

## ENVIRONMENT

**Title:** Literature Review - Deep Pit Swine Facility Flash Fires and Explosions: Sources, Occurrences, Factors, and Management –

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**Date Submitted:** December 21, 2009

### Summary of Findings

Incidences of explosions and flash fires related to manure storage in deep pits were noted as early as 1969. Gases resulting from anaerobic decomposition of animal manure are the likely source of barn fires. Literature that specifically addressed which of the flammable gases is the problem ( $\text{CH}_4$ ,  $\text{H}_2\text{S}$ ,  $\text{PH}_3$ , or a combination of the three) was not available. However, methane was the only one of the three combustible gases that was reported as being measured at concentrations high enough to combust. Additionally, the lower explosive limit for both  $\text{H}_2\text{S}$  and  $\text{PH}_3$  are far above the toxic level of these gases for both swine and humans. As such, animal death would occur before either  $\text{H}_2\text{S}$  or  $\text{PH}_3$  reaches combustible levels within swine facilities. The reported literature verified there was significant potential for  $\text{CH}_4$  generation from swine manure deep pit storage, and  $\text{CH}_4$  concentrations in the flammable range were reported in deep pit swine systems.

Foaming in anaerobic systems has been reported to trap gases within the created bubbles. The reviewed literature suggested that foam which forms in swine manure deep pit systems can entrain or trap methane, and that when the foam is broken methane concentrations far above the lower explosive limit can be released. Methane is lighter than air; therefore once it is released from the foam, high levels could easily dissipate to explosive levels between 5 and 15% methane in air.

While foam may seem to be a possible cause associated with elevated gas levels, foam itself is likely an effect of another influence on the system. Because limited literature was available in relation to manures and foaming, information was sought related to foaming in municipal and industrial anaerobic systems. However, reasons for foaming in anaerobic sludge treatment systems and digesters are still somewhat theoretical and foam production is likely the result of multiple factors. For deep pit manure storage systems feeding DDGS rations, reduced water use during the cool summers, and choice of barn cleanser may contribute to foam production. Evidence indicated that DDGS inclusion in swine diets increased excreted manure volumes due to higher levels of indigestible fiber in the feed, and decreased water usage in the barn for animal cooling and hydration can result in more concentrated chemical and physical parameters in the manure.

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These research results were submitted in fulfillment of checkoff-funded research projects. This report is published directly as submitted by the project's principal investigator. This report has not been peer-reviewed.

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Currently the best management practice that has been identified to reduce the risk of barn flash fires and explosions is to reduce the build-up of methane concentrations through adequate ventilation of deep-pit head-space. The majority of the reported flash fires and explosions were noted to have occurred during periods when pit-fans were not being operated, or when the fans were unable to provide significant air exchange due to limited pit head-space resulting from either high manure or foam levels in the pits. Many of the reported flash fires and explosions have been reported to have occurred when no animals were in the barns and ventilation was at minimal levels. During periods when no animals are in the barns, the use of pit exhaust fans to avoid build-up of methane in the pit head-space is suggested. When barn fans are more powerful than the pit exhaust fans, operation of only pit exhaust fans should be considered to avoid drawing additional gases in the animal area when barns are empty. It is also important that adequate head-space in the deep-pit be maintained to allow effective operation of the pit exhaust fans. While the foam noted to have been formed in many barns prior to fires is not the source of the methane, the foam does trap methane that would otherwise be removed from the pit head-space by ventilation. As such, it would be helpful to develop methods to decrease or stop the formation of foam in deep-pit swine manure storage systems.

This literature review did not identify sufficient information to fully explain the sources of foam formation and control in swine manure storage systems. Some compounds used to clean barns could inadvertently enhance foaming. Ionic detergents are known for their foaming ability, while non-ionic detergents can have properties that act as de-foamers. Antifoaming agents have potential, but foam collapse and antifoaming characteristics are not fully understood. Literature suggests the best way to determine the effectiveness of an antifoaming agent is to conduct performance tests for each suggested antifoaming agent. Literature has shown that foam suppression is a result of the balance between various surface active agents including the amended foam. Specifically, while some agents were capable of destroying a foam in one processes, the same agent acted as a foam stabilizer in another.