secondary lagoon system.

The improved flushing efficiency claimed by some dairy operators for the use of the pit water for lane flushing may reduce emissions by removing more of the fresh manure in the initial flush operation. The balance between additional emissions from the, untreated solids in the pit water and reduced emissions from less fresh manure left in the flushlanes will have to be evaluated by research to compare the two practices.

11.4 Control Efficiency

The control efficiency of the elimination of the processing pit is not exactly known but some DPAG members believe that it can be assumed to be as high as a 100% since a similar practice (flushing from the storage lagoon) can be employed without any of the emissions concerns outlined for processing pit in section 1.3.

Some DPAG members believe the control efficiency of this technology can be assumed to be 0% since there is no difference between either of the two systems (processing pit and flushing from storage pond) as described in section 1.3.

11.5 Considerations Regarding Use of the Technology or Practice

Some DPAG members believe that this type of system should not be considered on new dairies due to the potential emissions generated from it. While some members believe that there is no data to suggest that there would be an increase in emissions. These members believe the emissions to be the contrary.

a) Pros

- This system potentially decreases the amount of fresh water required at a dairy.
- The energy costs to operate pumps is lower from a processing pit when compared to flushing from the lagoon.
- Separator pumping time is greatly reduced. Since flush water is recycled from the processing pit to increase manure concentration, the separator pump only runs when the pit has reached a preset level. Generally you can see a 30% to 50% reduction in separator pumping time.
- Sand and fine materials can be collected
- Solids removal efficiency can be increased.

b) Cons

- A processing pit is an additional emission source at a dairy
- There is a potential for an increase in emissions from each flush due to the higher manure solids content in the flush and the fact that the manure has had no treatment prior to each flush

11.6 Cost

The cost of this system is not known but can be obtained by vendors of this technology

11.7 Feasibility at Dairies

Some DPAG members believe ~~T~~the current standard of washing or cleaning the concrete feedlanes appears to have lower emissions than a processing pit, while serving the same purpose. Therefore, the application of processing pits at a dairy should not be considered any further.

However, some DPAG members disagree and believe there is no increase in emissions associated with a processing pit and believe the processing pits should be considered.

11.8 Missing Data

Emissions data from both the processing pit ~~itself~~ and from the flush is needed.

11.9 Further Resources

US Farm Systems

11.10 Recommendation

Some DPAG members believe that ~~D~~due to the potential of emissions generated from the processing pits when compared to the standard method, it is recommended that that application of processing pits on dairies be discontinued or eliminated. Since the standard method (flush from the storage lagoon) for cleaning flush lanes is utilized at many dairies, this technology/practice should be considered Achieved in Practice.

Some DPAG members believe there is no difference in emissions between either the processing pit nor the standard method of flushing and to assume that there would be a significant increase in emissions when no data is available is illogical. Therefore, the recommendation is to allow the installation of processing pits on dairies.

12. Cover Processing Pit and vent biogas to biofilter

12.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC and NH_3

12.2 Where Technology Comes From

Engineering Judgment and technology transfer

12.3 Description of Technology or Practice

A processing pit is an additional emission unit ~~to a dairy system~~ which has recently been adopted on new dairies. The basic function of a processing pit is described in section 11.1 to temporarily store flush water so that it can be used to flush the concrete feedlanes, however, in the process, this system has the potential of increasing overall emissions from a dairy as explained in section 1.

In order to reduce emissions from the processing pit, a cover can be applied, and the biogas generated can be sent to a biofilter which is capable of reducing emissions of greater than 80%. Refer to section xxx IV.A.5.3 for a discussion on biofliters.

12.4 Control Efficiency

Biofilters have been shown and proven to have control efficiencies greater than 80%. According to the SCAQMD Rule 1133.2 final staff report (page 18) Technology Assessment Report, a well designed, well operated, and well-maintained biofilter is capable of achieving 80% destruction efficiency for VOC and NH_3. Therefore, a 80% control efficiency will be applied to the emissions generated directly off of the processing pit.

The cover alone will not be sufficient in reducing any other emissions associated with the use of a processing pit such as those emissions generated from the flush water from the processing pit. As mentionedstated by some DPAG members in section 11.3, emissions would be greater due to the increase in solids content of the flush water and lack of pretreatment. Therefore, a further control technology or practice will may need to be applied to reduce those emissions. Some DPAG members believe, there are no increase in emissions from the flush and should not be a cause of concern.

12.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- Processing pits potentially decreases the amount of fresh water required at a dairy.
- The energy costs to operate pumps is lower from a processing pit when compared to flushing from the lagoon.
- Separator pumping time is reduced. Since flush water is recycled from the processing pit to increase manure concentration, the separator pump only runs when the pit has reached a preset level.
- 80% reduction in emissions can be obtained from the emissions generated off of the processing pit.

b) Cons

- A processing pit is an additional emission source at a dairy

- There is a potential for an increase in emissions from each flush due to the higher manure solids content in the flush and the fact that the manure has had no treatment prior to each flush. This process will remain uncontrolled even with a cover over the processing pit.
- An effective cover over the processing pit would likely prevent the routine removal of mineral sediment by the usual method of a tractor scraper or loader. An additional, small sand trap would need to be added to the system prior to the processing pit to remove mineral sediment.

12.6 Cost

The cost of adding a cover and venting the gas to a biolfilter is not known but can be compared to similar industries where the use of covers and biofilters have been used.

12.7 Feasibility at Dairies

This technology would be considered feasible at dairies. However, the detailed cost effectiveness of this system needs to be performed prior to its application.

12.8 Missing Data

Emissions data from both the processing pit itself and from the flush is needed.

12.9 Further Resources

12.10 Recommendation

This technology should be considered technologically feasible and the District should perform a cost-effective analysis for this technology.

ii COMPOSTING

Composting is the aerobic decomposition of organic materials in the thermophilic temperature range (104 –149 degrees F). Aerobic decomposition is the same process that decays leaves and other organic debris in nature. Compost conditions (available oxygen, moisture, carbon to nitrogen ratio) are managed to enhance decomposition.

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 most weed seeds. Composting reduces material volume through natural biological action and produces a product that enhances soil structure.

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 NH_3 emissions occur during the first 22 days of composting.[30] 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.

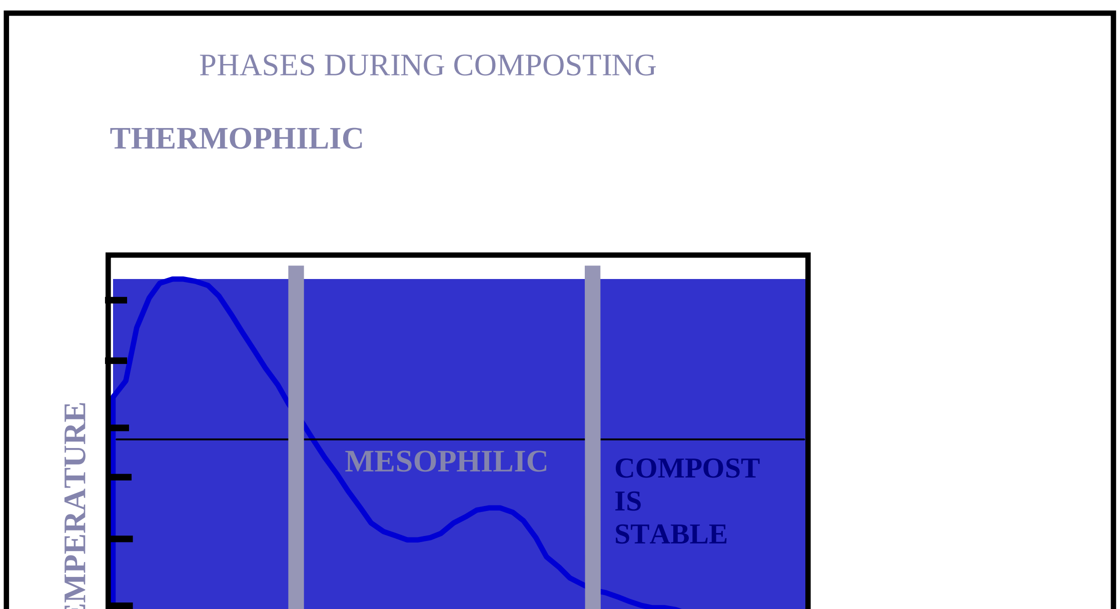
Curing phase (Mesophilic stage):

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 NH_3 emissions are expected to occur during this phase.[31]

VOC emissions from composting:

VOC emissions occur during the active and curing phases of the composting. To promote consistent temperatures within the piles, a layer of finished compost can be placed on top of the active and curing phase piles. This 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[32].



~~6.~~
31
~~7.~~

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:[33]

- **Moisture content** – Moisture is an essential part of composting. It allows microorganisms to move about and transport nutrients, and 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 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.

- **pH** –pH value, the level of acid or base, is critical to composting as 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). Optimum pH values range between 6.5 and 8.0. 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

~~8.~~[33] Definitions are defined in Technology assessment for Proposed SCAQMD Rule 1133 (Pages 1-6) 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** - Composting occurs within two temperatures ranges, known as mesophilic (50^{o}F to 105^{o}F) and thermophilic (over 105^{o}F). Thermophilic temperatures are preferred because they promote rapid composting, and destroy pathogens, weed seeds, as well as fly larvae. However, extreme temperatures (above 160^{o}F) will kill most of the active, important microorganisms. Temperatures in the range of 110^{o}F to 150^{o}F have been cited as optimal for composting. The U.S. EPA requires that a minimum temperature of 131^{o}F be maintained for several days to eliminate bacteria and pathogens.

- **Level of oxygen available** –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)** –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.[34] Increasing the carbon-to-nitrogen ratio by incorporating high carbon materials (leaves, plant residue, paper, sawdust, etc.) can reduce nitrogen loss.

1. Windrow Composting

1.1 Pollutants Targeted and Expected Range of Control Efficiencies

Potentially VOC & NH_3

1.2 Where technology comes from

Currently in use on some dairy operations as well as in other industries.

1.3 Description of "technology"

A windrow composting 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 can be sprayed with water and are turned periodically to mix, introduce and rebuild bed porosity.

[34] University of Nebraska-Lincoln

1.4 Control Efficiency

Emissions from windrow composting are understood to be quite large. Emissions from composting may potentially even have more emissions than from an uncontrolled manure pile due to the build-up and release of the by-products of anaerobic digestion. However, there is no information available to make that distinction at this time. Since windrow composting is an uncontrolled process, and when compared to the baseline emissions, no control is expected from this system. Therefore, the control efficiency from is recommended to be 0%.

1.5 Considerations regarding use of the technology or practice

Windrow composting requires adequate land space availability. Permeability of underlying soil types or base materials need to be addressed to protect groundwater sources. Collection systems need to be in place to collect leachate and drainage during wet months.

a) Pros

- Creates a stable endproduct material which retains much of the nutrients and can be land applied with no need for further control
- Composting reduces the manure volume by approximately 40-50%

b) Cons

- Windrow composting has the potential of generating significant emissions
- Adequate land space is required
- Permeability of underlying soil types or base materials need to be addressed to protect groundwater sources.
- Collection systems need to be in place to collect leachate and drainage during wet months.
- Cost for handling equipment may be substantial

1.6 Cost

- Tractor requirements: minimum of 115-120 HP tractor with creeper gear, estimated cost $75,000 depending on model.

- Pull Behind Windrow turner: estimated cost $20,000 - $30,000 depending on model.

- Self-propelled/self-powered Windrow turner: $118,000-$228,000

- Added labor-specific costs dependent on volume handled
- Installation of piping, pumps and drains for proper leachate collection
- Value of land use opportunity costs.

1.7 Feasibility/Applicability at dairies

Windrow composting is currently done on some California dairy operations-typically to improve the quality of bedding material.

1.8 Missing Data

Emissions testing from dairy manure windrow composting operations have not been performed.

1.9 Further Resources

"On-Farm Composting Handbook" NRAES-54

1.10 Recommendation

Due to the large potential emissions that may be generated from windrow composting operations, the approval of these systems should be very limited or prohibited.

2. Increased Turning of Composting Piles to Increase Aeration

2.1 Pollutants Targeted and Expected Range of Control Efficiencies

Potentially VOC & NH_3

2.2 Where technology comes from

SCAQMD Tetratech report for Rule 1127 and Agriculture and Agrifood Canada

2.3 Description of "technology"

Turn the compost piles more frequently to encourage complete decomposition to CO_2 rather than release of VOCs.

2.4 Control Efficiency

Emissions from windrow composting are understood to be quite large. Emissions from composting may even potentially have more emissions than from an uncontrolled manure pile due to the build-up and release of the by-products of anaerobic digestion. However, there is no information available to make that distinction at this time. Although, there is a potential to have fewer emissions from increased turning of the pile when compared to a standard windrow composting operation, this system is still uncontrolled. Windrow composting is an uncontrolled process, and when compared to the baseline emissions, no control is expected from this system. Therefore, the control efficiency from this system is recommended to be 0% until further scientific data are available.

2.5 Considerations regarding use of the technology or practice

a) Pros

Same as previous section on Windrow Composting

b) Cons

Same as previous section on Windrow Composting

2.6 Cost

Increased labor costs will be experienced with the implementation of this practice when compared to standard windrow composting

2.7 Feasibility/Applicability at dairies

Windrow composting is currently done on some California dairy operations-typically to improve the quality of bedding material.

2.8 Missing Data

Emissions testing from dairy manure composting operations have not been performed.

2.9 Further Resources

http://www.aqmd.gov/rules/support.html#r1127
http://res2.agr.ca/publications/ha/2d7c_e.htm

2.10 Recommendation

Due to the large potential emissions that are generated from windrow composting operations, the approval of these systems should be very limited or prohibited until further scientific data are available.

3. Adding Clay/Clay Soil to Compost

3.1 Pollutants Targeted and Expected Range of Control Efficiencies

Potentially VOC, NH_3, odor

3.2 Where technology comes from

Discussions with composting industry representatives, used in other countries such as Austria and China.

3.3 Description of technology or practice

Ten percent clay or clay soil is added to the compost pile during the initial mixing phase. The odiferous compounds (ammonia and sulfur) that may be generated during the composting process may adsorb to the clay particles within the pile until further use by the microorganisms thereby reducing or eliminating their volatilization.

3.4 Control Efficiency

A control efficiency of this control is not known and there is not enough information available to estimate one at this time.

3.5 Considerations regarding use of the technology or practice

a) Pros

- Potential to reduce emissions of odiferous and other compounds of concern during the composting process.
- Same as previous section on Windrow Composting

b) Cons

- Importation of soil will also import nutrients. Nutrient balance considerations regarding water quality regulations. If native soil has sufficient clay then soil will need to be mined at the site and redistribution of soil may alter farming operations.
- Same as previous section on Windrow Composting
- Addition of clay may block the pores in the pile, hence inhibiting aeration and enhancing anaerobic decomposition.

3.6 Cost

Purchases of external sources of clay may be required in some areas. Needed volumes will be based on the volume of manure being composted at the site. Currently 32-35% clay soil costs $180 for a 23-yard truckload, delivered.

3.7 Feasibility/Applicability at dairies

This technology is feasible at dairy facilities.

3.8 Missing Data

Emissions data are needed to properly validate an emissions benefit.

3.9 Further Resources

3.10 Recommendation

Since there are not many data available for this technology, it should be placed in a "future evaluation" category. When more information becomes available, the applicability of this technology should be addressed at that time.

4. Open ASP With Thick Layer Of Bulking Agent Or Equivalent

4.1 Pollutants Targeted and Expected Range of Control Efficiencies

Potentially VOC, NH_3, particulates, & H_2S

4.2 Where technology comes from

SJVAPCD Draft Dairy BACT

4.3 Description of "technology"

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

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.

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.[35]

4.4 Control Efficiency

The control efficiency can be estimated from the Technology Assessment for Proposed Rule 1133 Table 3-2 which uses a capture efficiency of 25 to 33% from an open ASP and multiplies it by a conservative 80% control equipment efficiency. The average control efficiency for open aerated static piles based on the Technology Assessment is 23.2%. Additional emission reduction potential from open ASPs cannot be quantified at this time. Therefore, a conservative control efficiency of 23.2% will be applied to this technology.

4.5 Considerations regarding use of the technology or practice

a) Pros

Same as those in previous section on Windrow Composting

b) Cons

Same as those in previous section on Windrow Composting
Piping system will need to be continually maintained and replaced.

4.6 Cost

Estimated costs using municipal experiences are between $20-50/ton of raw product depending on specific technology used. This does not include initial capital costs or bulking agent costs. The estimated total capital investment for a 40,000 ton/year ASP is estimated at 1.1 million. Annual variable costs per ton of raw material are $7.64. (NRAES-54, “On-Farm Composting Handbook” 1992 Edition, pg. 92)

[35] Technology Assessment for SCAQMD proposed Rule 1133 Page 3-2

4.7 Feasibility/Applicability at dairies

This technology is feasible at dairies. However, the detailed cost effectiveness of such systems needs to be performed prior to their application.

4.8 Missing Data

Data on the cost effectiveness of this technology on a dairy operation need to be determined.

4.9 Further Resources

SCAQMD

4.10 Recommendation

This technology should be considered technologically feasible and the District should perform a cost-effective analysis for this technology.

5. Open negatively-aerated ASP piles (covered with thick layer of bulking agent or equivalent) vented to biofilter (or equivalent)

5.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC, NH_3, particulates, & H_2S

5.2 Where technology comes from

SJVAPCD Draft Dairy BACT document dated April 22, 2004

5.3 Description of "technology"

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

Biofiltration 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 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.

5.4 Control Efficiency

The overall control efficiency from this technology can be estimated by adding the combined control efficiencies of the open aerated system (23.2% - as calculated above in section x) and the biofilter. (80%), calculated as follows:

CE = (0.232) + (1-0.232)*0.8 =84.6%

A conservative, estimated control efficiency of 80% can be applied.

5.5 Considerations regarding use of the technology or practice

a) Pros

Same as previous section on Windrow Composting

b) Cons

Same as previous section on Windrow Composting
Regular replacement of biofilter

5.6 Cost

The costs of ASP composting systems vary considerably, however, the initial and maintenance costs of these systems are believed to be quite large. Detailed cost estimates can be obtained from various vendors of this technology, but will vary based on site-specific needs.

5.7 Feasibility/Applicability at dairies

This technology is feasible at dairies. However, the detailed cost effectiveness of such systems needs to be performed prior to their application.

5.8 Missing Data

Data on the cost effectiveness of this technology on a dairy operation need to be determined.

5.9 Further Resources

SCAQMD Final Staff Report for Rule 1133, page 18

5.10 Recommendation

This technology should be considered technologically feasible and the District should perform a cost-effective analysis for this technology.

6. Enclosed ASP (AgBag, Gore Cover, or equivalent)

6.1 Pollutants Targeted and Expected Range of Control Efficiencies

Potentially VOC, NH_3, particulates, & H_2S

6.2 Where technology comes from

SJVAPCD Draft Dairy BACT document dated April 22, 2004

6.3 Description of "technology"

An enclosed aerated static pile uses the same forced aeration principle of an open ASP (see explanation above in section x), except that the entire pile is fully enclosed, either inside of a building or with a tarp around it.

6.4 Control Efficiency

There is no control efficiency available at this time for enclosed aerated static piles. A study is under way by SQAQMD and the Milk Producers Council to determine the control efficiencies for VOC and ammonia emissions from enclosed aerated composting systems. Until the study is completed, this technology will be conservatively assumed to control emissions by 10% more than open aerated static piles, with a minimum control efficiency of 33.2% until additional data are available.

6.5 Considerations regarding use of the technology or practice

a) Pros

Same as previous section on Windrow Composting

b) Cons

Same as previous section on Windrow Composting

6.6 Cost

The costs of ASP composting systems vary considerably, however, the initial and maintenance costs of these systems are believed to be quite large. Detailed cost estimates can be obtained from various vendors of this technology, but will vary based on site-specific needs.

6.7 Feasibility/Applicability at dairies

This technology is feasible at dairies. However, the detailed cost effectiveness of such systems needs to be performed prior to their application.

6.8 Missing Data

Data on the cost effectiveness of this technology on a dairy operation need to be determined.

6.9 Further Resources

SCAQMD – AgBag International Ltd, Gore Cover and various others

6.10 Recommendation

This technology should be considered technologically feasible and the District should perform a cost-effective analysis for this technology.

7. In-Vessel/Enclosed (Building, AgBag, Gore Cover, or equivalent) negatively-aerated ASP vented to biofilter (or equivalent)

7.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC, NH_3, particulates, & H_2S

7.2 Where technology comes from

SJVAPCD Draft Dairy BACT document dated April 22, 2004

7.3 Description of "technology"

An in-vessel aerated static pile uses the same forced aeration principle of an open ASP, except that the entire pile is fully enclosed, either inside of a building or with a tarp around it. In addition to the in-vessel ASP, the biogas must be sent to a biofilter capable of reducing at least 80% emissions.

7.4 Control Efficiency

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% - calculated above in section 19) and the biofilter (80%), calculated as follows:

CE = (0.332) + (1-0.332)*0.8 =86.6%

A conservative, estimated control efficiency of 80% can be applied.

7.5 Considerations regarding use of the technology or practice

Little experience is available on this technology using agricultural products.

a) Pros

Same as previous section on Windrow Composting

b) Cons

Same as previous section on Windrow Composting
Additional costs for infrastructure (i.e cover, AgBag, building)

7.6 Cost

Data on the cost effectiveness of this technology on a dairy operation need to be determined. Estimated costs using municipal experiences are between $50-150/ton of raw product depending on specific technology used. Source: NRAES-54 "On-Farm Composting Handbook, 1992 edition, pg. 94.

7.7 Feasibility/Applicability at dairies

This technology is feasible at dairies. However, the detailed cost effectiveness of such systems needs to be performed prior to their application.

7.8 Missing Data

7.9 Further Resources

SCAQMD- Various vendors

7.10 Recommendation

This technology should be considered technologically feasible and the District should perform a cost-effective analysis for this technology.

8. Vermi-composting

8.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC, NH_3, particulates, & H_2S

8.2 Where technology comes from

Dairy Technology Feasibility Assessment Panel Draft Report

8.3 Description of technology or practice

The vermicompost process utilizes three types of earthworms (epigeic, endogeic and diageic) in composting materials into castings or "earthworm dirt." Vermicomposting is generally done in manure windrows or slurry beds. The earthworms burrow a network of tunnels throughout the compost introducing oxygen into the piles. In addition, the epigeic worms ingest the anaerobic microbes responsible for foul odors during manure decomposition, while the remaining two earthworm types reduce manure tonnage.

8.4 Considerations regarding use of the technology or practice

Requires mild temperatures in order to maintain viability of worm population (60-85 F)-beds may necessitate heating or moving indoors during cold winter months.

Relatively large volumes of earthworms are needed for proper vermicomposting. Increased land base requirements as well as limited markets for end products (both earthworm dirt and worms themselves) may limit the viability of this practice.

Because process occurs at low temperatures, pathogen reduction and drying may be reduced. Fly control may also be a problem.

8.5 Control Efficiency

The control efficiency of this technology is not known at this time. A more detailed analysis of this technology is required before a control efficiency can be applied.

a) Pros

Same as previous section on Windrow Composting

b) Cons

Same as previous section on Windrow Composting

8.6 Cost

No reliable cost information is available at this time.

8.7 Feasibility/Applicability at dairies

Feasibility at dairies is limited based on manure volume, land space, temperature stability and animal health concerns associated with this process.

8.8 Missing Data

Data on the cost effectiveness of this technology on a commercial dairy operation need to be determined.

8.9 Further Resources

8.10 Recommendation

Since there are not many available for this technology, it should be placed in a “future evaluation” category. When more information becomes available, the applicability of this technology should be addressed at that time.

9. Adding Lime to Composting Piles to Maintain pH in Specific Ranges (VOC)

9.1 Pollutants Targeted and Expected Range of Control Efficiencies

Potentially VOC & NH_3

9.2 Where technology comes from

SCAQMD – Rule 1127

9.3 Description of “technology”

Lime is added to compost piles to maintain pH in desirable ranges to attempt to optimize composting process and decrease intermediate metabolite volatilization.

9.4 Control Efficiency

The control efficiency of this technology is not known at this time. A more detailed analysis of this technology is required before a control efficiency can be applied.

9.5 Considerations regarding use of the technology or practice

This technology needs to be further reviewed to understand both the pros and cons of this technology.

Lime and other additives are generally thought to be unnecessary for optimal composting when composting manure and other agricultural products. The normal pH of manure products falls within the optimal composting range. Lime addition can be detrimental to final product quality and beneficial use as a soil amendment. The majority of San Joaquin Valley soils are in the higher pH range and further additions of high pH material could be detrimental and require remediation.

a) Pros

May potentially reduce moisture and odors

b) Cons

Lime addition can be detrimental to final product quality and beneficial use as a soil amendment. The majority of San Joaquin Valley soils are in the higher pH range and further additions of high pH material could be detrimental and require remediation.

The use of lime may increase pH and result in an increased ammonia emissions.

9.6 Cost

Current costs for lime in the San Joaquin Valley range from $50-75/ton delivered. Costs are associated with delivery and will range depending on actual transport distances.

9.7 Feasibility/Applicability at dairies

The feasibility of this technology still needs to be evaluated.

9.8 Missing Data

Data on the emissions reduction benefit of this technology are needed.

9.9 Further Resources

9.10 Recommendation

Since there are not many data available for this technology, it should be placed in a "future evaluation" category. When more information becomes available, the applicability of this technology should be addressed at that time.

10. Wet Composting – Timed aeration

10.1 Pollutants Targeted and Expected Range of Control Efficiencies

Potentially VOC, NH_3, particulates, & H_2S

10.2 Where technology comes from

~~Dairy Technology Feasibility Assessment Panel Draft Report~~ (Change)

10.3 Description of "technology"

Wastewater and manure from a flush dairy are mixed in a tank along with air and proprietary enzymes and microbes. The microbes are specially bred for a particular dairy. The material is then added to chopped municipal yard waste in a static pile aerated from below with air forced through perforated 3-inch diameter PVC pipes. The air blower is on a timer and operates about 3 minutes out of every 30 minute period. Excess liquid is recycled back into the pile or drawn off for use as a compost tea to irrigate and fertilize a nearby pasture. Plastic beneath the pile prevents leaching; plastic on top of the pile retains heat and sheds rainwater. Details of pile size, material composition, pipe size, air flows, collection of leachate, etc., are available from the vendor. The system functions as a sort of trickling filter which uses the municipal yard waste as the filter media. Microbial activity heats the pile to an average daily temperature of approximately 140 F. After 30 to 45 days the pile has become compost and must be replaced.

10.4 Control Efficiency

The control efficiency of this technology is not known at this time. A more detailed analysis of this technology is required before a control efficiency can be applied.

10.5 Considerations regarding use of the technology or practice

a) Pros

Same as the previous section on Windrow composting

b) Cons

Same as the previous section on Windrow Composting.

10.6 Cost

Costs of the implementation of this technology on a dairy operation still need to be determined.

10.7 Feasibility/Applicability at dairies

It is not known whether application of this technology will result in any emission benefits. Therefore, prior to consideration of this technology, more emissions data are needed.

10.8 Missing Data

Additional information is needed to assess control effectiveness

10.9 Further Resources

10.10 Recommendation

Since there are not many data available for this technology, it should be placed in a "future evaluation" category. When more information becomes available, the applicability of this technology should be addressed at that time.

11. Organic Waste Composting Unit

11.1 Pollutants Targeted and Expected Range of Control Efficiencies

Potentially VOC, NH_3, particulates, & H_2S

11.2 Where technology comes from

Dairy Technology Feasibility Assessment Panel Draft Report

11.3 Description of "technology"

This composting technology is from Korea. The structure of the composter is similar to a silage pit, covered with a transparent roof. Auger(s) are installed vertically on a frame which moves along the pit. The augers turn and inject air into the material lowering the moisture content of the feedstock. The system is fitted to spray liquid manure and leachate over the top of the pile. The floor of the pit has a drainage/collection system and also operates as a forced air aeration system. Air from the structure is exhausted by fans to evaporate the liquid. The company is testing the integration of a biofilter. Currently the system is used to compost poultry and pig manure (with bulking material), but they have begun looking at dairy manure.

11.4 Control Efficiency

The control efficiency of this technology is not known at this time. A more detailed analysis of this technology is required before a control efficiency can be applied.

11.5 Considerations regarding use of the technology or practice

More information on this technology needs to become available for an evaluation of the Pros and Cons to be made.

a) Pros

b) Cons

11.6 Cost

The only cost data that could be found that resembled this technology was described as an agitated bed, in-vessel system with a capacity of 40,000 wet tons/year. Capital cost estimates for the system were $1.4 million with annual variable costs of $8.40/ton of material. Cost estimates included land, structures, labor and equipment. Source: NRAES-54 "On-Farm Composting Handbook, 1992 edition, pg. 94.

11.7 Feasibility/Applicability at dairies

It is not known whether application of this technology will result in any emission benefits. Therefore, prior to consideration of this technology, more emissions data are needed. However, the control from this system may be comparable to windrow composting operations.

11.8 Missing Data

<u>Additional information is needed to assess control effectiveness</u>

11.9 Further Resources

Jeesung Livestock Engineering Co. Ltd.

11.10 Recommendation

Since there are not many data available for this technology, it should be placed in a "future evaluation" category. When more information becomes available, the applicability of this technology should be addressed at that time.

12. Additives for Composting to favor decomposing by aerobic bacteria and/or more rapid decomposition (VOC & ???)

In discussions with compost industry representatives, no additives were recommended for this category. Instead, representatives conveyed that more attention to basics had much higher potential to increase composting efficiency and effectiveness with associated decreases in intermediate metabolite volatilization. Since no additives are known, this technology can be placed in a future evaluation" category. When more information becomes available, the applicability of this technology should be addressed at that time. Therefore, no further analysis will be performed.

13. Black Soldier Fly Composting

13.1 Pollutants Targeted and Expected Range of Control Efficiencies

???

13.2 Where technology comes from

North Carolina State University- on-going research project on hog operations.

13.3 Description of "technology"

Black soldier fly larvae digest fresh manure typically dropped into shallow pits below the animal holding area as a feedstuff. Side edges of the shallow pits are sloped up at a 45 degree angle. Fly pre-pupae are then self-harvested using the 45 degree ramp, a gutter and collection bucket. Fly pre-pupae move by inching along and have a natural tendency to move up and away from the fly larvae. They inch up the ramp leaving the larvae below. Pre-pupae are then dried and potentially sold as animal feed.

13.4 Control Efficiency

The control efficiency of this technology is not known at this time. A more detailed analysis of this technology is required before a control efficiency can be applied.

13.5 Considerations regarding use of the technology or practice

This technology has not been researched in the dairy industry. Housing systems utilized in the poultry and hog industry are significantly different than those used in the dairy industry. The dairy industry in California does not utilize an underground pit collection system. Sizing of facilities, collection methods, processing methods and animal health issues need to be evaluated prior to implementing this practice.

a) Pros

b) Cons

13.6 Cost

No applicable cost information could be found at this time.

13.7 Feasibility/Applicability at dairies

It is not known whether application of this technology will result in any emission benefits. Therefore, prior to consideration of this technology, more emissions data are needed.

13.8 Missing Data

Additional information is needed to assess control effectiveness

13.9 Further Resources

13.10 Recommendation

Since there are not many data available for this technology, it should be placed in a "future evaluation" category. When more information becomes available, the applicability of this technology should be addressed at that time.

14. Bin Composting

This "technology" is recommended for removal based on two reasons: 1. It is essentially a simple form of in-vessel composting (with or without a roof) utilizing ASP practices in a more controlled environment and shares the same considerations included in above sections 2. It is most commonly found in the poultry industry for the composting of chicken carcasses and does not necessarily apply to dairy manure composting. Photos of the this process in practice can be found in NRAES-54 "On-Farm Composting Handbook" Figure 4.18

15. Wood Chips -Use of woodchips

This item was eliminated, as it in and of itself does not constitute an emissions reduction "technology." It is being noted here as a source of bulking agent material that may be used in implementing various other technologies that use bulking agents within the section.

The City of Bakersfield generates a significant volume of wood chips as part of its green waste program. It is offering these wood chips as either a stand-alone product for covering loafing areas, or as a bulking agent in composting of dairy manure, and is mentioned here because some may believe it to be a control technology

iii DRYING TECHNOLOGIES

1. Solar Drying of solid or slurry manure

1.1 Pollutants Targeted and Expected Range of Control Efficiencies

NH3, VOC

1.2 Where technology comes from

Dairy Technology Feasibility Assessment Panel Draft Report.

1.3 Description of technology or practice

The technology is a passive process for solar drying of manure using a greenhouse structure to contain the fresh manure and protect it from the wintertime elements. The manure is collected from the cow housing areas and may or may not be spread under a greenhouse to promote drying in wet weather.

Another use of solar drying is "Thin bed drying" of solids. This is accomplished by distributing a 6-8" layer of solids on corrals or on soil. Manure is harrowed daily to enhance rapid drying, minimize fly habitat, and expedite moisture loss.

1.4 Control Efficiency

The control efficiency of this technology is not known at this time. However, it appears that significant emissions reductions can be obtained based on the description of this technology. More data are needed in order to estimate a control efficiency.

1.5 Considerations regarding use of the technology or practice

Material handling may be excessive. Based upon the manure production of a larger facility, a wintertime greenhouse or cover may be massive. Additional amendments or heating may be required for drying. Must address indoor air quality concentrations regarding human health as workers will need to enter the greenhouse to deliver material or manage material. OSHA has indoor air quality requirements for some compounds. Handling moisture removed from the manure is important. It is not clear how this occurs. Need to identify what gaseous emissions will be emitted from the machinery used to transport and manage manure. Emissions from greenhouse may need to be scrubbed through a biofilter altering the management of the existing technology.

a) Pros

b) Cons

1.6 Cost

Greenhouse structure and maintenance costs needed. Additionally, must identify if scrubbing will be needed and any specific requirements for OSHA.

Land dedicated to solar drying (if separated from corrals) is a cost. Equipment (emissions) and labor are needed to effectively accomplish drying.

1.7 Feasibility/Applicability at dairies

Greenhouse solar drying not used in California.

Some dairies handle solids from separators or settling basins via thin bed drying during the warmer months. These dairies typically spread out the manure in corrals or on pads for solar drying.

1.8 Missing Data

There are no data available to specify changes in VOC from not drying manure solids versus rapid/enhanced drying of manure solids (those separated from liquid material). Need to define if there would be any OSHA concerns associated with greenhouse atmosphere itself.

1.9 Further Resources

Need another resource

1.10 Recommendation

Since there are not many data available for this technology, it should be placed in a "future evaluation" category. When more information becomes available, the applicability of this technology should be addressed at that time.

2. Cyclonic Drying Systems

2.1 Pollutants Targeted and Expected Range of Control Efficiencies

NH_3 & H_2S

2.2 Where technology comes from

Dairy Technology Feasibility Assessment Panel Draft Report. Tests have been conducted on a variety of applications (pulp, biosolids, plastics and animal manure).

2.3 Description of technology or practice

This process is a pneumatic high velocity process resulting in the reduction of water content and the reduction of particle size of feed materials. The process utilizes high volume airflows, cyclonic separations, centrifugal actions, heat of compression, impact frictional, kinetic energies and psychrometrics to dry the material.

2.4 Control Efficiency

The Control efficiency of this technology is not known at this time. However, it appears that significant emissions reductions can be obtained based on the description of this technology. More data are needed in order to estimate a control efficiency.

2.5 Considerations regarding use of the technology or practice

Has not been demonstrated at full scale on a dairy facility.
May be particulate concerns once manure is dried to less than 15% moisture?
The energy demand for the technology is not known.

a) Pros

b) Cons

2.6 Cost

Cost per ton is yet to be determined.

2.7 Feasibility/Applicability at dairies

This technology is feasible at dairies. However, the detailed cost effectiveness of this system needs to be performed prior to its application.

2.8 Missing Data

Need to document emissions reductions.

2.9 Further Resources

www.grro.net/tempest.html

2.10 Recommendation

Since there are not many data available for this technology, it should be placed in a "future evaluation" category. When more information becomes available, the applicability of this technology should be addressed at that time.

3. Pelletizing

3.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC & NH3

3.2 Where technology comes from

Biosolids and poultry industries.

3.3 Description of technology or practice

This technology consists of dehydrating solid manure (settling basins, lagoons, corrals) and pelletizing the manure to be used as a fertilizer, soil amendment, or energy fuel. The manure is compacted at high temperature and pressure and compressed to form pellets.

3.4 Control Efficiency

The Control efficiency of this technology is not known at this time. However, it appears that significant emissions reductions can be obtained based on the description of this technology. More data are needed in order to estimate a control efficiency.

3.5 Considerations regarding use of the technology or practice

This process is done at a central processing plant. Increased hauling costs and road traffic must be considered. This technology is not available for on farm application at this time. Markets must be identified ahead of time. The mineral content of the manure may limit markets.

a) Pros

b) Cons

3.6 Cost

Cost data only exist in proprietary forms at this time.

3.7 Feasibility/Applicability at dairies

Field demonstration not available at individual livestock facilities in the US.

This technology is feasible at dairies. However, the detailed cost effectiveness of this system needs to be performed prior to its application.

3.8 Missing Data

Need to define emission reduction compared to actual emissions without pelletizing.

3.9 Further Resources

www.agrirecycle.com

3.10 Recommendation

Since there are not many data available for this technology, it should be placed in a "future evaluation" category. When more information becomes available, the applicability of this technology should be addressed at that time.

iv ADDITIVES

1. Addition of Ph modifiers (lime or gypsum) to manure stockpiles to adjust the pH and minimize moisture (VOC)

1.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC & NH3 – Research indicates that the addition of lime reduced NH3 emissions by 28%.

1.2 Where technology comes from

Various studies and practices in areas where lime additive is abundant.

1.3 Description of technology or practice

Considered a counteractant, adding lime or gypsum to manure stockpiles can adjust pH, reduce moisture and block the volatilization of certain compounds. Lime is basic and would potentially increase manure pH thereby increasing ammonia emissions.

1.4 Control Efficiency

1.5 Considerations regarding use of the technology or practice

Adding lime may reduce levels of VOC & NH_3 production, but can increase levels of other compounds such as hydrogen sulfide in the process. Can be highly damaging when applied to certain soils. Gypsum may also carry undesirable trace elements that one would not want to increase in soil over time.

a) Pros

b) Cons

1.6 Cost

Potentially very expensive depending on the volume necessary to achieve desirable emission control results. Gypsum costs range from $7 to $14 a ton.

1.7 Feasibility/Applicability at dairies

Is feasible if lime or gypsum is an abundant resource. However, careful consideration must be given to soil conditions if the stockpiles with the lime additive are land applied. Certain soils are unable to absorb a lime additive.

1.8 Missing Data

Further review of the research is needed.

1.9 Further Resources

1.10 Recommendation

Since there are not many data available for this technology, it should be placed in a "future evaluation" category. When more information becomes available, the applicability of this technology should be addressed at that time.

2. Addition of Oxidants (Potassium Permanganate) to the manure stockpiles (VOC)

2.1 Pollutants Targeted and Expected Range of Control Efficiencies

Potentially VOC, H_2S

2.2 Where technology comes from

Research and practices within other CAFO industries.

2.3 Description of technology or practice

Oxidizers chemically oxidize compounds or reduce the microbial activity responsible for certain emissions.

2.4 Control Efficiency

The control efficiency of this technology is not known at this time. A more detailed analysis of this technology is required before a control efficiency can be applied.

2.5 Considerations regarding use of the technology or practice

Can create insoluble MnO_2 precipitate. Does not treat NH_3 or disulfides. Long contact time may also be required. Little data are available-data available refers to potential control of odiferous compounds, but no citation of VOC control.

a) Pros

b) Cons

2.6 Cost

Costly if large amounts needed.

2.7 Feasibility/Applicability at dairies

Oxidizers such as potassium permanganate are stable, easily handled and non-corrosive. This technology is feasible at dairies. However, the detailed cost effectiveness of this system needs to be performed prior to its application.

2.8 Missing Data

Data are needed to describe association with VOC emissions.

2.9 Further Resources

2.10 Recommendation

Since there are not many data available for this technology, it should be placed in a "future evaluation" category. When more information becomes available, the applicability of this technology should be addressed at that time.

3. Biological additives

3.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC, NH3, H2S

3.2 Where technology comes from

Various studies and vendor information

3.3 Description of technology or practice

Microbiological additives, or digestive deodorants, generally contain mixed cultures of enzymes or microorganisms designed to enhance the degradation of solids and reduce the volatilization of ammonia and/or hydrogen sulfide and alter the endproducts emitted. The microorganisms digest the manure.

3.4 Control Efficiency

The control efficiency of this technology is not known at this time. A more detailed analysis of this technology is required before a control efficiency can be applied.

3.5 Considerations regarding use of the technology or practice

Results from laboratory biological additive testing are usually subjected to significant variations and do not allow for any definite conclusion. Little success has been reported in using biological additive to dry manure storage piles.

a) Pros

b) Cons

3.6 Cost

Cost range but typically these additives are expensive

3.7 Feasibility/Applicability at dairies

Application devise and amount is key. A unevenly or over/under applied additive can impact certain emission rates. This technology is feasible at dairies. However, the detailed cost effectiveness of this system needs to be performed prior to its application.

3.8 Missing Data

Cost data including emissions data are needed.

3.9 Further Resources

3.10 Recommendation

Since there are not many data available for this technology, it should be placed in a "future evaluation" category. When more information becomes available, the applicability of this technology should be addressed at that time.

4. EMERGING CONVERSION TECHNOLOGY

Emerging conversion technologies utilizing high heat performance such as gasification, pyrolosis, and combustion theoretically can convert manure solids into a source of energy. Depending on the process, that source of energy can take a variety of forms (i.e., methane, ethanol, hydrogen, steam, etc.)

Although there is tremendous promise with these innovative technologies, there is not unit that exists today that has consistently performed on cow manure. There are, however, a number of pilot projects being proposed throughout the United State and the dairy industry should continually evaluate their potential applications.

5. Gasification/Pyrolysis

5.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC, NH_3

5.2 Where technology comes from

Various private industry claims; some studies of other industries (poultry manure and brewery waste); may not yet be commercially available for dairies. Pilot scale protocol, however, scheduled to be "tested" in several locations over the next couple of months. (i.e.,. Agricultural Waste Solutions pilot project in Chino, California)

5.3 Description of "technology"

Pyrolysis and gasification technologies have been available for many years. Pyrolysis is the decomposition of complex molecules in the absence of oxygen to produce Syngas, oil and char. Gasification is the decomposition of solid organic material into a gas and char by controlling the amount of oxygen available. These processes are usually achieved by planning the manure inside a sealed vessel with either an inert or vacuum atmosphere and externally apply heat.

5.4 Control Efficiency

The control efficiency of this technology is not known at this time. However, it appears that significant emissions reductions can be obtained based on the description of this technology. More data are needed in order to estimate a control efficiency.

5.5 Considerations regarding use of the technology in practice

As discussed above, has not been proven in a "real world" scenario. Gasification/pyrolsis technology generally requires a "dry" feedstock. Liquid waste would probably have to go through a pre-treatment drying devise.

a) Pros

b) Cons

5.6 Costs

Initial capital costs for gasification/pyrolsis is significant.

5.7 Feasibility/Applicability at dairies

High temperature conversion technology requires constant O&M by specialized personnel.
Many dairies need the nutrient value of the solids within the liquid stream or field application.

5.8 Missing Data

Need to evaluate potential NOX and SOX emissions.

5.9 Further Resources

5.10 Recommendation

Since there are not many data available for this technology, it should be placed in a "future evaluation" category. When more information becomes available, the applicability of this technology should be addressed at that time.

6. Combustion

6.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC, NH_3, particulates, & H_2S

6.2 Where technology comes from

Use in agro-industrial or forestry applications.

6.3 Description of technology or practice

Direct combustion furnaces usually employ two states. The first stage is for the drying and possible partial gasification, and the second for complete combustion. More advanced version of these systems use rotating or vibrating grates to facilitate ash removal, with some requiring water-cooling. Can be done in combination with fossil fuels (co-firing).

6.4 Control Efficiency

The control efficiency of this technology is not known at this time. However, it appears that significant emissions reductions can be obtained based on the description of this technology. More data are needed in order to estimate a control efficiency.

6.5 Considerations regarding use of the technology or practice

Same as 10 (Pyrolsis/Gasificaiton).

a) Pros

b) Cons

6.6 Cost

Initial capital costs for combustion is significant.

6.7 Feasibility/Applicability at dairies

This technology may be feasible at dairies. The detailed cost effectiveness of this system needs to be performed prior to its application.

6.8 Missing Data

Cost data including emissions data are needed.

6.9 Further Resources

6.10 Recommendation

Since there are not many data available for this technology, it should be placed in a “future evaluation” category. When more information becomes available, the applicability of this technology should be addressed at that time.

7. Carbonization

7.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC & NH3

7.2 Where technology comes from

Dairy Technology Feasibility Report Change

7.3 Description of technology or practice

This company proposes to convert collected manure solids into charcoal using continuous kilns. The advantage of continuous-kilns/continuous multiple-hearth-kilns is that they are more amendable to the control emissions than are batch kilns. This is largely achieved by cycling the gases that would otherwise escape through the kiln exhaust into an afterburner to ensure that they are completely combusted. More benign compounds are thereby produced to be exhausted to the air. Substantial overall emissions reduction can be achieved in this manner. An afterburner is used after the process.

7.4 Control Efficiency

The control efficiency of this technology is not known at this time. However, it appears that significant emissions reductions can be obtained based on the description of this technology. More data are needed in order to estimate a control efficiency.

7.5 Considerations regarding use of the technology or practice

a) Pros

b) Cons

7.6 Cost

Cost of this technology is not known

7.7 Feasibility/Applicability at dairies

This technology may be feasible at dairies. The detailed cost effectiveness of this system needs to be performed prior to its application.

7.8 Missing Data

Cost data including emissions data are needed.

7.9 Further Resources

7.10 Recommendation

Since there are not many data available for this technology, it should be placed in a "future evaluation" category. When more information becomes available, the applicability of this technology should be addressed at that time.

~~XI.~~X. LAND APPLICATION

A. Description

Manure applied to land falls into three separate categories, based on the different techniques used to apply dairy waste. Dairies, based on their manure management have the option to apply their waste either as a solid, semi-solid, slurry, or a liquid.[36] Solid manure usually refers to material that has a solids content greater than ~15% and can easily be handled as a solid. Semi-solid manure has a lower solids content from 10 to 15%, allowing stacking, yet seepage may occur. Slurry manure refers to material that has a solids content between 3% -10% and is not solid enough to form piles and not liquid enough to flow uniformly, though it can be easily pumped. Slurry manure can usually be found in the concrete feed lanes, where the cows are fed and/or in the settling basins. Liquid manure refers to material that has less than 3% solids content and is usually stored in treatment lagoons or storage ponds.

B. Control Technologies/Practices for Land Application

i <u>Land Application of Liquid Manure</u>

1. Irrigation of crops using liquid manure from a holding/storage pond after being treated in a covered lagoon/digester

1.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC & H_2S

1.2 Where Technology Comes From

SJVAPCD Draft Dairy BACT document dated April 27, 2004

1.3 Description of Technology or Practice

This practice would only allow the irrigation of liquid manure to cropland from the secondary lagoon after proper treatment has taken place in a covered lagoon/anaerobic digester. The reasoning behind this is that the

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[36] Manure categories according to solids content are based on the American Society of Agricultural Engineers, Standard for Uniform Technology for Rural Waste Management, ASAE S292.5 FEB04.

majority of the manure would have a chance to properly digest, leaving a small portion of the undigested manure in the effluent.

1.4 Control Efficiency

Some DPAG members believe that more research is necessary to establish a control efficiency. At this time control efficiency is estimated to be between 0 and 100 percent.

Some DPAG members believe that the control efficiency of such a system can be estimated as follows:

Assumptions:

- 70-85% of the Volatile Solids (VS) can be removed from the covered anaerobic digestion process.
- 15-30% of the remaining VS will be assumed to be in the manure during land application as a worst-case. This will be considered worst-case because further digestion of the VS is likely to occur from the secondary lagoon.
- As a worst-case scenario, it will be assumed that all remaining VS will be emitted as VOCs during land application.

Since 70-85% of the VS is removed or digested in the covered lagoon and the remaining VS have been assumed to be emitted as VOCs, a control efficiency of 70-85% can be applied when applying liquid manure to land from a holding/storage pond after a covered lagoon.

1.5 Considerations Regarding Use of the Technology or Practice

a) Pros

This system allows for capture and combustion of emissions including methane. It is also designed to facilitate production of methane preferentially to other carbon-containing gases. This may reduce the emissions of VOCs in subsequent application to cropland. However, no data is available to determine whether pre-treatment in this fashion would create a reduction, increase or no change to any air emissions from effluent.

b) Cons

Substantial expense is involved in constructing and covering the treatment lagoon. It is likely that a covered lagoon/digester conserves nitrogen and if so, conservation of nitrogen and some degree of transformation to the nitrate form can become a threat to groundwater due to its susceptibility to leaching.

1.6 Cost

Land application costs will be similar in all systems. Construction costs are significant, ranging from $500,000 to $2 million or more for a complete biogas digester system.

1.7 Feasibility at Dairies

Some DPAG members believe there is presently no data to support a conclusion as to whether emissions from the effluent are higher, lower or about the same as emissions from undigested effluent. Therefore a determination of technological feasibility for reduction of VOC, ammonia and H_2S is not possible, because control efficiency cannot yet be determined (for the effluent), and thus cost effectiveness cannot be calculated. Western United Resource Development, Inc (WURD) has administered a Dairy Power Production Program for the California Energy Commission. Digesters of various designs have been constructed or are being constructed on California dairy farms. The cost data is being refined and will be provided for district use as soon as it is brought up to date. Once control efficiency data and cost data become available, a cost effectiveness determination could be made.

Some DPAG members believe that due to the large VS reductions achieved in the anaerobic digester, less emissions would be generated from both the secondary lagoon and from land application. Some dairies currently utilize this technology on their dairies. Therefore, these members believe that this technology is feasible on dairies.

1.8 Missing Data

1.9 Further Resources

1.10 Recommendation

To be determined pending analysis of cost data

Some DPAG members believe that this technology should be considered Achieved in Practice. Others disagree based on lack of empirical data confirming reductions of VOCs and/or the potential for adverse water quality impacts.

2. Irrigation of crops using liquid manure from the secondary lagoon/holding/storage pond where preceded by an uncovered anaerobic treatment lagoon.

2.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC, NH_3, & H_2S

2.2 Where Technology Comes From

SJVAPCD Draft Dairy BACT document dated April 27, 2004
USDA/NRCS Practice Standard 390
NRCS Field Office Technical Guide

2.3 Description of Technology or Practice

This practice would only allow the irrigation of liquid manure to cropland from the secondary lagoon after going through a treatment phase in an anaerobic treatment lagoon, or the primary lagoon. The reasoning behind this is that the majority of the manure would have a chance to properly digest, leaving a small fraction of the undigested manure in the effluent.

2.4 Control Efficiency

Some DPAG members believe that more research is necessary to establish a control efficiency.

Some DPAG members believe that the control efficiency of such a system can be estimated as follows:

Assumptions:

- Anaerobic treatment lagoons will be assumed to be slightly less efficient in reducing Volatile Solids than covered lagoons. Covered lagoons are completely anaerobic systems, while anaerobic treatment lagoons are open systems and may have slightly different conditions on the surface. Therefore, it will be estimated that 60-75% of the Volatile Solids (VS) will be removed from the anaerobic treatment lagoons.
- 25-40% of the remaining VS will be assumed to be in the manure during land application as a worst-case. This will be considered worst-case because further digestion of the VS is probable from the secondary lagoon.
- As a worst-case scenario, it will be assumed that all remaining VS will be emitted as VOCs during land application.

Since 60-75% of the VS has been removed or digested in the covered lagoon and the remaining VS have been assumed to be emitted as VOCs, a control efficiency of 60-75% can be applied when applying liquid manure from a holding/storage pond after an anaerobic treatment lagoon.

2.5 Considerations Regarding Use of Technology or Practice

a) Pros

Utilization of a specifically designed anaerobic treatment lagoon preceding the final storage pond is expected to allow for more complete digestion and conversion of the carbon containing components of manure into methane. The expectation is therefore for less carbon remaining available for VOC production and release when applied to cropland. H_2S emissions are also expected to respond in a similar manner.

Impacts on NH_3 are unknown at this time.

b) Cons

Requires a two-stage system of lagoon and storage pond.
Lagoon and storage pond cost will be significantly increased due to the need for a staged system.

2.6 Cost

Land application costs will be similar in all systems; construction cost for this type of system would be significantly higher than a standard lagoon (see liquid manure BACT). The California Department of Food and Agriculture is developing a program to track costs associated with manure management.

2.7 Feasibility at Dairies

This technology is considered feasible for maximizing anaerobic digestion and consequently reducing emissions of reactive organic gases. However, some DPAG members believe that the control efficiency for the reactive gases is unknown at this time (0 to 100 percent).

Some members believe that a control efficiency can be estimated as shown in section 2.4 above.

2.8 Missing Data

<u>Additional information is needed to assess control effectiveness</u>

2.9 Further Resources

2.10 Recommendation

Additional information on control efficiency and cost will be needed to accurately determine cost effectiveness.

Some DPAG members believe that since many dairies currently utilize a two-stage treatment lagoon system, this system should be considered Achieved in Practice. Others disagree based on lack of empirical data confirming reductions of VOCs and/or the potential for adverse water quality impacts.

3. Irrigation of crops using liquid manure from the primary lagoon and/or secondary lagoon

3.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC, NH_3, & possibly H_2S

3.2 Where Technology Comes From

Existing dairies; USDA/NRCS

3.3 Description of Technology or Practice

Currently, this is the practice for many existing dairies, especially dairies that only have one lagoon at their facility. However, some dairies with multiple lagoons still flush their cropland with liquid manure from either of their lagoons including the primary lagoon.

3.4 Control Efficiency

Control efficiency is unknown at this time and is expected to depend on treatment volume in the lagoon and residence time (digestion time) prior to application, as well as overall loading rate (dilution). However, control efficiency may be much lower from this system than a two-stage anaerobic treatment lagoon system.

3.5 Considerations Regarding Use of the Technology or Practice

a) Pros

Construction costs are reduced; land requirements may be less.

b) Cons

This system has the effect of reducing average residence time for the effluent (compared to sequential lagoons), thus reducing treatment time overall. However there is currently no data to compare the systems.

3.6 Cost

Land application costs will be similar in all systems. Cost would presumably be lower for this system as it does not require the extra treatment volume necessary to operate an anaerobic treatment lagoon or covered lagoon digester. That data is not yet available but the California

Department of Food and Agriculture is developing a program to track these types of costs.

3.7 Feasibility at Dairies

This technology is in common use on California dairy farms and is considered feasible.

3.8 Missing Data

3.9 Further Resources

USDA/NRCS pond construction guidance - Field Office Technical Guide

3.10 Recommendation

Achieved in practice

4. Land application of lagoon water such that there is no standing water

4.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC, NH_3, & possibly H_2S

4.2 Where Technology Comes From

Existing dairy practices along with recommendations from local county ordinances, public agencies, such as Regional Water Quality Control Boards, and universities regarding irrigation methods and recent research relating emissions of ammonia with climatic conditions.

4.3 Description of Technology or Practice

During land application, minimize or eliminate standing water in an irrigated field within 24 hours, which reduces the potential to volatilize into the atmosphere and/or emit due to anaerobic conditions.

4.4 Control Efficiency

Undetermined at this time; additional study required. While emission rates are not well known for land application practices, new data may be available soon from on-going research in California. In the absence of emission rates, emission reductions could potentially be assumed to occur where practices are used that decrease the time, temperature or area of water surface from which VOC's could be emitted.

4.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- Brings subject compounds into contact with soil particles and prevents volatilization.

- Reduces wind and sun influences on volatilization.
- Avoids creating an anaerobic condition.
- Also facilitates compliance with water quality regulations.
- Practices that could reduce emissions by matching the irrigation method to soil type and specific field conditions can be readily identified. Irrigation auditing services are available from both public and private agencies where professional assistance is warranted. The improvement in efficiency and, potentially, the emissions reductions could be quantified with considerable accuracy. The improvement in irrigation efficiency may also increase uniformity, which could potentially reduce the groundwater quality hazard from excess nutrients that leach from areas in the field that are over-irrigated.

b) Cons

May require a higher level of irrigation management or a change in irrigation practice. Could potentially require the construction of a "tailwater return" system.

4.6 Cost

The cost of this management practice is not determined at this time. The cost associated with the construction and pumping of a tailwater return system is available from local engineering firms and the NRCS.

Some modifications to irrigation to prevent standing water, such as night irrigation or altering the number of rows/checks to be irrigated per set would have very little additional cost. Other factors such as land leveling, changing the pumping system, or installation of a tail-water return system could add several hundred dollars per acre.

4.7 Feasibility at Dairies

Currently required by the Central Valley Regional Water Quality Control Board, so is considered feasible.

4.8 Missing Data

<u>Additional information is needed to assess control effectiveness</u>

4.9 Further Resources

Central Valley Regional Water Quality Control Board
USDA/NRCS
Sommer and Hutchings, *Ammonia Emissions from Field Applied Manure and Its Reduction – An Invited Paper,* European Journal of Agronomy, 15 (2001) 1-15.

4.10 Recommendation

Achieved in practice

ii Land Application of Slurry Manure

1. Slurry injection before planting crops and post-planting until crop damage would occur

1.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC, NH_3, PM, & H_2S

1.2 Where Technology Comes From

SJVAPCD Draft Dairy BACT document dated April 27, 2004

1.3 Description of Technology or Practice

This practice requires manure in a slurry-state to be injected below the soil surface, reducing emissions and surface run-off while minimizing the loss of nitrogen into the atmosphere. Research has shown that as much as 30% of the nitrogen can be lost through volatilization.[37] Based on a study by a local Valley dairy, there is a great potential of reducing emissions by incorporating manure rapidly into the soil.

Manure slurry (cattle feces and urine in semi-solid form) is a source of odors, ammonia, VOCs and other emissions. Intensity of the emissions can vary based on conditions. For example, ammonia in the liquid phase may be volatilized as wet manure (feces and urine) dry out. VOCs may continue to form due to biological processes present in slurry but are expected to taper off as the slurry dries. Odor intensity is a function not only of the slurry condition and biochemical content but also of local meteorological conditions (e.g. inversion layers versus well-mixed air).

Injection involves gathering manure slurry, usually in a tanker, and transporting it to an agricultural field where it is injected under pressure through steel tubes that place the slurry below the soil surface, effectively depositing the slurry and incorporating it into the soil in a single step. This reduces odors by using soil as a natural biofilter while minimizing exposure to wind.

Rapid incorporation of both wet (slurry) and dry manure (solid or semi-solid) is considered a best management practice (BMP) for odor management. Injection is a particularly effective method of rapid incorporation, although it may be a risky practice that would require approval from a regional water board and potentially other authorities.

[37] http://www.lpes.org/Lessons/Lesson36/36_1_Selecting_Application.pdf

1.4 Control Efficiency

Manure injection into the soil is the most effective way to reduce odor during the land application of untreated manure.[38] Some information indicates that odor levels using this process are essentially equal to background levels.[39] One study found that downwind odor intensity of surface application of manure at 400 meters was roughly equivalent to injection at 50 meters.[40]

However, odor intensity and quantifiable emissions of ammonia, VOCs, etc. are not the same. Unfortunately there are no data available to support quantification of other emissions and the U.S. Department of Agriculture's Agricultural Air Quality Task Force has suggested that odors are not a surrogate for emissions of VOCs, ammonia or hydrogen sulfide.

The control efficiency of this technology is unknown at this time. However, some portion of odors, which are a complex mix of hundreds of compounds, are likely to be made up of VOCs and therefore are also likely to be reduced. VOCs are anticipated to be reduced due to the combination of drying out the slurry, bio-filtering, adsorption and reduced exposure to wind. Likewise, ammonia is readily adsorbed to soil and thus air emissions are reduced.

Though emission reductions would be expected to be higher from manure injection than from manure incorporation some DPAG members believe that a similar control efficiency can be applied to this technology based on an emissions study at a Kern County dairy evaluating the reductions of VOC and ammonia emissions from the immediate incorporation of manure through a discing process. The emissions reductions shown from that study are as follows:

1. 58-% VOC
2. 82% H2S
3. 98-% ammonia

This study did not analyze all the VOC compounds at a dairy such as VFAs, phenols, and amines; however, both the pre-manure incorporation and post-manure incorporation tests were done. It would be anticipated that similar reductions may have been achieved for the pollutants not measured in this study. In spite of this, in order to be conservative, the following control efficiencies will be applied (assuming 0-50% discounted reductions for each pollutant);

1. 29-% - 58% VOC

[38] Livestock and Poultry Environmental Stewardship Curriculum, Lesson 44, Module E, "Liquid Manure Odor Control Techniques," pps. 6 to 12 (www.lpes.org).
[39] Ibid., page 8.
[40] Bergland and Hall 1987

2. 41-% - 82% H_2S
3. 49-% -98% ammonia

1.5 *Considerations Regarding Use of the Technology or Practice*

a) Pros

- Potentially significant VOCs and ammonia emission reductions
- Nitrogen losses are expected to be minimized, which may increase the fertilizer value of the manure while reducing ammonia volatilization. [41]

b) Cons

- Increased costs due to specialized equipment and increased maintenance and labor
- Potential damage to crop canopy and root structure
- Decreased flexibility/efficiency of application of nutrients to land/increased need for more land to maintain proper nutrient balance
- Potential groundwater contamination
- Rainfall patterns may limit the use of injection
- While there may be strong advantages for certain operations, there may also be strong disadvantages that could pose potential environmental consequences that merit careful consideration. It is unlikely that this control strategy alone will be adequate for most typical California dairies.

1.6 *Cost*

Cost data is not available at this time. A cost analysis should take into account multiple factors including labor, equipment and maintenance, and potential need for additional land acquisition. However, there may be offsetting costs depending on how effectively this system can replace other capital, equipment and labor costs. There may also be offsetting costs in reduced nitrogen losses to the atmosphere, potentially increasing nitrogen availability for crops while reducing the need for other types of fertilizer.

1.7 *Feasibility at Dairies*

This technology is technologically feasible for reduction of odors and may be feasible for other emissions reductions, although such reductions have not been quantified. It appears most feasible for systems where *un*treated manure will be applied to land. Data demonstrating reduction of VOCs and ammonia from injection sites versus similar sites where manure has been spread but not incorporated will be of great use in

[41] LPES Lesson 44, Module E, page 9.

finalizing a determination that this practice is technologically feasible. This technology may not be feasible for operations where climate, rainfall, drainage or other factors do not allow its use year-round, unless this is used in combination with other manure management systems that account for limitations. It is only feasible if adequate nutrient management is maintained to protect groundwater quality.

Some members believe that a control efficiency can be estimated as shown in section 5.4 above.

1.8 Missing Data

Additional information is needed to assess control effectiveness

1.9 Further Resources

http://www.lpes.org/Lessons/Lesson36/36_1_Selecting_Application.pdf

Livestock and Poultry Environmental Stewardship Curriculum, Lesson 44, Module E, "Liquid Manure Odor Control Techniques," pps. 6 to 12 (www.lpes.org).

"Air Quality Research and Technology Transfer White Paper and Recommendations for Concentrated Animal Feeding Operations," July 19, 2000, adopted by the USDA Agricultural Air Quality Task Force, Sweeten et al., see especially pages 47-49, "Enhanced Dispersion of Odor."

"Odor – The Issue for the New Decade," USDA-Natural Resources Conservation Service web site, http://wmc.ar.nrcs.usda.gov/technical/WQ/odor.html

1.10 Recommendation

More data is needed on costs (labor, equipment, land requirements) and potential for reduction of specific emissions. More data is also needed on best nutrient management practices related to use of injection, particularly given the likelihood that nitrogen losses to the atmosphere may be reduced.

2. Rapid incorporation of slurry manure into the soil after land application

2.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC & NH_3

2.2 Where Technology Comes From

SJVAPCD Draft Dairy BACT document dated April 27, 2004

2.3 Description of Technology or Practice

Rapid incorporation involves spreading liquid manure on the surface and immediately plowing or harrowing into the soil. This reduces odors in a similar manner to injection (see section 5 above) although to a lesser extent.

This practice requires the immediate incorporation of fresh or slurry type manure into the soil, reducing emissions and surface run-off while minimizing the loss of nitrogen into the atmosphere. Based on a study by a local Valley dairy, there is a great potential of reducing emissions by incorporating manure rapidly into the soil.

2.4 Control Efficiency

Some DPAG members believe that there were no data available for review to support a quantification of the reduction in expected VOC, ammonia or other specific emissions.

The U.S. Department of Agriculture's Agricultural Air Quality Task Force has suggested that odors are not a surrogate for emissions of VOCs, ammonia or hydrogen sulfide. However, some portion of odors, which are a complex mix of hundreds of compounds, are likely to include some VOCs. If odors are reduced, then VOCs are also anticipated to be reduced due to the combination of drying out the slurry, bio-filtering, adsorption and reduced exposure to wind. Likewise, ammonia is readily adsorbed to soil and thus air emissions are reduced.

It is unlikely that reductions from rapid incorporation would be as great as with injection due to less complete coverage of the manure slurry. However, reductions would still be expected.[42]

Some DPAG members believe that control efficiency can be applied to this technology based on an emissions study at a Kern County dairy evaluating the reductions of VOC and ammonia emissions from the immediate incorporation of manure through a discing process. The emissions reductions shown from that study are ~~as follows~~shown in section X.B.ii.1.4:

~~1.58 % VOC~~
~~2.82% H2S~~
~~3.98 % ammonia~~

~~This study did not analyze all the VOC compounds at a dairy such as VFAs, phenols, and amines; however, both the pre-manure incorporation and post-manure incorporation tests were done. It would be anticipated that similar reductions may have been achieved for the pollutants not measured in this study. In spite of this, in order to be conservative, the~~

[42] Ibid., page 9.

~~following control efficiencies will be applied (assuming 50% discounted reductions for each pollutant);~~

~~1.29 % VOC~~
~~2.41 % H_2S~~
~~3.49 % ammonia~~

2.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- Potential reductions in VOC and ammonia emissions
- Nitrogen losses are expected to be minimized which may increase the fertilizer value of the manure while reducing ammonia volatilization[43]
- Necessary equipment may already be available on the dairy

b) Cons

- Some specialized equipment may be necessary
- Additional costs including labor
- Potential damage to the crop canopy and root structure
- Rainfall patterns may limit the ability to incorporate into soil Potentially decreased flexibility/efficiency of application of nutrients to land/ Increased need for more land to maintain a proper nutrient balance

2.6 Cost

Cost data is not available at this time. A cost analysis should take into account multiple factors including labor, equipment and maintenance, and potential need for additional land acquisition. However, there may be offsetting costs depending on how effectively this system can replace other capital, equipment and labor costs. There may also be offsetting costs in reduced nitrogen losses to the atmosphere, potentially increasing nitrogen availability for crops while reducing the need for other types of fertilizer.

2.7 Feasibility at Dairies

This technology is feasible for reduction of odors and may be feasible for other emissions reductions, although such reductions have not been quantified (with the exception of hydrogen sulfide). It appears most feasible in systems where *un*treated manure will be applied to land. Data demonstrating reduction of VOCs and ammonias from injection sites versus similar sites where manure has been spread but not incorporated will be of great use in finalizing a determination that this practice is technologically feasible. This technology may not be feasible for operations where climate, rainfall, drainage or other factors do not

[43] Ibid., page 9.

allow its use year-round, unless this is used in combination with other manure management systems that account for limitations. It is only feasible if adequate nutrient management is maintained to protect groundwater quality.

Some members believe that a control efficiency can be estimated as shown in section 6.4 above.

2.8 Missing Data

Additional information is needed to assess control effectiveness

2.9 Further Resources

Testing performed on a Kern County Dairy – Looking into making data available for DPAG members

Livestock and Poultry Environmental Stewardship Curriculum, Lesson 44, Module E, "Liquid Manure Odor Control Techniques," pps. 6 to 12 (www.lpes.org).

"Air Quality Research and Technology Transfer White Paper and Recommendations for Concentrated Animal Feeding Operations," July 19, 2000, adopted by the USDA Agricultural Air Quality Task Force, Sweeten et al., see especially pages 47-49, "Enhanced Dispersion of Odor."

"Odor – The Issue for the New Decade," USDA-Natural Resources Conservation Service web site, http://wmc.ar.nrcs.usda.gov/technical/WQ/odor.html

2.10 Recommendation

More data is needed on costs (labor, equipment, land requirements) and potential for reduction of specific emissions. More data is needed on best nutrient management practices related to use of injection, particularly given the likelihood that nitrogen losses to the atmosphere may be reduced. (Technology feasible?)

iii Land Application of Solid or Semi-Solid Manure

1. Rapid incorporation of solid or semi-solid manure into the soil after land application

1.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC & NH_3

1.2 Where Technology Comes From

SJVAPCD Draft Dairy BACT document dated April 27, 2004

1.3 Description of Technology or Practice

Various types of spreading techniques, such as ~~-~~box spreaders, flail type spreaders,~~.~~ side discharge spreaders, spinner spreaders, and possibly also dump trucks, are used to apply solid manure to cropland. Regardless of which technique is used, this practice requires the immediate incorporation of the manure into the soil, reducing emissions and surface run-off while minimizing the loss of nitrogen into the atmosphere. Based on a study by a local Valley dairy, there is a great potential of reducing emissions by incorporating slurry manure rapidly into the soil. A similar reduction may be obtained by the rapid incorporation of solid manure. Refer to section 6 above for more information about rapid incorporation.

1.4 Control Efficiency

Based on testing performed at a Kern County Dairy, the control efficiency for rapid incorporation of slurry manure resulted in VOC and NH_3 reductions of 58% and 98% respectively. Similar reductions can be expected from rapid incorporation of solid manure.
However, a similar control efficiency will be applied to this technology as applied to earlier in sections X.B.ii.1 and X.B.ii.2~~5 and 6~~ as follows:

29 - 58% VOC
41 - 82~~-~~% H_2S
49 –98.7% ammonia

1.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- Fairly high control efficiency for both VOC and NH_3
- Better uptake of nutrients for crops

b) Cons

- Increase in equipment use and labor
- Possible need for more land

1.6 Cost

The cost of disking in the manure is not available but could be calculated, if necessary. However, the cost does not appear to be significant.

1.7 Feasibility at Dairies

This practice is currently used at many dairies and can easily be incorporated into existing and new dairies.

1.8 Missing Data

Additional information is needed to assess control effectiveness

1.9 Further Resources

Testing with slurry manure was performed on a Kern County Dairy Looking into making data available for DPAG members. Since this is the only study available that shows emissions reduction, the process may be applicable to solid manure.

1.10 Recommendation

Since many dairies may already be incorporating their solid manure into the soil after land application, this practice should be considered Achieved in Practice BACT.

2. Land application of solid or semi-solid manure that has been processed by an open negatively aerated static pile (ASP)

2.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC, NH_3, PM, & H_2S

2.2 Where Technology Comes From

SJVAPCD Draft Dairy BACT document dated April 27, 2004

2.3 Description of Technology or Practice

Prior to applying solid manure to land, the manure should be pre-treated in an open negatively aerated static pile (ASP). By pre-treating the manure in this system, the release of emissions during land application will be decreased.

ASPs are piles of manure that are aerated directly with forced or drawn air systems to speed up the compost process. The ASP is constructed to allow forced airflow, through 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 of windrow composting, which are non-aerated piles turned mechanically with front-end loaders or scarabs as discussed in Section X of solids handling section.~~

Refer to Section IX.ii.5 for a detailed description of this technology.

By pre-treating the manure through this technology, the release of emissions during land application will be reduced.

VOC emissions primarily occur during the active and curing phases of the composting. To ensure consistent temperatures and prevent the 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 collect odors for 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.

A study conducted by the 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 an 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.[44]

2.4 Control Efficiency

The control efficiency can be estimated based on the 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 ASPs based on the Technology Assessment is 23%. Additional emission reduction potential from ASPs cannot be quantified at this time. Therefore, control efficiency for open ASPs will be 23%

2.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- Improvement of the handling characteristics by reduction of manure volume and weight
- Pathogens and weed seed destruction

[44] Technology Assessment for SCAQMD proposed Rule 1133 Page 3-2

- End product enhances soil structure and benefits new growth

b) Cons

- Increase in equipment use and labor
- Possible need for more land

2.6 Cost

The cost of ASPs can be reasonably calculated; they are somewhat costly to install and operate.

2.7 Feasibility at Dairies

This technology is feasible at dairies. However, the detailed cost effectiveness of such systems needs to be performed prior to their application.

2.8 Missing Data

Additional information is needed to assess control effectiveness

2.9 Further Resources

Technology Assessment for SCAQMD proposed Rule 1133 Page 3-2

2.10 Recommendation

The District should perform a cost-effective analysis for this technology. ~~consider~~

3. Land application of solid or semi-solid manure that has been processed by an enclosed ASP

3.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC, NH_3, PM, & H_2S

3.2 Where Technology Comes From

SJVAPCD Draft Dairy BACT document dated April 27, 2004

3.3 Description of Technology or Practice

Prior to applying solid manure to land, the manure should be pre-treated in an enclosed negatively aerated static pile. An enclosed aerated static pile uses the same forced aeration principle of an open ASP, except that the entire pile is fully enclosed. ~~A handful of companies are promoting this type of system.~~ Refer to Section IX.ii.6 for a detailed description of this technology

By pre-treating the manure through this technology, the release of emissions during land application will be reduced.

3.4 Control Efficiency

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 completed, 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%.

3.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- Improvement of the handling characteristics by reduction of manure volume and weight
- Pathogens and weed seed destruction
- End product enhances soil structure and benefits new growth

b) Cons

- Increase in equipment use and labor
- Possible need for more land

3.6 Cost

The cost of enclosed ASPs can be reasonably calculated.
They are more costly to install and operate than open ASPs.

3.7 Feasibility at Dairies

This technology is feasible at dairies. However, the detailed cost effectiveness of such systems needs to be performed prior to their application.

3.8 Missing Data

Additional information is needed to assess control and cost effectiveness

3.9 Further Resources

To be added

3.10 Recommendation

The District should perform a cost-effective analysis for this technology.

4. Land application of solid or semi-solid manure that has been processed by an open or negative ASP with rapid incorporation of the manure into the soil after land application

4.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC, NH_3, PM, & H_2S

4.2 Where Technology Comes From

Combination of control technologies

4.3 Description of Technology or Practice

Prior to applying solid manure to land, the manure should be pre-treated in an open negatively aerated static pile, (refer to Section IX.ii.5 for a detailed description of this technology) as explained in section 8 above and in conjunction with immediate incorporation, the treated manure should be immediately incorporated into land, as discussed in section ix.iii.17. By pre-treating the manure in this system, and the immediate incorporation of the manure, the release of emissions during land application will be further decreasedreduced.

4.4 Control Efficiency

As shown in section X.B.ii.17 and 8, the control efficiency for VOCs from immediate incorporation range from 29-58% and the negatively ASP control efficiency is 50% and 23% respectively. The overall control efficiency from land application can be calculated as follows:

The overall control efficiency of the combination of both practices is equal to the combined control efficiencies of the open aerated system (23%) and immediate incorporation (29-5850%).

Overall Control efficiency (0.23) + (1-0.23)*(29% to 58%0.5) = 61.645.3 % to 67.7%

4.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- Fairly high control efficiency for both VOC and NH_3
- Improvement of the handling characteristics by reduction of manure volume and weight
- Pathogens and weed seed destruction
- End product enhances soil structure and benefits new growth Better uptake of nutrients for crops

b) Cons

- Increase in equipment use and labor

- Possible need for more land

4.6 Cost

The cost of the combination of disking in the manure and the ASPs is not immediately available but could be calculated if necessary.

4.7 Feasibility at Dairies

The combination of these two practices is feasible at dairies. However, the detailed cost effectiveness of the combination of these systems needs to be performed prior to their application.

4.8 Missing Data

Additional information is needed to assess control and cost effectiveness

4.9 Further Resources

To be added

4.10 Recommendation

The District should perform a cost-effective analysis for the combination of ASP and immediate incorporation.

5. Land application of solid or semi-solid manure that has been processed by an open negatively ASP with exhaust (V) vented to a biofilter with a control efficiency greater than or equal to 80%

5.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC, NH_3, PM, & H_2S

5.2 Where Technology Comes From

SJVAPCD Draft Dairy BACT document dated April 27, 2004

5.3 Description of Technology or Practice

Prior to applying solid manure to land, the manure should be pre-treated in an open, negative ASP with the exhaust vented to a biofilter. By pre-treating the manure in this system, the release of emissions during land application will be ~~decreased~~ reduced significantly.

A biofilter is 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), which contains large populations of microbes. Refer to Section XI.A.ii.5 for a detailed description on biofilters.

5.4 Control Efficiency

The overall control efficiency of this technology is equal to the combined control efficiencies of the open aerated system (23%) and the biofilter (80%), calculated as follows:

(0.23) + (1-0.23)*(0.8) =84.6%

However, the overall control efficiency may be limited by the biofilter design to 80%.

5.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- Fairly high control efficiency for both VOC and NH_3
- Improvement of the handling characteristics by reduction of manure volume and weight
- Pathogens and weed seed destruction
- End product enhances soil structure and benefits new growth

b) Cons

- Increase in equipment use and labor
- Possible need for more land

5.6 Cost

The cost of the combination of the ASPs and biofilters is not immediately available but could be calculated, if necessary.

5.7 Feasibility at Dairies

The technology is feasible at dairies. However, the detailed cost effectiveness of this system needs to be performed prior to its application.

5.8 Missing Data

Additional information is needed to assess cost effectiveness

5.9 Further Resources

To be added

5.10 Recommendation

The District should perform a cost-effective analysis for this technology.

6. Land application of solid or semi-solid manure that has been processed by an enclosed negative ASP with exhaust vented to biofilter with a control efficiency greater than or equal to 80%

6.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC & NH_3

6.2 Where Technology Comes From

SJVAPCD Draft Dairy BACT document dated April 27, 2004

6.3 Description of Technology or Practice

Prior to applying solid manure to land, the manure should be pre-treated in an in-vessel negatively aerated static pile with the exhaust vented to a biofilter. By pre-treating the manure in this system, the release of emissions during land application will be ~~decreased~~ significantly reduced.

6.4 Control Efficiency

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%) and the biofilter. (80%), calculated as follows:

(0.33) + (1-0.33)*(0.8) =86.6%

However, the overall control efficiency may be limited by the biofilter design to 80%.

6.5 Considerations Regarding Use of the Technology or Practice

a) Pros

- Fairly high control efficiency for both VOC and NH_3
- Improvement of the handling characteristics by reduction of manure volume and weight
- Pathogens and weed seed destruction
- End product enhances soil structure and benefits new growth

b) Cons

- Increase in equipment use and labor
- Possible need for more land

6.6 Cost

The cost of the combination of the ASPs and biofilters is not immediately available but could be calculated if necessary.

6.7 Feasibility at Dairies

The technology is feasible at dairies. However, the detailed cost effectiveness of this system needs to be performed prior to its application.

6.8 Missing Data

Additional information is needed to assess cost effectiveness

6.9 Further Resources

To be added

6.10 Recommendation

The District should perform a cost-effective analysis for on this technology.

7. Land application of solid or semi-solid manure that has been processed by either an open or in-vessel negatively ASP with exhaust (V) vented to a biofilter with a control efficiency greater than or equal to 80%, with rapid incorporation of the manure into the soil after land application

7.1 Pollutants Targeted and Expected Range of Control Efficiencies

VOC, NH_3, PM, & H_2S

7.2 Where Technology Comes From

SJVAPCD Draft Dairy BACT document dated April 27, 2004

7.3 Description of Technology or Practice

This technology is the same as described in the sections above with the added control of rapid incorporation of the manure into the soil. The combination of these controls would result in the largest amount of emissions reductions from land application of solid manure.

7.4 Control Efficiency

As shown in sections ~~7, 11, and 12~~ X.B.ii.1.4, above, the control efficiency for VOCs from immediate incorporation is 29%-58% and the in-vessel negatively ASP vented to biofilter is ~~50% and~~ > 80%, ~~respectively~~. The overall control efficiency from land application can be calculated as follows:

The overall control efficiency of the combination of both practices is equal to the combined control efficiencies of the in-vessel Aerated Static Pile system (> 80%) and immediate incorporation (50%).

Overall Control efficiency (0.80) + (1-0.80)*(~~0.5~~29% to 58%) = ~~90~~ 85.8 % to 91.6%

7.5 Considerations Regarding Ue of the Technology or Practice

a) Pros

- Fairly high control efficiency for both VOC and NH_3.
- Improvement of the handling characteristics by reduction of manure volume and weight
- Pathogens and weed seed destruction
- End product enhances soil structure and benefits new growth
- Better uptake of nutrients for crops

b) Cons

- Increase in equipment use and labor
- Possible need for more land

7.6 Cost

The cost of the combination of disking in the manure and the ASPs and biofilters is not immediately available but could be calculated if necessary.

7.7 Feasibility at Dairies

The combination of these three practices is feasible at dairies. However, the detailed cost effectiveness of the combination of these systems needs to be performed prior to their application.

7.8 Missing Data

Additional information is needed to assess control and cost effectiveness

7.9 Further Resources

To be added

7.10 Recommendation

The District should perform a cost-effective analysis for the combination of ASPs, biofilters, and immediate incorporation.

C. ~~Technologies Placed on the Sidelines~~Other Technologies

1. On-field Crop(s) Activities to reduce dust Emissions(PM_{10})

The following practices have the potential of reduce fugitive dust emissions from farming activities, however, these practices are required as part of the Conservation management Plan, therefore, no further analysis will be performed.

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

2. Control of Frequency & Concentration of Land Application

This technology needs further thought & development

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