Comments on EPA's Proposed

Mandatory Greenhouse Gas Reporting Rules

On April 10, 2009 USEPA published proposed Mandatory Greenhouse Gas Reporting Rules in the Federal Register. The 60-day comment period for the proposed rule will close June 9, 2009.

The following comments were developed by faculty at the University of Missouri and address proposed monitoring requirements for manure storage facilities (section JJ).

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Executive Summary

We support the elimination of greenhouse gas (GHG) reporting requirements for manure storage facilities (termed manure management systems in the rule) for the following reasons: 1) EPA can independently estimate contributions from this sector of agriculture with existing sources of information; and 2) the information and process called for in the reporting rule do not address the recognized sources of uncertainty in emissions estimates from manure management as stated in the EPA's *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007 Annexes.* For these reasons mandatory reporting of GHG emissions from manure storage facilities provide no better emissions estimates than currently exist.

We also found significant errors and an incomplete understanding of some modeled systems in the Tier 2 approach used to estimate GHG emissions from animal storage facilities and in the equations and supporting tables in the proposed rule. It is possible that GHG emissions are more than double those predicted by the proposed equations for uncovered anaerobic lagoons. We estimate the size of operation affected by monitoring requirements is likely to be ~70% less than estimated in the proposed rule. The proposed rule fails to fully represent the current state of knowledge of GHG emissions from manure storage facilities and the approach proposed by EPA should not be codified in EPA regulations.

If the EPA insists on requiring GHG emissions reporting for manure storage facilities we submit the following comments to the proposed rule.

1. The estimate of no cost for first year capital cost fails to recognize the cost of specialized pens necessary to obtain volatile solids estimates as required by the rule.
2. We recommend substituting the term "manure storage facility" for "manure management system" throughout the proposed rule. The term "manure management system" has a common use definition that is much broader than the definition suggested in the proposed definition. The term "manure storage facility" clearly defines the intended target of structures where manure is stored.
3. We support EPA's proposal to not require CAFOs to directly measure methane and nitrous oxide emissions from manure storage facilities.
4. Estimation of volatile solids excreted per animal per day needs revision. The primary approach should be based on feed intake and conversion efficiency as defined in American Society of Agricultural Engineers Standard D384.2 M*anure Production and Characteristics*, or using tabular values provided in the same publication.
5. The equations and factors used to estimate GHG emissions from manure storage facilities need substantial revision. The current equations and tables contain errors, are unnecessarily confusing and do not accurately estimate GHG emissions from these facilities.
6. The best case approach for reporting and monitoring operations from this sector would be a reporting tool that requests only information on animal numbers and manure storage type. Actual GHG emissions would then be modeled based on the evolving understanding of GHG emissions from these facilities.

More detail and justification to these comments follow.

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I. Should agricultural operations be included in the EPA monitoring program?

EPA should reconsider if any agricultural sources should be included in the GHG monitoring program. Emissions from manure storage facilities are the only agricultural emissions covered by this proposed rule.

We support EPA's decision not to include enteric fermentation in the GHG emission monitoring program. Information on animal inventories is already collected and readily available through the National Agricultural Statistics Service so estimates of this pool of GHG emissions are readily implemented without requiring famer-based reports and estimates. The technology for direct measurement of enteric fermentation from livestock is beyond the technical capacity of most farmers. Estimates of enteric fermentation contributions to GHG emissions are readily completed using available information with no obvious benefit of farmer reporting. A similar argument can be made for excluding manure storage facilities from the GHG monitoring program.

The objective of mandatory emissions reporting is to understand the contributions of the targeted sectors to greenhouse gas emissions in order to obtain more accurate emissions estimates. The *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2007 Annexes* (page A-334) lists the factors that contribute to the uncertainty in emissions estimates for manure management as lack of information on: 1) the usage of various management systems in each regional location; and 2) lack of information on the exact CH_4 generating characteristics of each type of manure management system. We contend that there are no reasonable farm-specific monitoring requirements that would increase the accuracy of EPA's current estimate of GHG emissions from these facilities.

Operations affected by the proposed GHG rule all exceed the CAFO regulatory threshold so the number of animals (average annual inventory) should be known in most states. Permit information also includes the type of manure storage facility(s) on each operation. It is not apparent that GHG monitoring requirements provide any new information on animal number and manure storage facility compared to these other regulatory requirements. For example, in Missouri, all operations with 1000 animal units or more are permitted and the permit information includes a declaration of the maximum inventory and the type of manure storage facility(s). The recently approved revisions to the Federal CAFO rule (FR, 2008) may result in some currently permitted operations choosing to not obtain permits. If EPA continues to consider manure storage facilities an important source of GHG's needing monitoring this change in EPA rules may justify having affected operations report animal numbers and manure storage types.

The proposed EPA strategy for monitoring manure storage facilities is to estimate total volatile solids entering the manure storage facility and then use an equation to estimate methane generation. EPA is correct in concluding that direct measurement of GHG emissions from these facilities is beyond the technical and financial capabilities of most farmers. We support the use of research-based equations to estimate GHG emissions from this sector. The use of such equations means that once animal numbers and manure storage type are known the reporting requirements provide no additional information that improves the accuracy of the GHG emission estimate. As with enteric emissions from ruminants, GHG monitoring from manure storage facilities should be excluded from this rule because the proposed monitoring requirement would provide no information that would significantly increase the accuracy of emission estimates.

Including GHG emission monitoring requirements for manure storage facilities may result in less accurate estimates of emissions from these facilities in the future. We will discuss in detail later in these comments improvements needed in the EPA method used to estimate GHG emissions from manure storage facilities. Our review of the scientific literature indicates there is still substantial uncertainty in the efficiency of these facilities in turning volatile solids into greenhouse gases. A multi-year national study, as a result of a consent agreement with EPA, is currently collecting data on emissions from manure storage facilities. It is premature to lock into regulation a set of equations and associated parameters for estimating GHG emissions from manure storage facilities.

The proposed monitoring of manure storage facilities captures a small percentage of estimated total GHG emissions and a small percentage of estimated agricultural GHG emissions according to the proposed rule.

- Manure management (storage and land application) represents about 10% of all agricultural emissions and is less than 1% of all US GHG emissions measured as CO_2 equivalents.
- The 25,000 metric ton equivalent annual emission rate would capture less than three percent of GHG emissions from manure management (1.5 million CO2e monitored/55.7 million CO2e from manure management X100%= 2.6%) which is a trivial amount of total US GHG emissions.

In summary:

- We support the elimination of GHG reporting requirements for manure storage facilities (termed manure management systems in the rule).
- The regulatory reporting requirements will place burdens on specific operations with little expectation that the accuracy of GHG emissions estimates have been improved.
- The proposed reporting rule does not address any of uncertainty factors and therefore does not provide any additional certainty to the estimates already being generated. This is due, in part, to the extensive technical and financial resources needed to directly measure GHG emissions from these facilities. EPA is correct in concluding that these measurements cannot be the responsibility of individual farmers.
- As with enteric fermentation by ruminants, EPA can independently estimate contributions from this sector of agriculture with existing sources of information.

II. Correct the "definition of the source category".

We recommend that the definition of the source category be changed from "manure management systems for livestock manure" to "manure storage facilities for livestock manure."

Section 98.360 (a) defines the source category as "manure management systems for livestock manure." The subsequent section (98.360 (b)) then clarifies that a "manure management system is a system that stabilizes or stores livestock manure in one or more of the following system components: uncovered anaerobic lagoons, liquid/slurry systems, storage pits, digesters, dry lots, solid manure storage, feedlots and other dry lots, high rise houses for poultry production (poultry without litter), poultry production with litter, deep bedding systems for cattle and swine, and manure composting. This definition of manure management system encompasses the treatment of wastewaters from manure."

The system components described by section 98.360(b) are all manure storage structures. There is no benefit to using the broader terminology "manure management system" but the proposed terminology does invite confusion because the terminology "manure management system" usually includes more than the manure storage structure. The term "manure management system" has a common use definition that is much broader than the definition suggested in the proposed definition. The term "manure management system" typically describes the how manure is collected, stored and distributed to agricultural fields. Common manure management systems in the Midwest include:

- Anaerobic lagoons using a recycled water flush system for collecting manure and traveling gun or center pivot for land-applying the effluent.
- Under-building pit slurry system using a dragline injection or tanker wagon/truck system for land application.
- In-building litter system for broiler chickens using truck-mounted solid spreader for land application.

The terminology "manure management system" implies to the casual reader that emissions from more than the manure storage facility are to be included in the assessment. The proposed rule is very clear that the intended target of monitoring is manure storage. Using the term "manure storage facility" clearly defines the intended target of this GHG reporting requirement.

A related section in the rule preamble digresses into a discussion of "anaerobic" and "primarily aerobic" manure storage facilities. This discussion includes erroneous information about the aeration status of many manure storage facilities. The proposed language incorrectly states that solid storage, dry lot and manure composting is "primarily aerobic". Well aerated and recently turned compost piles are aerobic but anaerobic conditions dominate in most manure piles and liquid manure storages unless some form of mechanical aeration is used.

We also recommend refining the list of example manure storage structures. The current list has some duplication (dry lots are mentioned twice) and a list organized by type of storage would simplify the list.

We propose the following wording for sections 98.360 (a-c):

(a) This source category consists of manure storage/treatment facilities for livestock manure.

(b) **A manure storage/treatment facility is a facility that stores livestock manure in one or more of the following structures:**
- **earthen pits, lagoons, cement and glass-lined tanks and other structures for holding liquid manure;**
- **litter, bedded manure packs, dry lots, high rise poultry and pig houses and other structures where solid manure is collected within or directly below the area animals are confined;**
- **stack houses, manure pads, and other structures where dry manure is stored;**
- **digesters, anaerobic lagoons, composting facilities and any other manure treatment facilities that also serves as a manure storage facility.**

(c) **This source category does not include components of at a livestock operation unrelated to the storage of manure such as manure handling equipment or infrastructure used to distribute manure from animal pens to the manure storage facility and from the manure storage facility to the field, or greenhouse gas emissions associated with land application or other methods of manure utilization that are not a component of the manure storage/treatment facility.**

III. The methodology used to estimate GHG emissions from manure storage facilities is fatally flawed.
The proposed rule relied primarily on methodology developed by the Intergovernmental Panel on Climate Change for estimating GHG emissions from manure storage facilities (IPCC, 2006). Our examination of the methods used to estimate the parameters used in the IPCC model of GHG emissions from manure storage facilities found significant errors in both the way core parameters were estimated and in the estimates reported for the parameters. Of particular concern was the estimation of methane conversion factors (MCFs). The flaws in the methodology and the resulting estimates of GHG emissions based on this methodology affect the proposed EPA GHG monitoring rule in two ways. First, the erroneously estimated coefficients have been integrated into the tabular information to be used by farmers to estimate GHG emissions from this sector of agriculture. Second, the erroneous factors were used for estimating GHG emissions from this sector when developing the current rule.

In the following comments we detail the mistakes in the proposed methodology. We then provide detailed information on the potential for GHG emissions from anaerobic lagoons. Operations with anaerobic lagoons are the most likely to be affected by this rule. This discussion includes estimates of the size of uncovered anaerobic lagoon operation to be affected by the annual 25,000 metric ton carbon dioxide equivalent threshold for GHG emissions.

Errors in estimating methane conversion factors (MCFs)
The proposed rule relied primarily on the publication *2006 IPCC Guidelines for Greenhouse Gas Inventory* (IPCC, 2006) for the method used to calculate GHG emissions from manure storage facilities. The proposed EPA rule used the same approach as the IPCC method to estimate the methane generation from total volatile solids (TVS) entering the manure storage facility. In this approach the estimate of TVS entering the manure storage facility is first multiplied by a factor (Bo) that estimates the maximum methane that can be generated from the TVS. That quantity is then multiplied by a second factor (MCF) that estimates the proportion of the maximum methane that can be generated under the specific conditions of the manure storage.

The technical support document for section JJ of the proposed rule (Technical Support Document for Manure Management Systems: Proposed Rule for Mandatory Reporting of Greenhouse Gases (EPA, 2009)) referenced the IPCC 2006 document for both the equation and the estimates of the parameters Bo and MCF reported in Table JJ-1 and JJ-2, respectively, of the proposed rule. Estimates of MCF used in the rule came directly from table 10.17 in volume 4 of IPCC (2006). The cited reference for MCF in the 2006 IPCC publication is "judgment of IPCC Expert Group in combination with Mangino et al., 2001."

Unfortunately the methods used to estimate MCF in Mangino et al., 2001 are fundamentally flawed in two ways: First, the methodology presented does not estimate what it claims to estimate; and second, the methodology used provided an obviously erroneous estimate of MCF.

The problem arises in how Mangino et al., 2001 estimated MCF. Their approach was to:

- **a.** Estimate the TVS *excreted* by the animals;
- **b.** Estimate the amount of the TVS *consumed* by digestion in the manure storage;
- **c.** Estimate MCF as the ratio of TVS *consumed* and TVS *entering* the storage.

This estimate of MCF is fatally flawed because it estimates the conversion of TVS into methane as a percentage of TVS in excreted manure, not as a percentage of the maximum degradable TVS in the storage. Remember that Bo is used to estimate the maximum amount of methane that can be derived from TVS entering the storage. MCF should be determining the proportion of this TVS that is actually degraded in the manure storage. Instead the method used in Mangino et al. (2001) and referenced by IPCC (2006) estimates MCF by erroneously using TVS entering the storage as a starting point instead of the maximum degradable TVS entering the storage system. If the current proposed MCF value were used as it was developed in this paper, there is no role for Bo in the equation. The current estimate of MCF is providing an estimate of the ability of the specific manure storage type to degrade TVS.

As it turns out this estimate is also clearly an erroneous estimate of what it actually measured (as opposed to what Mangino et al (2001) claimed it measured). The example determination of MCF in Mangino et al. (2001) is for a breeding swine anaerobic lagoon in Iowa. In the example calculation, they claimed that 70% of the TVS entering the lagoon were degraded. Note that Bo for swine lagoons is listed as 0.48 m^3 methane generation per kg TVS added to the lagoon which is consistent with ~50% of the TVS being converted into methane (assumes that 65% of the biogas generated is methane; Bo = 0.49 kg TVS consumed/kg TVS added X 0.65 kg methane/kg TVS consumed X 1/0.662 m^3 methane/kg methane = 0.48 m^3/kg TVS entering the manure storage). By definition, Bo represents the *maximum* break down of TVS here estimated to be ~50%. Instead, the methodology of Mangino et al. (2001) estimates that the breakdown of TVS entering the manure storage approaches 70%, an impossible result for that value of Bo.

We note that Mangino et al. (2001) is not a peer-reviewed paper but is instead published as a proceeding for an EPA sponsored conference. To be blunt, the paper is riddled with careless errors and clear errors in logic and does not represent a scientifically relevant assessment of methane release from liquid manure storages.

We conclude that the methodology proposed by Mangino et al. (2001) and adopted by IPCC (2006) and by extension, the proposed GHG monitoring rule is flawed. It fails to provide an estimate of MCF consistent with the definition of MCF. In addition, the estimate it provides of TVS breakdown is in conflict with the tabular values provided in other parts of the rule implying either those values are incorrect and/or the approach used to estimate TVS breakdown in Mangino et al., (2001) is incorrect. Table JJ-3 in the proposed rule provides extensive estimates of MCF for a wide range of average annual temperatures and manure storage types. Mangino et al. (2001) is cited as the source of the methodology for anaerobic lagoons and liquid slurry manure storages with residence times of greater than one month. These values, referenced as based on the methodology of Mangino et al., (2001) must be assumed to be erroneous.

What are the likely emissions of methane from anaerobic lagoons?
The IPPC (2006) methodology for estimating methane generation relies heavily on concepts derived from the methane digester scientific literature. The concept of Bo (maximum methane generation potential) and the estimates of Bo in the proposed rule all come from research papers focused on biological activity in methane digesters (e.g. Hashimoto et al., 1981). There is no reference to the extensive literature on the design of anaerobic storage lagoons and an apparent failure to understand some of the concepts used to design anaerobic lagoons.

An influential paper outlining the key objectives of lagoon facilities was published by Barth (1985). That paper defined success in lagoon design if the lagoon adequately addressed odors and sludge buildup. The seminal work on lagoons was not focused on the degree of TVS consumption as a design standard. However, this paper does highlight the importance of temperature in determining the rate of VS degradation and outlined a "rationale" design standard that adjusted the lagoon treatment volume for VS based on the accumulation of temperature units. Consequently, anaerobic lagoons are typically sized in part based on having sufficient volume to treat volatile solids entering the lagoon.

A number of technical standards have been established (e.g. NRCS, 1992; ASAE, 1999; MWPS, 1985) that provide guidance on the treatment volume requirements for degrading volatile solids entering the lagoon. These estimates are adjusted by average annual temperature with larger treatment volumes required for more northerly located lagoons. In theory, the larger treatment volume in cooler locations compensates for the reduced rate of degradation at cooler temperatures. The assumption behind the design standards of anaerobic lagoons is that they have similar capacity to degrade volatile solids throughout the country recognizing that treatment volume in a lagoon located in Minnesota is over double the volume of the treatment volume of a lagoon for a similar number of animals in Texas. This is also reflected in predicted sludge accumulation rates which are predicted to be the same nationally (Barth, 1985; NRCS, 1992; ASAE 1999).

It is not apparent that the ability of an anaerobic lagoon to degrade volatile solids will be similar to an anaerobic digester. Similarly, it is not apparent that un-covered lagoons will generate the same ratio of methane to carbon dioxide as covered lagoons and methane digesters. Lagoons contain a complex biological community including aerobic bacteria, aerobic phototrophs, nitrate reducing bacteria, anaerobic phototrophs, acid forming bacteria, sulfate reducing bacteria and methanogenic bacteria

(Hamilton et al., 2006). Some of these microorganisms will not be found in anaerobic digesters because the cover eliminates sunlight penetrating the surface of the lagoon and contact of the surface of the lagoon with ambient air. In addition, lagoons are subject to annual temperature swings which in northerly climates can include times when temperatures will inhibit methane producing bacteria and at times all bacteria in the lagoon (Barth, 1985). The residence time of sludge in a lagoon can be many years whereas in many anaerobic digester systems the residence time is in terms of days.

The broader microbial community may affect the maximum degradation potential of the lagoon and the proportion of methane to other gases in biogas released from the lagoon. Longer residence times may also lead to higher degradation rates. In contrast, cooler temperatures typical of ambient temperature lagoons may reduce the potential breakdown capability of the lagoon. Land application of manure in spring when the lagoon has a surplus of volatile solids may reduce methane generation by removing material before it has a chance to be degraded in the lagoon.

Estimation of VS breakdown efficiency is difficult for uncovered lagoons. Most of the data based on work in uncovered lagoons suggests a properly operating lagoon can breakdown solids to a higher degree than is predicted by the anaerobic digester model. Most of the historic lagoon literature on VS breakdown efficiency has focused on sludge accumulation (e.g. Barth (1985); Fulhage(1980); Smith (1980)). Table 1 summarizes estimated TVS degradation for anaerobic lagoons for a range of studies. These universally estimate that the breakdown of volatile solids in an uncovered anaerobic lagoon exceeds that of anaerobic digesters. It is also important to note that there are numerous reports that the sludge accumulation rates in anaerobic lagoons are significantly less than predicted by the NRCS (1982) and ASAE (1999) standards (e.g. Hamilton, 2004; Tyson et al., 2002; Hamilton, 2002; Bicudo et al., 1999; see also Chastain, 2006). These studies are consistent with higher VS degradation rates in anaerobic lagoons. Data collected on sludge accumulation in operational lagoons may overestimate VS degradation to some degree because they typically do not account for VS removed by land application of effluent from the liquid layer of the lagoon.

Table 1. Estimates of TVS degradation in anaerobic lagoons.

	Swine	Dairy Cows	Layer
	TVS degradation as a % of TVS entering structure		
Based on Bo for anaerobic digesters[1]	49	24	40
Based on sludge accumulation rate design standards for anaerobic lagoons[2]	75	45	100
Fulhage (1980)[3]	0.88	-	-
Barth and Kroes (1985)[4]	81	55	79
Using data of Bicudo et al. (1999)[5]	71	-	-

[1] Based on Bo values reported in Table JJ-1 in the proposed rule. These are 0.48, 0.24 and 0.39, respectively, for swine, dairy cows and layers. Assumes that 65% of the biogas produced is methane.

[2] From sludge accumulation standards including NRCS (1992) and ASAE (1999). Standards are 0.00303, 0.00455 and 0.00184 m^3/kg TS added accumulation for swine, dairy cows and layers, respectively. Assumes that TS of sludge is 13.5%, and the ratio of total volatile solids to total solids in manure entering the storage is 0.80, 0.84 and 0.72 for swine, dairy cows and layers, respectively (ASAE, 2005).

[3] Estimated based on the change in ratio of VS to fixed solids (FS) for manure entering the lagoon and lagoon sludge.

[4] Estimated by measuring VS entering and recovered from lagoons.

[5] Calculated using the approach of Fulhage (1980). Assumes VS/TS ratio of manure entering the facility is 0.80 (ASAE, 2005).

Based on this analysis, the EPA proposed rule significantly underestimates the degradation of TVS in anaerobic lagoons.

- Our literature review indicates that TVS degradation can approach 80% in swine lagoons. If we assume 65% of the biogas produced by the lagoon is methane, we estimate swine operations with more than approximately 20,000 finishing pigs would need to report under the 25,000 metric ton CO_2 equivalent threshold. This compares to 73,000 for swine farrow-to-finish in the proposed rule.
    - Calculation details:
        - 56 kg TS excreted per finished animal (ASAE, 2005).
        - 2.5 animals raised per year per pig space (turns per year).
        - 0.80 ratio of TVS to TS in excreted manure (ASAE, 2005).
        - 0.8 ratio of mass biogas produced to TVS entering manure storage.
        - 0.65 ratio of mass methane released to biogas produced.
        - 21 global warming potential (GWP) of methane.
    - CO_2 equivalent released per animal space per year
      = 56 kg TS excreted X 2.5 turns per year X 0.80 TVS:TS ratio X 0.8 TVS degradation
      X 0.65 methane:biogas ratio X 21 GWP X 1 metric ton/1000 kg
      = 1.22 metric tons CO_2 equivalents per animal space per year
    - Threshold
      = 25,000 metric tons CO_2 equivalents per year / 1.22 metric tons CO_2 equivalents per animal space per year
      = 20,440 animal spaces

- Our literature review indicates for dairy cows that TVS degradation is likely to exceed 40% in uncovered dairy lagoons. If we assume 65% of the biogas produced by the lagoon is methane, we estimate dairies with more than 1,500 cows would need to report under the 25,000 metric ton CO_2 equivalent threshold. In the proposed rule USEPA estimated 5,000 dairy cows.
    - Calculation details:
        - 8.9 kg TS excreted per dairy cow per day (ASAE, 2005).
        - 0.84 ratio of TVS to TS in excreted manure (ASAE, 2005).
        - 0.45 ratio of mass biogas produced to TVS entering manure storage.
        - 0.65 ratio of mass methane released to biogas produced.
        - 21 GWP of methane.
    - CO_2 equivalent released per animal space per year
      = 8.9 kg TS excreted per day X 365 days X 0.84 TVS:TS ratio X 0.45 TVS degradation
      X 0.65 methane:biogas ratio X 21 GWP X 1 metric ton/1000 kg
      = 16.8 metric tons CO_2 equivalents per animal space per year
    - Threshold
      = 25,000 metric tons CO_2 equivalents per year / 16.8 metric tons CO_2 equivalents per animal space per year
      = 1,492 animal spaces

These two estimates represent a 70% reduction in the reporting threshold compared to the USEPA estimate in the proposed rule. The primary reason for the difference between our estimate and the estimate in the proposed rule is the methodology in the proposed rule likely underestimates the ability of uncovered anaerobic lagoons to degrade volatile solids.

IV. How should GHG emissions from manure storage facilities be calculated?

We support the use of a simple model to calculate GHG emissions from manure storage facilities. However the proposed calculation methods must be revised. This section will detail the following suggested changes:

1. Revise how total volatile solids (TVS) are estimated.
2. Revise how estimated TVS are converted to an estimate of carbon loss potential from the manure storage.
3. Other comments on the equations and tables in section JJ of the proposed rule.

1. Revise how total volatile solids (TVS) are estimated.

Section 98.360 (a) details the proposed calculation of total volatile solids (TVS) excreted by animals and being collected in a manure storage. The proposed approach requires estimating or measuring the volume of manure excreted by the animals and then measuring the percent TVS in manure entering the manure storage. Multiplying the measured fraction of the manure as TVS by the quantity of manure entering the manure storage provides an estimate of the TVS entering the manure storage. Unfortunately this apparently straight forward calculation provides significant challenges for implementation on animal feeding operations.

Most animal feeding operations do not have a way to measure excreted manure volume (urine plus feces) and percent TVS of excreted manure on their farm. Typically when animals defecate, the manure is either deposited in bedding under the animal or carried by gravity or flushing to a manure storage facility. Historically, manure sampling and testing has focused on obtaining a representative sample of manure mixed with bedding and wastewater from the manure storage facility. This type of manure testing would not be appropriate for the proposed method because it provides an estimate of TVS leaving the storage, not entering the storage.

The proposed calculation of TVS requires an estimate of the volume of manure excreted by the animal and the percent TVS in the freshly excreted manure entering the manure storage facility. These measurements would require specialized procedures and facilities to collect freshly excreted manure. For many operations this would mean isolating representative animals in a specially designed pen that would isolate excreted urine and feces for measuring volume. This material would then need to be mixed well, subsampled and analyzed for percent TVS. The proposed rule requires collection of such samples monthly.

The rule does propose that book values could be used for manure volume. However manure volume is quite variable from operation to operation and even animal to animal based on water consumption of the animal and other factors that have no impact on the TVS excreted by the animal. For example, Brumm et al. (2000) showed that wet-dry feeders reduced manure volume by ~30% compared to pigs fed dry feed and watered through nipple waterers. Plus, the rule does not allow the use of book values for estimating percent TVS in excreted manure. Consequently the operation will still be required to create a specialized system that allows for the collection of freshly excreted urine and feces.

There is a superior way to estimate TVS excreted by the animal that does not require collection of freshly excreted manure. The quantity of dry matter excreted by an animal is easily predicted by the quantity of feed consumed by an animal. There already are published equations for estimating dry matter excretion for chickens, pigs, cows and horses in the American Society of Agricultural Engineers (ASAE) standard D384.2, *Manure Production and Characteristics* (ASAE, 2005). Feed-based approaches to estimating dry matter excretion typically are based on dry matter intake of the animal and the dry matter digestibility of the ration. This same reference (ASAE, 2005) also provides book values for the quantity of dry matter excreted by a wide range of animal types. The estimate of dry matter excreted by a confined animal is likely to be less variable then the estimate of manure volume. If book values are to be used, the rule should suggest or allow book value estimates of dry matter excretion.

To convert dry matter excreted by the animal to TVS excreted by the animal requires an estimate of the fraction of dry matter as TVS. Again, this ratio has been estimated in the scientific literature for different animal species and diets for decades and can be derived from published technical standards including ASAE (2005).

We recommend the following text:
Total volatile solids (total volatile solids excreted per animal per day (kg/day); TVS) should be estimated by either 1) direct measurement of excreted manure (urine plus feces); 2) verifiable feed intake and conversion efficiency as defined in American Society of Agricultural Engineers Standard D384.2 M*anure Production and Characteristics*; or 3) using tabular values based on the same publication.

2. Revise how estimated TVS are converted to an estimate of carbon loss potential from the manure storage.

In section III of these comments we detailed:

- How the proposed rule estimates of the Methane Conversion Factor were flawed;
- How it was likely that Bo factors derived for methane digesters likely underestimated TVS breakdown potential in uncovered lagoons;
- How the proposed EPA approach likely significantly underestimates the quantity of methane released from uncovered lagoons.

The proposed calculation of methane release from manure storage facilities relies heavily on approaches developed for anaerobic digesters. This has led USEPA to propose a calculation approach that includes inaccurate assessment of methane release from some manure storage facilities and to propose an equation that is difficult to interpret and to implement.

We propose that an alternative equation be used to estimate methane generated by manure storage facilities. This alternative equation provides a clearer description of the key assumptions in such a calculation and will promote research that will improve the quality of the parameters in the equation and the estimates of methane loss from these facilities.

Our suggested equation is:

CH_4 emissions (metric tons/yr)

= TVS entering the storage (kg/year/animal space)

X Fraction of TVS destroyed in the storage

X Fraction of the resulting biogas released as methane

X 1 metric ton/1000 kg

X average annual occupied animal spaces

X Fraction of excreted manure entering storage

To implement this equation, book values for the "fraction of TVS destroyed in the storage" would need to be developed for a wide range of manure storage facilities based on an expanded literature review similar to what we completed for lagoons for Table III-1. Farm-specific values of this fraction could be developed based on comparing the TVS to fixed solids ratio of manure entering the storage and lagoon sludge in lagoons or the agitated manure from a slurry storage facility (see Fulhage (1980) for an example of this calculation for lagoons). These measurements can be difficult and have a lot of error if done poorly so such measurements should not be required of any operations reporting under the rule. They are also not appropriate for storages that have bedding, soil, or other foreign material entering the facility or for operations with solid separators.

3. Other comments on the requirements, equations and tables in section JJ of the proposed rule.

- Table JJ-2 in the proposed rule has many problems.
    - The temperatures listed in the table are "average annual temperature" for a location. The table in the proposed rule and in the supporting documentation does not make this apparent. However it is very clear in the listed reference for this table that the values in the table are based on average *annual* temperature.
    - We discussed in detail in section III of our comments how the estimates of MCF in Table JJ-2 are incorrect for lagoons. Please refer to that section for why these values are incorrect and developed using a flawed analysis. Please also note that the use of temperature in the development of MCF's for anaerobic lagoons is also erroneous. As we discussed in our comments in section III, properly sized lagoons have a treatment volume that varies with average annual temperature. According to the design standard used for these lagoons, the annual capacity of these lagoons to degrade volatile solids should be similar in different parts of the country although the size of the lagoon will be larger in northerly climates to insure similar treatment capacity.
    - We did not spend time researching the MCF values for slurry storages. We anticipate there are problems in these values as the referenced method for these MCF values is the same as the approach we demonstrated as flawed for anaerobic lagoons. By definition, slurry tanks have no defined treatment volume for volatile solids. Given this fact it seems highly unlikely that some of the treatment percentages quoted in Table JJ-

2 for slurry tanks can be attained. The development of this component of the rule must be thoroughly reviewed, corrected, and better referenced.

- The understanding of gaseous losses from anaerobic lagoons is still evolving quickly. Only five years ago it was suggested that the majority of the nitrogen loss from such a lagoon was in the form of N_2 gas when previously it had been assumed that nitrogen losses were nearly exclusively as ammonia (Harper et al., 2004). There is currently an on-going national study, associated with a consent agreement with EPA, to measure gaseous emissions from animal barns and manure storages. It is likely that emerging science and a better summary of existing science will lead to different equations for predicting GHG emissions from manure storage facilities and to different parameter estimates. It is premature to lock in the proposed equations and parameter estimates in the proposed rule for estimating GHG emissions from manure storage structures.
- The use of the constant 365.25 days instead of 365 days for a year in most equations in section JJ demonstrates a lack of appreciation of the degree of precision of these calculations. Yes this is a small point, but it implies a lack of appreciation for the precision of the equation.

V. Other topics

1. Economic Impact of the Proposed Rule

Table VIII-1 reports that the first year capital costs are $0 for the 43 entities expected to report manure management emissions. In our comments above on calculating total volatile solids we show that such measurements will require a specially designed pen for collecting feces and urine. We do not have a cost estimate for this pen or the increased labor costs associated with managing this specialized facility (because none are known to exist in commercial production); we do know that the estimate cost will not be $0.

2. Suggested modification to the "content of the annual report"

The current wording (98.3 (c)(4)) suggests that the annual report should include "Annual emissions of CO_2, CH_4, N_2O and each fluorinated GHG." For some GHG sources CO_2 emissions are not required to be reported. For example, in manure management systems CO_2 emissions are not considered to be derived from anthropogenic sources so do not require reporting under the rule. Consider rewording this requirement as "Annual emissions *from anthropogenic sources* of CO_2, CH_4, N_2O and each fluorinated GHG."

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