Confined Space Manure Storage and Facilities Safety Assessment

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ABSTRACT. *A mail survey of 1,200 farms across 16 states was conducted to identify the number, type, and size of manure storages per farm, as well as safety-related behaviors or actions related to entry into confined-space manure storage and handling facilities. Respondents provided data on 297 storage units and facilities, with approximately 75% reporting up to three storages per farm operation. Dimensions were provided for 254 manure pits: nearly 66% were less than or equal to 100 feet long, 75% were less than or equal to 40 feet wide, and 75% were less than or equal to 10 feet deep. Almost 14% of the reported storages were over 300 feet long, seven were wider than 100 feet, and 17 were more than 20 feet deep. Survey results suggest that most farm operations with confined-space manure storages do not follow best safety practices regarding their manure storages, including using gas detection equipment before entering a manure pit, using rescue lines when entering storages, or developing a written confined-space safety policy or plan. Survey results also suggest that few farmers post warning signs around their storages, post recommended ventilation times before entry, or conduct training for workers who enter confined-space manure storages. This article provides a benchmark against which the effectiveness of educational programs and design tools for confined-space manure pit ventilation systems and other confined-space manure pit safety interventions can be measured.*

Keywords. *Agricultural confined spaces, Manure safety, Manure safety practices, Manure storage.*

There is very little published information regarding the numbers, types, and characteristics of confined-space manure storages and facilities on farms across the U.S. The National Institute of Occupational Safety and Health (NIOSH) estimates that in 2006 there were nearly 57,000 manure pits in operation on farms in the U.S. (Layne et al., 2008). The number of on-farm manure storage pits is expected to increase significantly in coming years because of increasing regulatory pressure on animal agriculture operations to dispose of manure in ways that help reduce nonpoint-source pollution. For two examples of this pressure, see "Pollution from Giant Livestock Farms Threatens Public Health" (NRDC, 2005) and "Environmental Impacts of Factory Farm Manure" (HSUS, 2013). Collecting and storing manure for later disposal is considered a manure best management practice (MCA, 2010).

The safety and health issues related to manure storage are well documented (Beaver

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and Field, 2007; Riedel and Field, 2013; Donham et al., 1982; CDC, 1994, 1993, 1989; Millar, 1990). Documented consequences range from a variety of respiratory ailments to death. Fatalities most frequently occur when a victim without necessary life support equipment enters an unventilated manure pit to affect maintenance or repairs and is overcome by toxic gases or a lack of oxygen. Tragically, these incidents often develop into multiple fatalities when other poorly trained and equipped farm personnel attempt a rescue and become victims as well.

Layne et al. (2008) reported that nearly 40% of farmers admitted entering their pit at least once during the previous 12 months, with 20% admitting entering the pit six or more times in those 12 months. This supports the finding of an earlier study in Pennsylvania, where 36% of the participants admitted entering a pit without respiratory protection (Thompson and Bowers, 1991). Beaver and Field (2007) documented that the rate of manure storage fatalities per year more than doubled from 1.6 during 1975-1984 to 3.5 during 1995-2004. Riedel and Field (2013) recently reported on 132 manure storage injury incidents from across the U.S. Of the 132 cases, 110 (83%) were fatal, and 20% involved children under the age of 16, with nearly all of them fatal (96%). The most frequent (34%) activity was conducting repairs or maintenance activities, with the second most frequent activity (22%) a rescue attempt of another person entrapped or overcome in a manure storage structure or facility. Thirteen cases (10%) involved multiple victims, including two incidents with five fatalities each.

A more recent survey estimates that manure is stored in nearly 127,000 storages on almost 98,000 farms in the U.S. (NASS, 2013). Of the storages on these farms, an estimated 63,685 are manure ponds (the term used by NASS), 46,571 are open pits, and 16,582 are enclosed manure pits. NIOSH has analyzed these data, and of those with enclosed manure pits, an estimated 18,618 farmers have entered the enclosed pit, with approximately 52% estimated to have entered 1 to 5 times and approximately 30% estimated to have entered 25 or more times. Of the 18,618 farmers who reported entering enclosed manure pits, only an estimated 790, or 4.2%, tested the air prior to entering. Of the 16,582 estimated enclosed manure pits, only 1,414, or 8.5%, were equipped with rescue lines. An estimated 3,521, or 21.2%, had permanent pit ventilation, and 1,960, or 11.8%, had portable pit ventilation. Of the estimated 97,828 farms with stored manure, only an estimated 26,154, or 26.7%, had a written confined-space policy (NIOSH, 2013).

Researchers at Pennsylvania State University recently developed ventilation strategies to reduce the risk associated with entry into confined-space manure storages. They used computational fluid dynamics protocols to simulate removal of noxious contaminant gases, by forced ventilation, from solid and slotted floor covered, confined-space, on-farm manure storage tanks. These simulation protocols were then used to determine the ventilation requirements (air exchange rates, fan and air outlet locations, and operation times) to reduce concentrations of contaminant gases to levels below gas-specific threshold limit values (TLVs) for human entry. These ventilation requirements are applicable for a wide range of manure storage facilities typical of those on farms throughout the U.S. All research findings were published in either the *Transactions of the ASABE* (Zhou et al., 2007a, 2007b, 2008b) or the *Journal of Agricultural Safety and Health* (Pesce et al., 2008; Zhou et al., 2008a).

Subsequently, an international engineering safety standard, "Ventilating Manure Storages to Reduce Entry Risk" (ASABE/ANSI, 2010), was written and approved by the American Society of Agricultural and Biological Engineers (ASABE) and the American

National Standards Institute (ANSI). An educational program was developed to inform extension educators, engineers, regulators, and farmers about the standard and how to use its provisions to reduce risk when entering confined-space manure storage tanks. The educational program included:

- A large-scale, trailer-mounted demonstration model that can be used to identify the occupational hazards associated with entry into confined-space manure tanks and facilities and explain how to mitigate the hazards with proper ventilation.
- High-quality videos of educational programs, using the demonstration model, to show how to properly ventilate solid and slotted covered confined-space manure storages.
- Comprehensive instructional manuals for "education extenders" to use the ventilation demonstration unit in the field.
- Four fact sheets covering confined-space manure storage hazards, monitoring manure gases, ventilating storages prior to entry, and emergency rescue procedures for confined-space manure storages.
- A website (www.manurepitsafety.psu.edu) that includes a link to the safety standard, educational videos, and fact sheets.

Due to the dearth of published information on numbers, types, and characteristics of confined-space manure storages and facilities across the U.S., and a limited amount of information related to safety practices in and around these confined spaces, a national survey was conducted as a means of establishing baseline data on confined-space manure storages, facilities, and safety practices. A limited amount of funds were available to develop and administer the survey, and there were no readily available databases of names, addresses, or phone numbers of farmers with confined-space manure storages. Consequently, decisions were made by the researchers to focus on dairy and swine operations in states thought to have the highest numbers of confined-space manure storages on farms. More details about survey development and sampling are provided in the sections below.

Survey Methods

An eight-page paper survey was created to collect data on the number, size, and characteristics of confined-space manure storage and handling facilities, number and types of animals, safety practices, and demographic information relating to the farm operation. Space was provided for respondents to list up to five manure storage units. If the farm had more than five storage units, no criteria were provided for selecting which to report. Safety practice questions were based on best safety practices around confined-space manure storages. Several of the safety practice questions matched questions asked of farm and ranch operators during the 2011 survey by the USDA National Agricultural Statistics Service (NASS) on behalf of the National Institute of Occupational Safety and Health (NIOSH). The data collected by NASS are yet to be published in detail. A copy of the NASS survey can be obtained by contacting the first author.

The initial survey was mailed to a stratified random sample of 1,200 swine and dairy farms across 18 states. The 18 states were identified as those most likely to have the largest numbers of confined-space manure storages based on communications with engineers from the USDA Natural Resource and Conservation Service (NRCS), consulting the 2007 Agriculture Census, and literature searches by the authors. The Survey Research Center of Pennsylvania State University's Social Science Research Institute purchased a proportional survey sample, based on the number of dairy and swine farms located in each state,

from Survey Sampling International (SSI). The sample was requested based on the SIC (Standard Industrial Classification) codes that represented dairy or swine farms. In comparing this list with the agricultural census information, we found that the number of operations provided in the list approximated the distribution in the agricultural census. As the total list of addresses available from SSI exceeded the target mailing sample of 1,200, SSI was asked to deliver randomly selected addresses from the target states proportional to the number of addresses available for each state. Extra addresses were requested assuming 10% replacement of undeliverable addresses. The Survey Research Center then randomly selected 1,200 addresses to be mailed out, again proportional to state allotment, and then set aside an additional 120 addresses in case of the need for sample replacement.

A three-contact mailing sequence was implemented in this study, consisting of a mailing of the survey, a reminder postcard, and another mailing of the survey (Dillman et al., 2008). The initial survey mailing was in early January 2012 and consisted of a cover letter, the survey, and a business reply envelope. An additional 13 farms (5 swine and 8 dairy) were mailed a survey packet in February to replace farms for which surveys were returned as undeliverable. A reminder postcard was sent to all farmers in late January (early February for the replacement group). To increase the response rate, an additional mailing of the survey was mailed to all non-respondents in mid-February (late February for the replacement group). This mailing was sent to 894 non-respondents (and 9 replacement non-respondents) and consisted of a cover letter, another copy of the survey, and another business reply envelope.

The 1,200 farms included in the study consisted of 244 swine farms and 956 dairy farms. An additional 13 farms were included to replace farms for which a survey was returned as undeliverable. Table 1 is a breakdown of the number and type of farms that were included from each state.

Table 1. States and number of farms surveyed by type of farm.[a]

State	No. of Swine Farms	No. of Dairy Farms	Total *N*
Iowa	62 (5)	40	107
Illinois	27	28	55
Indiana	24	23 (1)	48
Kentucky	3	23	26
Maryland	1	15	16
Michigan	9	59	68
Minnesota	34	116 (1)	151
Missouri	9	13	22
North Carolina	15	11 (1)	27
North Dakota	1	3	4
Nebraska	15	9	24
New York	1	124 (3)	128
Ohio	19	62 (1)	82
Oregon	1	10	11
Pennsylvania	7	106 (1)	114
South Dakota	6	9	15
Virginia	1	20	21
Wisconsin	9	285	294
Total	249	964	1213

[a] Numbers in parentheses indicate number of replacement farms added due to undeliverable surveys.

Survey Response

Sixteen surveys were returned as undeliverable and were not replaced, as they were returned as undeliverable long after the initial survey mailing. This reduced the number of potential participants to 1197. A total of 532 farmers returned a survey, for an overall response rate of 44.4%. Of those surveys returned, 31 respondents contained notes indicating that they no longer had livestock, were retired, or were no longer farming and provided no other information. Of the remaining 501 returned surveys, 111 respondents indicated that they had at least one enclosed confined-space manure storage pit or facility (e.g., reception pit, pump-out pit, transfer pipe) on their property (question 1). The other 421 farmers answered "No" to question 1 and thus did not need to continue with the survey.

Survey Results

Farm Operations Characteristics

The majority of farms (n = 108 of 111) reporting at least one confined-space manure storage were full-time operations run by independent operators. Nearly 60% were dairy operations, while the remaining were swine operations. Nearly 40% of the respondents had operations of 500 acres or less, 32% had operations of 501 to 999 acres, and 27% had operations of 1000 acres or more. Additional details on these characteristics are provided in table 2. Table 3 shows that the majority of dairy operations had 300 or fewer cows and heifers. Table 4 shows that approximately 25% of swine operations had 1000 or fewer hogs and approximately 20% to 25% had between 1001 and 5000 animals.

Table 2. Characteristics of the 111 farms with identified manure storages.

Category		No.	%
Type of operation	Full-time	93	83.8
	Part-time	13	11.7
	No response	5	4.5
Type of operator	Independent operator	95	85.6
	Contract operator	13	11.7
	No response	3	2.7
Acreage	<100	7	6.3
	101-300	13	11.7
	300-500	23	20.7
	501-700	17	15.3
	701-999	18	16.2
	1000+	30	27.0
	Not sure	3	2.7
Type of animal	Dairy	66	59.4
	Swine	45	40.6

Table 3. Dairy operation size by type of animal.

	No. of Animals						
Animal Type	0	1-100	101-300	301-500	501-1000	>1000	Total
Heifers	3	25	20	6	10	2	66
Milk cows	5	15	24	9	7	6	66
Veal calves	60	5	1	0	0	0	66

Table 4. Swine operation size by type of animal.

	No. of Animals					
Animal Type	0	1-500	501-1000	1001-5000	>5000	Total
Farrow/nursery	24	9	3	8	1	45
Grow/finish	16	3	9	14	3	45
Sows	29	9	2	4	1	45

Manure Storage Characteristics

Of the 111 respondents, 109 indicated that they had manure storage facilities on their farm. However, only 105 of those 109 respondents indicated in subsequent survey items that manure storages existed on the farm (table 5). These 105 respondents reported a total of 297 storage structures and facilities, with approximately 75% (80 of 105) reporting up to three storages per farm operation (table 5). Of the 297 manure storages reported, 66 (22.2%) had solid covers, 191 (64.3%) had slotted covers, and 40 (13.5%) had no cover (table 6). Many farms reported multiple types of storage structures or facilities (table 7). Of the 105 farms reporting manure storages, many also reported other confined-space manure storage facilities, such as pump-out pits, reception pits, collection pits, and transfer pipes. Of the 297 reported manure storage pits, pit dimensions were provided for only 254. Of these 254 storage structures, 161 (63.4%) were less than or equal to 100 feet long, 198 (77.9%) were less than or equal to 40 feet wide, and 190 (74.8%) were less than or equal to 10 feet deep. Almost 14% of the reported storages were over 300 feet long, seven were wider than 100 feet, and 17 were more than 20 feet deep (table 8).

Table 5. Number of farms with enclosed storages.

No. of Storages per Farm	No. of Farms	Total No. of Storages
1 to 3	80	132
4 to 6	19	93
7 to 9	3	22
10 to 12	1	10
12+	2	40
No storages reported	4	0
Total	109[a]	297

[a] Although 111 respondents indicated having at least one confined-space manure storage facility, only 109 reported the number of storages by size, and only 105 ultimately acknowledged having a manure storage pit in subsequent survey responses.

Table 6. Number of storage pits by cover type.

Cover Type	No.	%
Solid cover	66	22.2
Slotted cover	191	64.3
No cover	40	13.5
Total	297	100.0

Table 7. Types of manure storage structures and facilities.

Structure or Facility Type	No. of Farms	No. of Structures or Facilities
Pump-out pits	50	N/A
Reception pits	38	N/A
Collection pits	23	N/A
Transfer pipes	35	N/A
Storage pits	105	297
Other[a]	89	N/A

[a] Other includes cross gutters, lagoons, open solid manure slabs, gravity-flow gutters, piston pump, slurry stores, and septic tanks.

Table 8. Manure storage pits by size.

Length Range (ft)	No.	%	Width Range (ft)	No.	%	Depth Range (ft)	No.	%
0 to 10	17	6.7	0 to 10	80	31.5	0 to 5	46	18.1
11 to 50	79	31.1	11 to 20	38	15.0	6 to 10	144	56.7
51 to 100	65	25.6	21 to 40	80	31.5	11 to 15	23	9.1
101 to 150	32	12.6	41 to 60	29	11.4	16 to 20	24	9.4
151 to 200	26	10.2	61 to 80	14	5.5	>20	17	6.7
201 to 300	13	5.1	81 to 100	6	2.4			
>300	22	8.7	>100	7	2.8			
Total	254[a]	100	Total	254[a]	100	Total	254[a]	100

[a] Dimensions provided for only 254 of the 297 reported confined-space manure storages identified earlier by respondents.

Table 9. Number and status of responders who entered a confined-space manure facility on their farm at least once within last 12 months.

Worker Position	No. of Workers	% of Workers
Owner/operator	26	49.1
Unpaid adult family member	6	11.3
Hired adult worker	16	30.2
Unpaid youth family member	4	7.5
Hired youth worker	1	1.9
Total	53	100

Characteristics of Manure Storage Entrants

Respondents reported that 53 workers had entered a confined-space manure facility on their farm at least once within the past twelve months (table 9). Nearly half (26) of the entrants were owner/operators, and an additional six were adult family members. Nearly one-third (16) of the entrants were hired adult workers. Five of the entrants (approximately 10%) were either unpaid family youth or hired youth workers.

Safety Behaviors and Actions on Participant Farms

Of the 111 survey farms, 87% reported restricted access (for example, access points covered or blocked) to all manure storages and facilities. Only 24% posted warning signs. Fewer still (7%) used gas detectors to monitor concentrations of manure gases and oxygen in manure storage and handling facilities prior to and during entry events. About the same proportion (9%) posted the recommended duration of manure pit or facility ventilation prior to entry. Approximately one-quarter (26%) of survey farms provided rescue and retrieval equipment near manure storage facilities. The same percentage provided safety training for workers who had to enter the facilities. Only 12% of responding farms reported having a written safety plan, although 19% were familiar with the manure pit ventilation standard (ASABE/ANSI, 2010), and only 1% had accessed the agricultural safety website (www.manurepitsafety.psu.edu) (table 10).

Manure Pit and Manure Handling Facility Ventilation Systems

Approximately one-third of survey participants who reported having manure storage facilities also reported having ventilation systems in manure storage pits (table 11). This may be the result of a poorly worded survey question. The survey instrument did not distinguish between dedicated ventilation systems designed to evacuate manure gases to levels suitable for human entry and those designed to keep manure gas levels in animal living spaces above the manure storage facility below hazardous levels. We acknowledge that

Table 10. Safety behaviors and actions on participant farms (*N*= 111).

Behavior or Action	No. of Farms	% of Farms
Has restricted access to manure storages and facilities.	87	78.4
Posts warning signs at manure storages and facilities.	24	21.6
Uses gas detectors prior to and during entry into manure storages and facilities.	7	6.3
Posts recommended ventilation times prior to entry into manure storages and facilities near entry point.	9	8.1
Provides rescue and retrieval equipment near manure storages and facilities.	26	23.4
Has written safety policy or program for entering manure storages and facilities.	12	10.8
Provides safety training for workers who enter manure storages and facilities	26	23.4
Is familiar with ASABE/ANSI Standard S607.	19	17.1
Management has visited the safety website (www.manurepitsafety.psu.edu).	1	0.9

Table 11. Number of participant farms with ventilation systems for evacuating contaminant manure gases from manure storage and transfer facilities.

Facility Type	No. of Farms Providing Ventilation (No. of Farms Reporting Facility Type)	% of Farms with Facility Type and Ventilation System
Storage pit	39 (111)	35.1
Reception pit	12 (38)	31.6
Pump-out pit	18 (50)	36.0
Collection pit	6 (23)	26.1
Transfer pipe	1 (35)	2.9

ventilation of a manure storage tank to levels suitable to provide good air quality within the animal living spaces may not provide suitable air quality for entry into the storage tank. Thus, fewer than 35.1% of participating farms may have satisfactory ventilation systems to provide manure storage tank air quality suitable for human entry. Between 26.1% and 31.6% of participating farms with reception, pump-out, and collection pits reported having ventilations systems installed. Only one of 35 farms (2.9%) with transfer pits had a ventilation system.

Eighty-nine (30.0%) of the 297 manure storage tanks represented in the survey had permanently installed manure tank ventilation systems; 15 (5.1%) had portable ventilation systems. Permanently installed systems outnumbered portable ventilation systems for manure storages by a 6:1 margin (89:15). Eighty-four (28.3%) of manure storage tanks represented in the survey were professionally designed; 18 (6.1%) were home-made systems. The ratio of professionally designed to home-made ventilations systems was 84:18, or approximately 5:1 (table 12).

Table 12. Characteristics of ventilation systems in manure storage tanks on participating farms (N = 297).

Ventilation System Characteristic	No. of Storage Tanks with Vent System Characteristic	% of Storage Tanks with Vent System Characteristic
Permanently installed	89	30.0
Portable	15	5.1
Uncertain if permanent or portable	4	1.3
Total by installation type	108	
Professionally designed	84	28.3
Home-made	18	6.1
Uncertain if professionally designed or home-made	6	2.0

Table 13. Characteristics of ventilation systems in manure pump-out pits, reception pits, collection pits, and transfer pipes on participant farms.

Facility Type	No. of Farms in Survey	Farms with Ventilation Systems		Permanent Vent System (No.)	Portable Vent System (No.)	Professionally Designed System (No.)	Home-made System (No.)
		No.	%				
Pump-out pit	68	20	29.4	14	6	16	4
Reception pit	47	14	29.8	9	5	7	6
Collection pit	38	8	21.0	6	2	4	2
Transfer pipe	36	4	11.1	4	0	2	1

Table 13 summarizes the survey results for ventilation systems for pump-out, reception, and collection pits, as well as for transfer pipes. The percentages of pump-out, reception, and collection pits with ventilation systems (29.4%, 29.8%, and 21.0%) are similar to those reported for manure storage tanks in table 12. Very few transfer pipes (4 of 36) had ventilation systems. Fourteen of 20 pump-out pit ventilation systems were permanent installations, and 6 were portable; 9 of 14 reception pit ventilation systems were permanent installations, and 5 were portable; 6 of 8 collection pit ventilation systems were permanent installations, and 2 were portable. Of the 20 pump-out pit ventilation systems, 16 were professionally designed, 7 of the 14 reception pit ventilation systems were professionally designed, and 4 of 8 collection pit ventilation systems were professionally designed. The remaining 18 ventilation systems for these manure facilities were home-made.

NASS 2011 Farm and Ranch Safety Survey

The National Agricultural Statistics Service (NASS) has conducted several national farm safety and health related surveys for the National Institute of Occupational Safety and Health (NIOSH) over the last two decades (e.g., Myers, 1998; NIOSH, 2013). The most recent general farm safety survey was in 2011, and only a few brief data points from the 2011 survey are publicly available at this time (NASS, 2013). More specific details relating to manure storages and safety practices have been shared with the researchers, and these data are summarized in the introductory section of this article.

The NASS-NIOSH survey and the survey discussed in the present study (Penn State survey) each contained several questions related to manure storage types and manure storage safety practices, and these data are shown in table 14. The NASS-NIOSH manure storage safety practices data are a subset of data collected in a statistically valid sample of all farms across the U.S. The NASS-NIOSH data shown are estimates based on a telephone survey of 25,000 farm operators (NASS, 2013). The Penn State survey was from a sample of 1,200 farms in selected states. In the interest of sharing as much information as possible on manure storage safety practices, the data from each survey are shown side-by-side in table 14. The percentage associated with each practice is based on the total number of farms, total number of manure pits, or total number of enclosed manure pits included in the survey. In one instance, the percentage is based on the total number of survey participants responding to the item.

The NIOSH-estimated percentage of farm operators who enter enclosed manure pits is nearly 30%, while farm operators on 17.8% of the Penn State survey farms entered enclosed manure pits within the past 12 months. One reason for the higher percentage of entry with the NIOSH data may be that the NIOSH percentage is based on the total number of manure pits, while the Penn State survey response to this item is based on the number

Table 14. Comparison of selected survey results to NIOSH (2013) survey results.

	NIOSH Survey			Penn State Survey		
Item	No.	Basis[a]	% of Basis	No.	Basis[b]	% of Basis
Open manure pits (OMP)	46,571	N/A	N/A	N/A	N/A	N/A
Enclosed manure pits (EMP)	16,582	N/A	N/A	297	N/A	N/A
All manure pits (AMP)	63,153	N/A	N/A	297	N/A	N/A
Farms with manure pits (F)	N/A	N/A	N/A	111	N/A	N/A
Farm operators enter manure pits	18,618	63,153 (AMP)	29.5	53	297 (AMP)	17.8
Farm operators test air before pit entry	790	63,153 (AMP)	1.3	7	111 (F)	6.3
Manure pits with ventilation system	5,480	16,582 (EMP)	33.0	108	297 (EMP)	36.4
Manure pits with permanent ventilation system	3,521	16,582 (EMP)	21.2	89	297 (EMP)	30.0
Manure pits with portable ventilation system	1,960	16,582 (EMP)	11.8	15	297 (EMP)	5.1
Manure pits with rescue lines	1,414	63,153 (AMP)	2.2	22	111 (F)	19.8
Farms with written confined-space policy	26,154	313,038 All responses	8.4	12	111 (F)	10.8

[a] Parenthetical entries define type of manure pit (OMP, EMP, or AMP) used for reporting and comparisons.

[b] Parenthetical entries define type of manure pit (OMP, EMP, or AMP) or farms with manure pits (F) used for reporting and comparisons.

of study farms. Nonetheless, both sets of data show that a significant number of farm operators enter confined-space manure storages and facilities.

The NIOSH-estimated percentage of farm operators who test air quality prior to entering a manure pit was 1.3%, while slightly over 6% of Penn State survey farms indicated that they tested air quality prior to pit entry. Both studies show clearly that the important safety practice of testing air quality prior to and during manure pit entry is widely ignored. Both the NIOSH and Penn State surveys show that approximately 33% of enclosed manure pits have some kind of ventilation system. The NIOSH data suggest that approximately 20% of the ventilation systems are permanent installations, whereas the Penn State survey results indicate that approximately 30% of the installations are permanent. Neither study distinguished between permanently installed manure pit ventilation systems for ensuring good air quality in the animal living space above enclosed manure storages and manure pit ventilation systems designed to ensure air quality suitable for human entry into the pit. As suggested earlier, many of the reported permanently installed manure pit ventilation systems may be traditional pit ventilation systems to ensure good air quality above partially or totally slotted manure pit covers.

Approximately 2% of all manure pits in the NIOSH study reported having rescue lines available, while nearly 20% of all farms in the Penn State survey indicated the availability of rescue lines. This difference in responses may be because the NIOSH rescue line availability question covered all types of manure storages, including ponds, enclosed pits, and open pits, whereas the Penn State survey question pertained only to enclosed pits. In addition, the wording of the NIOSH survey question was on a per manure storage basis, whereas the Penn State survey wording only identified the number of farms that had rescue lines and retrieval equipment. Approximately 10% of respondents to both surveys indicated that they had a written confined-space policy.

Summary

There are an estimated 127,000 manure storage facilities on approximately 98,000 farm operations in the U.S., and approximately 16,500 are considered enclosed manure pits (NASS, 2013). Manure storage facilities consist of a variety of unit types that are referred to as manure pits, reception pits, pump-out pits, collection pits, transfer pipes, open storages, and more. Storage facilities vary widely in length, width, and depth.

It is clear that most farm operations with confined-space manure storages do not follow best safety practices regarding their manure storages. For example, few farmers use gas detection equipment before entering a manure pit, a majority of farmers do not use rescue lines when entering storages, and only about one in ten farm operations has a written confined-space safety policy or plan. Additionally, the Penn State survey data suggest that less than a quarter of farmers post warning signs around their storages, post recommended ventilation times before entry, or conduct training for workers who enter confined-space manure storages.

This article provides additional evidence that entry into and safety practices related to confined spaces on farms and ranches across the U.S. is a continuing and growing concern. While much of this increased attention has focused on grain handling and storage because grain storage incidents dominate agricultural confined-space fatality statistics (Riedel and Field, 2013), the number of manure storages units is expected to increase over the next several years. With an increased number of units comes increased exposure and, most likely, fatal injury incidents.

It is important that entry into manure storages be a part of state and national agricultural confined-space entry best safety practices, research, intervention, and policy programs. The survey data reported in this article provide a benchmark against which the effectiveness of educational programs and design tools for confined-space manure pit ventilation systems and other confined-space manure pit safety interventions can be measured.

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