



American Society of

Agricultural and Biological Engineers

STANDARD

ASABE is a professional and technical organization, of members worldwide, who are dedicated to advancement of engineering applicable to agricultural, food, and biological systems. ASABE Standards are consensus documents developed and adopted by the American Society of Agricultural and Biological Engineers to meet standardization needs within the scope of the Society; principally agricultural field equipment, farmstead equipment, structures, soil and water resource management, turf and landscape equipment, forest engineering, food and process engineering, electric power applications, plant and animal environment, and waste management.

NOTE: ASABE Standards, Engineering Practices, and Data are informational and advisory only. Their use by anyone engaged in industry or trade is entirely voluntary. The ASABE assumes no responsibility for results attributable to the application of ASABE Standards, Engineering Practices, and Data. Conformity does not ensure compliance with applicable ordinances, laws and regulations. Prospective users are responsible for protecting themselves against liability for infringement of patents.

ASABE Standards, Engineering Practices, and Data initially approved prior to the society name change in July of 2005 are designated as "ASAE", regardless of the revision approval date. Newly developed Standards, Engineering Practices and Data approved after July of 2005 are designated as "ASABE".

Standards designated as "ANSI" are American National Standards as are all ISO adoptions published by ASABE. Adoption as an American National Standard requires verification by ANSI that the requirements for due process, consensus, and other criteria for approval have been met by ASABE.

Consensus is established when, in the judgment of the ANSI Board of Standards Review, substantial agreement has been reached by directly and materially affected interests. Substantial agreement means much more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that a concerted effort be made toward their resolution.

CAUTION NOTICE: ASABE and ANSI standards may be revised or withdrawn at any time. Additionally, procedures of ASABE require that action be taken periodically to reaffirm, revise, or withdraw each standard.

Copyright American Society of Agricultural and Biological Engineers. All rights reserved.

ASABE, 2950 Niles Road, St. Joseph, MI 49085-9659, USA, phone 269-429-0300, fax 269-429-3852, hq@asabe.org

ASAE EP470.1 OCT2011 (R2016)

Manure Storage Safety

Developed by the ASAE Swine Housing Committee; approved by the Structures and Environment Division Standards Committee; adopted by ASAE January 1992; reaffirmed December 1996, December 1997, reaffirmed for one year February 2003; reaffirmation extended one year by SE-03 February 2004; reaffirmed February 2005; periodic review extended for two years September 2009; revised October 2011; reaffirmed October 2016.

Keywords: Confined space, Gases, Manual, Manure, Safety, Safety signs, Storage

1 Purpose and scope

1.1 The purpose of this Engineering Practice is to set forth existing known practices on manure storages that help (1) minimize the hazards of manure gases to livestock and humans, and (2) minimize the potential for drowning at manure storage sites.

1.2 This Engineering Practice does not include the design loads or structural specifications for manure storages (see ASAE EP393, Manure Storage).

1.3 This Engineering Practice contains information on safety equipment, management suggestions on safety, and the manure gases hydrogen sulfide, methane, ammonia, and carbon dioxide. Also given is a listing of the maximum safe gas concentrations, related standards and practices, and pertinent references.

2 Background

2.1 Liquid or semi-solid manure that is handled or set in motion by pumping, mixing, spreading, or cleaning-out can release large amounts of gases. The quantity released depends on the animal species, temperature, fluidity of the manure, pH, length of storage time, and type of handling system. The gases of concern are hydrogen sulfide, H₂S, carbon dioxide, CO₂, methane, CH₄, and ammonia, NH₃. (See Section 9 Technical information on manure gases, for more information on these gases.)

2.2 Manure gases have been fatal to both livestock and humans. Humans have died when they enter manure storage without a supplied air respirator or a self-contained breathing apparatus. Animals and humans have died when liquid manure stored under slotted floors was agitated and gases were released. Animal performance in partial and total slotted floor enclosed buildings is impaired when pit gas concentrations are above the TWA in Table 2.

3 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies unless noted. For undated references, the latest approved edition of the referenced document (including any amendments) applies.

ANSI/NFPA 70, National Electrical Code

ASAE EP270, Design of Ventilation Systems for Poultry and Livestock Shelters

ASAE EP393, Manure Storages

ASAE S412, Ladders, Cages, Walkways, and Stairs

ASAE S441, Safety Signs

ANSI/ASABE S607, Ventilating Manure Storages to Reduce Entry Risk

4 Potentially lethal situations

4.1 Fatalities that occur when agitating manure are generally caused by compounding the toxic effect of H₂S with the asphyxiating effect of oxygen, O₂, depletion by other gases. (See Section 9 Technical information on manure gases, for toxic levels.)

4.2 Methane explosions can result from concentrations of the gas within flammable limits. These concentrations can occur during agitation or when the gas is trapped in an improperly ventilated space over extended periods of time.

4.3 When ventilation equipment fails, the concentrations of manure gases in occupied space increases due to the lack of fresh air dilution.

4.4 Drowning of humans or animals can occur in aboveground tanks, below-ground tanks, or earthen storages. Livestock deaths have occurred due to structural failure of floorings or covers over storages or due to open gates.

4.5 Protective barriers or railings around openings should be used to prevent accidents. Push-off platforms or ramps (piers) can be a site where the tractor scraper driver can tumble into an open storage. Structures which are capable of restraining an overextended vehicle from overturning should be used. Examples of these restraints include, but are not limited to a sturdy steel railing or semicircular metal support embedded in concrete (i.e., hook). Vehicles used to scrape manure into manure storages should have roll over protection systems (ROPS).

4.6 Thick crusts on dairy, beef and swine storage basins can appear solid on the surface but are liquid beneath the crust, and will give way from the weight of humans, animals, or equipment. Crust depths are dependent on a variety of factors including but not limited to feed, biological activity, climate, and cover materials (if used).

4.7 Foam accumulation on top of the manure in deep pit manure storage can occur. Special care should be taken when foam forms in the pit. Manure foam can allow for the accumulation of noxious and flammable gases in the manure pit. The foam could also impede pit ventilation from working properly by reducing the open air headspace needed between the slats and the manure. Higher concentrations of noxious and combustible gases are released into the building living area when the foam is quickly reduced through knockdown activity (chemical addition, water spray, etc.) Pit agitation should not be done until sufficient headspace (~0.3 m or 1 ft.) for the pit ventilation is reestablished in the manure pit. Ignition sources (i.e. heaters) should be prevented from operating during agitation.

5 Managing manure gases with ventilation

For proper ventilation before entering into a pit, ANSI/ASABE S607, Ventilating Manure Storages to Reduce Entry Risk, should be referenced. Information provided in this standard is not for ventilation needs of the inhabitants in the building with a manure storage pit located under the building.

5.1 Properly designed and operated ventilation systems help prevent accidents by removing or diluting levels of toxic gases in confinement units.

5.2 Exhausting air from below slotted floors, especially when agitating the manure, decreases concentrations of manure gases at animal level. However, the concentration still may be excessive for humans and animals. Two methods of gas removal are (1) isolated nonducted pit fans, and (2) pit fans connected to perforated plastic pipes or plenums under the slotted floors or under elevated pens (pig decks). Fans connected to correctly size perforated ducts or plenums have more exhaust points and generally reduce the undesirable gas concentrations more than isolated fans, especially at low airflow rates. Fan intakes should be at least 0.3 m (1 ft.) above the manure level for reducing pit gas levels. Spacing of perforated ducts or plenums should not exceed 4 m (13 ft.) in order to be effective.

5.3 The design of the air inlet system of a building has a significant effect on airflow patterns within the building and on pit gas concentrations. The airflow patterns should ensure that gases generated by the manure are moved away from the animals. (This airflow pattern may not always be the best design for keeping partially slatted pens clean in the case of swine.) Dilution and removal of gases is as important as controlling building temperature and humidity.

5.4 Isolated pit fans and pit ventilation should be installed at separate sites from the manure removal locations such as pump-outs and cleanout extensions. It is vital that ventilation continue at maximum rates during pit agitation.

5.5 Proper care should be taken to make sure that the gases produced in the sealed/capped pit do not enter the headspace of the building.

5.6 In mechanically ventilated buildings, precautions should be taken to allow adequate air in the building during power failure. A warning device should be installed to inform the owner or operator if there is a ventilation system failure. Brief power outages may be common in some areas. (See ASAE EP270, Design of Ventilation Systems for Poultry and Livestock Shelters).

6 Special design and construction safety considerations for new manure storage facilities

6.1 The following considerations should be incorporated in the design and construction of liquid manure systems for a new or remodeled building:

6.1.1 Manure slurry will tend to separate into solid and liquid fractions in storage. Agitation is needed to suspend the solids and to aid in completely emptying storage. Provisions such as pump-out ports, agitation pump drop-in access locations in the pit sidewall or pit lid or access for trailer-mounted pumps for earthen storages are needed. Without adequate agitation during unloading, solids will build up and result in reduced storage capacity and higher levels of gas production.

6.1.2 All manure pump-out openings should be located outside enclosed buildings in order to reduce the danger of working in a confined area when unloading or agitating storage. The number of manure access points and/or agitation points needed varies with pit length and width, under-slat style of storage, animal species, ration and type of hauling system employed. An umbilical hose system may utilize multiple vertical-shaft agitation pumps in unison to keep up with the application rate for the field. Vacuum tank pump out holes should be 6 m (20 ft.) on center on both sides of enclosed total slotted floor deep pit building and on one side of an enclosed partially slotted floor deep pit building. Agitation holes for vertical shaft pumps should be spaced no greater than 20 m (65 ft.) on center (depends on building width). Divider walls in pits may be needed to keep ventilation air separate in multiple room buildings. This can affect the agitation hole and pump out hole spacing.

6.1.3 Tank openings should be guarded with grills and/or covers to prevent humans, animals, equipment, and other objects from accidentally falling into the storage structure. Removable covers and grills should be provided on openings for agitation and pumping equipment. Removable covers and grills should be designed to prevent their accidental loss into the tank and their unintentional removal. They should be designed for simple removal and replacement to encourage their use.

6.1.4 Ladders should not be installed on the outside of aboveground tanks unless they are terminated above the reach of an innocent bystander. A safety decal indicating to not leave ladders or climbing equipment near or