ANSI/ASABE S607 OCT2010 R2019)
Ventilating Manure Storages to Reduce Entry Risk

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Ventilating Manure Storages to Reduce Entry Risk

Developed by Subject Matter Experts from the Ergonomics, Safety & Health and Structures & Environment Divisions of ASABE. Approved as an ASABE standard by the Ergonomics, Safety & Health Division October and approved as an American National Standard November 2010; reaffirmed January 2015, December 2019.

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1 Purpose

1.1 The primary purpose of this standard is to reduce risk from asphyxiation, poisoning, and explosions when entering confined space manure storages by specifying the positive pressure, forced ventilation requirements, including ventilation system layout, air exchange rates, and minimum ventilation times, for evacuation of contaminant gases from, and replenishment of oxygen into, empty or nearly empty covered or partially covered confined-space, on-farm, manure storages, reception tanks, agitation tanks and other similar containers that hold/contain manure prior to entry.

1.2 This standard is to be used in conjunction with the appropriate confined space entry considerations defined in ASAE EP470, JAN 1992 (R2005), Manure Storage Safety.

2 Scope

2.1 This Standard specifies the forced-ventilation times required to evacuate contaminant gases (H_2S, CH_4, and CO_2) from on-farm, confined-space, manure storages with either solid, totally slotted or partially slotted covers to concentrations below American Conference of Governmental Industrial Hygienists (ACGIH) recommended 8-hr. Threshold Limit Values (TLVs).

2.1.1 This Standard specifies forced-ventilation contaminant gas evacuation procedures and times for solid covered on-farm, confined-space manure storages located outside enclosed animal living quarters and for partially or totally covered on-farm, confined manure storages located beneath enclosed animal living quarters.

2.1.2 This Standard specifies forced-ventilation contaminant gas evacuation times for ventilation systems with supply air taken from directly above the manure storage or ventilation systems with supply air ducted from a location with negligible or nearly zero contaminant gas concentrations and approximately 20.4% oxygen by volume at sea level.

2.1.3 This Standard specifies forced-ventilation contaminant gas evacuation times for maximum possible initial contaminant gas concentration levels or for known (measured) initial contaminant gas concentration levels.

2.2 This Standard specifies the forced-ventilation times required to replenish oxygen levels from 0% to 20% by volume at sea level in on-farm, confined-space, manure storages with either solid, totally slotted or partially slotted covers.

2.2.1 This Standard specifies forced-ventilation times required to replenish oxygen levels for on-farm, confined-space manure storages located either beneath or outside enclosed animal living quarters.

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2.2.2 This Standard specifies forced-ventilation times required to replenish oxygen levels for supply air taken from directly above the manure storage or for supply air ducted from a location with negligible or nearly zero contaminant gas concentrations and approximately 20.4% oxygen by volume at sea level.

2.3 All forced ventilation systems in this standard are positive pressure systems unless otherwise noted.

2.4 The provisions of this standard may be used to design permanently installed or portable ventilation systems for any existing or new manure storage that fits within the stated scope.

2.5 The provisions of this standard assume the storage is empty or nearly empty (< 150 mm depth of residual manure) when entered.

2.6 The provisions of this standard may be used for manure storages for liquid, slurry, semi-solid, or solid manure.

2.7 The provisions of this standard are not applicable to earthen manure storages, or other manure storages with totally open tops.

2.8 The provisions of this standard are not applicable when manure is being agitated.

2.9 The provisions of this standard are not applicable when there is foaming on the top surface of the stored manure.

2.10 The provisions of this standard are not applicable to manure storages with partial partition walls.

3 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of the Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Standards organizations maintain registers of currently valid standards.

ASAE S441.3 FEB1999, Safety Signs

ASAE EP470 JAN 1992 (R2005), Manure Storage Safety

ASAE EP270.5 DEC 1999, Design of Ventilation Systems for Poultry and Livestock

ACGIH. Documentation of the Threshold Limit Values and Biological Exposure Indices, 7th Ed. American Conference of Governmental Hygienists, 2009

OSHA. 29 Code of Federal Regulations, 1910.146. Permit-required Confined Space Standard

4 Definitions

4.1 manure storage: An on-farm confined-space container, including storage tanks, reception tanks, agitation tanks and other similar facilities that hold/store manure.

4.2 confined space: A space that: 1) is large enough for an employee to enter fully and perform assigned work; 2) is not designed for continuous occupancy by the employee; and 3) has a limited or restricted means of entry or exit.

4.3 outdoor manure storage: A confined-space manure storage not located beneath an enclosed animal living space.

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4.4 indoor manure storage: A confined-space manure storage located beneath an enclosed animal living space.

4.5 partially slotted cover: The top of a confined-space manure storage with slotted floors extending over only a portion of the manure storage footprint, the remainder being solid.

4.6 solid cover: The top of a confined-space manure storage with only limited openings such as openable access ports, pump out ports, and/or manure filling ports/slots.

4.7 totally slotted cover: The top of a confined-space manure storage with slotted floors extending over the entire manure storage footprint, with the exception of solid narrow (less than ~ 600 mm) access walkways.

4.8 confined animal living space: An enclosed animal living space located above a confined-space manure storage.

4.9 forced ventilation: Air exchange produced by forcing ventilation air into the manure storage by positive pressure mechanical ventilation fans.

4.10 air inlet location: The location at which ventilation air enters the confined-space manure storage either directly through the ventilation fan or from the end of an air duct (Figure 1).

4.11 Ducted fan inlet: An air supply with an attached duct that transports nearly contaminant free ventilation air to the air inlet (Figure 1).

4.12 air outlet(s): The location(s) at which contaminated air leaves the confined-space manure storage during forced ventilation.

4.13 air exchange rate: The ventilation rate expressed in terms of the number of confined-space manure storage volumes per minute (*AC*/m).

4.14 manure storage volume: The total empty volume of the manure storage.

4.15 air inlet or air supply concentration: The concentration of contaminant gas entering the confined-space manure storage during forced ventilation (Figure 1).

4.16 inter-contamination ratio (ICR): The ratio of the contaminant gas concentration at the fan intake to the contaminant gas concentration at the air outlets in the confined-space manure storage. The ICR for outdoor manure storages with the ventilation fan located on top of the storage cover is 0.40; the ICR for all manure storages with fan intake air ducted from a location with negligible contaminant gas concentrations is zero.

4.17 evacuated volume: The region within the confined-space manure storage in which the contaminant gas(es) are evacuated to the desired concentrations after a prescribed time of ventilation at a prescribed air exchange rate.

4.18 gas evacuation time: The forced ventilation time required to reduce a contaminant gas concentration from an initial level, "*x*", to a desired final level, "*y*"; i.e., 1 ppm for hydrogen sulfide, 5,000 ppm for carbon dioxide, and less than 1,000 ppm for methane.

4.19 initial contaminant concentration: The initial concentration of a contaminant gas expressed in parts per million (ppm)

4.20 threshold limit value (TLV): The American Conference of Governmental Industrial Hygienists recommended exposure level to a hazardous gas over an 8-hr work day.

4.21 maximum initial gas concentration: The maximum documented concentrations of manure storage contaminant gas in manure storages: 10,000 ppm for H_2S; 450,000 for CO_2; and 700,000 ppm for CH_4.

4.22 oxygen replenishment time: The forced ventilation time required to increase the oxygen level from an initial concentration, "*x*", to 20.0% by volume at sea level.

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5 Ventilation Fan Air Exchange Rate and Type

5.1 The ventilation fan rated capacity shall be certified by the fan manufacturer in m^3/s (cfm) at 25 Pa (0.10 in. water static pressure). The rated fan capacity shall be based on conditions of use; if a ducted air inlet is used, the rated capacity shall be with the duct(s) attached.

5.2 Storage volume of a manure storage with a square or rectangular footprint shall be calculated as the total length times width times height when completely empty.

5.3 Storage volume of a manure storage with a circular footprint shall be calculated as the horizontal cross sectional area times the total height when completely empty.

5.4 Ventilation air exchange rate shall be determined by Equation (1).

$$AC/\text{m} = (\text{rated fan capacity} / \text{manure storage total volume}) \times K \qquad (1)$$

where:

K = 60 when rated fan capacity is in m^3/s and storage volume is in m^3

K = 1 when rated fan capacity is in cfm and storage volume is in ft^3

5.5 Use only explosion proof fans and motors for the manure storage ventilation system.

5.6 The air inlet opening area through the storage top shall be equal to or larger than the fan outlet area or the air supply duct area.

5.7 When the air inlet opening through the storage top is larger than the fan outlet area or the air supply duct area, seal off the excess area.

5.8 Axial or centrifugal fans may be used to provide the required ventilation air exchange.

6 Forced Ventilation Times to Evacuate Contaminant Gases

6.1 Outdoor Solid Covered Manure Storages with Square Footprints

6.1.1 The provisions of this section are for manure storages with square footprints with length and width dimensions ranging from 3.66 m (12 ft) to 12.2 m (40 ft) and with depths ranging from 2.44 m (8 ft) to 4.58 m (15 ft) (Figures 2 and 3).

6.1.2 Forced ventilation shall be supplied at a rate of 1.5 air changes per minute for a time period at least equal to the maximum times listed in Table 1. The ventilation times in this table assume that the source for the ventilation air is directly above the manure storage cover, the initial contaminant gas concentrations are the maximum documented levels in the literature and the initial oxygen concentration is 0% by volume. The ventilation times also assume that the final concentrations are less than 1 ppm for hydrogen sulfide, 5000 ppm for carbon dioxide, and 1000 ppm for methane and that oxygen levels are replenished to 20% by volume at sea level.

6.1.3 The air inlet location shall be on top of the storage at the center of one sidewall; the ventilation air outlet shall be located at the top of the storage at the center of the opposite sidewall (Figure 2). The air supply may be taken from directly above the manure storage cover, but it is preferred that the ventilation air supply be ducted from a location at which contaminant gas concentrations are approximately zero and oxygen level is approximately 20.4% by volume at sea level.

6.1.4 The ventilation air shall be directed downward towards the bottom of the manure storage.

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6.1.5 If initial gas contaminant levels are measured and are less than the maximum initial levels cited in Sections 4.21, forced ventilation times in Table 1 can be reduced according to Equation (2) for hydrogen sulfide and carbon dioxide and by Equation (3) for methane.

$$T_1 = 0.11(T_{max} + 1)[\ln(C_{01})] - 1.0 \quad (2)$$

$$T_1 = 0.07(T_{max} + 59)[\ln(C_{01})] - 59.3 \quad (3)$$

where:

T_{max} = ventilation time from Table 1

C_{01} = measured initial gas concentration level

T_1 = ventilation time required to evacuate contaminant gas at measured initial contaminant concentration

6.1.6 If the air exchange rate is different from 1.5 *AC*/m, the forced ventilation times in Table 1, or as modified by Equations (2) and (3), can be further modified according to Equation (4).

$$T_x = T_{max}\,[AC_x / 1.5]^y \quad (4)$$

where:

T_x = ventilation time at actual air exchange rate, AC_x

T_{max} = ventilation time from Table 1 or as adjusted by Section 6.1.5

AC_x = actual air exchange rate

Y = floor cover and contaminant gas dependent exponent from Table 2

6.1.7 If ventilation inlet air is ducted from a location with a dependable air supply that provides air with negligible or nearly zero contaminant gas concentrations and approximately 20.4% oxygen by volume at sea level, the maximum ventilation times in Table 1 can be reduced by 20%.

6.1.8 Final calculated ventilation times from Sections 6.1.2, 6.1.5, 6.1.6 and 6.1.7 shall be rounded up to the next full minute.

6.1.9 Provide continuous maximum hot weather ventilation to any enclosed confined animal living quarters attached directly to the manure storages by a manure conveyance system while ventilating the manure storage. Manure conveyance systems should be blocked off to minimize potential backdraft of contaminated air into the animal living quarters whenever the manure storage is ventilated.

6.2 Outdoor Solid Covered Manure Storages with Rectangular Footprints

6.2.1 The provisions of this section are for manure storages with rectangular footprints and with length up to 9.15 m (40 ft), width up to 3.05 m (10 ft) and depth of 2.44 m (8 ft) (Figures 4 and 5).

6.2.2 Forced ventilation shall be supplied at a rate of 1.5 air changes per minute for a time period at least equal to the maximum times listed in Table 1. The ventilation times in this table assume that the source for the ventilation air is directly above the manure storage cover, the initial contaminant gas concentrations are the maximum documented levels in the literature and the initial oxygen concentration is 0% by volume. The ventilation times also assume that the final concentrations are less than 1 ppm for hydrogen sulfide, 5000 ppm for carbon dioxide, and 1000 ppm for methane and that oxygen levels are replenished to 20% by volume at sea level.

6.2.3 The air inlet location shall be located on top of the storage near the center of one endwall; the ventilation air outlet shall be located at the top of the storage at the center of the opposite endwalls (Figure 4). The ventilation supply air may be taken from directly above the manure storage cover, but it is preferred ventilation supply air be ducted from a location at which contaminant gas concentrations are approximately zero and oxygen level is approximately 20.4% by volume at sea level.

6.2.4 The ventilation air shall be directed downward towards the bottom of the manure storage.

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