# Reducing $H_2S$, $NH_3$, PM, & Odor Emissions from Deep-pit Pig Finishing Facilities by Managing Pit Ventilation

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**Species:** Swine (maybe Dairy and Poultry)
**Use Area:** Animal Housing
**Technology Category:** Management
**Air Mitigated Pollutants:** Odor, Hydrogen Sulfide, Ammonia, Particulate Matter$_{10}$ (under 10 microns)

## Description:

Indoor air quality and emissions of hazardous gases such as ammonia ($NH_3$) and hydrogen sulfide ($H_2S$) plus particulate matter under 10 microns in diameter ($PM_{10}$) and odor are a concern in pig facilities where manure is stored in a deep pit (typically 2.5 m (8 ft) deep) under the barn's floor that is only separated from the animal and worker areas by concrete slats. Deep-pit, pig buildings are the standard housing systems for Midwestern U.S. pig nursery and grow-finish facilities and even for sow facilities in states like Minnesota that prohibit earthen manure storage basin for swine. The MidWest Plan Service (MWPS-32, 1990) recommends that "at least the cold weather rate but no more than the mild weather rate of a barn's ventilation airflow" be provided by pit fans. Unfortunately, the MWPS pit fan recommendation for deep pitted barn is not based on any known research results but rather on what seems to be a logical assumption that air exhausted from the pit area would remove more of the airborne contaminants (gases and odors especially) from the building and subsequently improve the indoor air quality in the barn compared to air removed by wall mounted fans.

A recent study (Jacobson, et al. 2005) determined that a large majority (75 to 80 %) of the total $NH_3$ and $H_2S$ emissions from a 2000-head tunnel-ventilated deep-pit pig-finishing barn for 45 days during August and September 2004 were emitted from the pit exhaust stream even though only 20 to 30 % of the total barn's ventilation air was being provided by pit fans. This information allows producers with deep-pit facilities to strategically utilize catch and treat emission control technologies, such as biofilters, ONLY on pit fans airstreams that would result in large reductions (>50%) in the emissions of hazardous gases, odor, and particulate matter by treating only a small portion of the total ventilation air (figure 1). Another follow up study (Jacobson, et al. 2007) found that emissions of certain pollutants, may be reduced slightly (10 to 20%) by simply eliminating pit fans altogether for a deep-pitted pig building.

**Figure 1. 2400 head, deep-pit, pig finishing barn with biofilter treated air from pit fans**

## Mitigation Mechanism:

The distribution or partitioning of the emission levels for certain gases, odor, and particulate matter between the pit and wall fan airstreams in deep-pit pig facilities for various pit ventilation rates is not well understood or predictable. Presently, the only viable method of determining this information is by monitoring existing pig facilities using robust instrumentation for both the measurement of pollutant concentrations as well as the airflow rates in the buildings to calculate emission rates. Mathematical modeling (Janni, et al. 2008) of this process is under development and when these models are refined and validated, they will provide a much less intensive method of determining the emission partitioning for important airborne pollutants for deep-pitted buildings.

# Applicability:

Based on recent research, pit fans exhaust air, from deep pitted swine finishing barns in the Midwest, emit a disproportionate amount of ammonia ($NH_3$), hydrogen sulfide ($H_2S$), particulate matter under 10 microns in diameter ($PM_{10}$), and odor compared to the air emitted by wall fans. For a typical 1200 head pig finishing room, with pit fan(s) capacity of 35 $m^3$/hr-pig (≈ 20 cfm/pig), which is approximately 20% of the total barn's ventilation rate, the pit exhaust airstream contains a majority (> 50 %) of the total $NH_3$,$H_2S$, $PM_{10}$ and odor emissions emitted from the barn (figure 2). Thus, if a pork producer needs to reduce emissions, it is important to know that some type of catch and treat technology (such as biofilters) only needs to be applied to the pit fans (20 % of total airflow) to achieve a sizeable reduction (50% or more) in a particular pollutant.

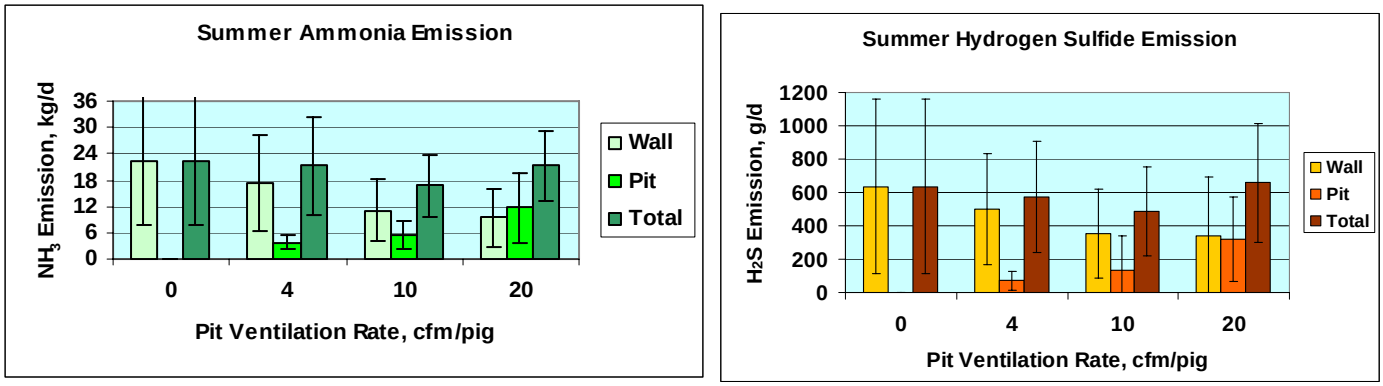


**Figure 2. Summer $NH_3$ and $H_2S$ emissions from one room of a 2400 head double wide, deep-pitted, tunnel ventilated pig finishing building with pit ventilation rates of 0, 4, 10, and 20 cfm/pig.**

As the percentage of pit to wall fan capacity is reduced, so does the percentage of gas and odor emissions from the pit fan's airstream. However, if no pit fans are used to ventilate a deep pit pig finishing barn, only slight reductions (0 to 20%) in the total barn's $NH_3$, $H_2S$, $PM_{10}$, and odor emissions are found. As indicated by $NH_3$ and $H_2S$ concentrations in the middle of the barn (figure 3), the indoor air quality is not appreciably affected by the presence of pit fans, assuming the ventilation system is well designed and there is adequate fan capacity in the walls.

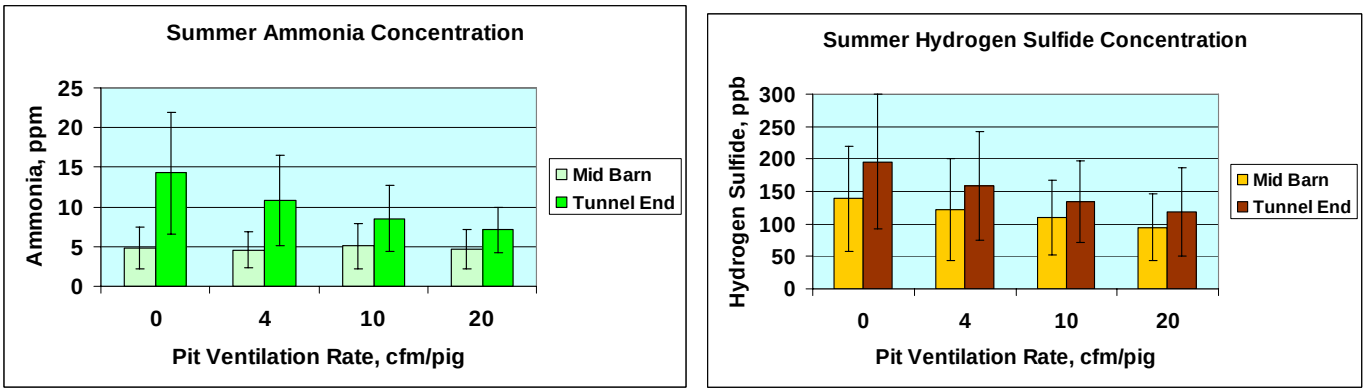


**Figure 3. Summer $NH_3$ and $H_2S$ conc. from one room of a 2400 head double wide, deep-pitted, tunnel ventilated pig finishing building with pit ventilation rates of 0, 4, 10, and 20 cfm/pig.**

# Limitations:

The selection and management of pit fan ventilation for deep-pit pig buildings has only been investigated for pig finishing units. Similar results are anticipated for other swine production stages (farrowing, gestation, and nursery) that are housed in deep-pit barns; however the estimated emission reduction potential for these facilities may be different than reported above for finishing barns. Only the two common hazardous gases ($NH_3$ and $H_2S$), odor, and $PM_{10}$ responses have been documented in pig finishing buildings. Greenhouse gases ($CO_2$, $CH_4$, $N_2O$, and others) will be of interest in the future.

Other animal species such as dairy and poultry may be housed in buildings that have deep-pit manure storage directly under the animal housing area. Again, knowing the distribution of the emissions coming from the "pit" air stream and the "wall" air stream from these housing systems will allow producers to optimize emission control technology use so emissions can be maximized.

## Cost:

There is no additional cost of this "technology" since a ventilation system is needed in deep-pit pig buildings anyway. There actually may be a cost saving if producers decided to install no or only limited (1 or 2) pit fans instead of the standard number for the industry which is approximately 20% of the total barn's ventilation system, that translate to 4 fans in the typical 1200 head finishing room. The cost savings is realized since the installation of pit fans is typically more expensive than wall fans plus pit fans have higher maintenance and more frequent replacement costs.

## Implementation:

The implementation of this technology is simply applying the knowledge of the disproportionate emissions of important gases, odor, and particulate matter through the pit fan airstreams compared to the emissions of these parameters via the wall fan airstreams. This can be applied to both existing and new facilities, although when retrofitting an existing buildings some switching of pit to wall fans may be necessary to optimize the use of certain control technologies and/or to obtain the necessary emission reduction level desired.

## Technology Summary:

A large portion of the $NH_3$, $H_2S$, $PM_{10}$, and odor emissions, from deep-pit pig finishing barns, were found in the pit fan exhaust air compared to air exhausted by the wall fans. This knowledge is important for producers that want or need to reduce a pig finishing barn's $NH_3$, $H_2S$, $PM_{10}$ and odor emissions, since there would be a benefit to treating only the pit fan exhaust air with an emission control technology rather than all of the exhaust air (wall and pit). The phenomenal of a majority of the barn's airborne pollutants being emitted by pit fans, may also be true for other swine production phases or for even other species (dairy and poultry) housed in deep pit facilities. This would mean that emission reductions of >50 % for certain pollutants are potentially possible when emission control technologies like biofilters are strategically placed on large emitting pit fan sources in deep-pit buildings. If only small reductions (<20%) of certain pollutants are needed, this maybe accomplished by the elimination of pit fans altogether.

## Additional Resources:

BAEU-18 Biofilter Design Information, available at http://www.manure.umn.edu/assets/baeu18.pdf.

## Acknowledgments:

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