Progress Report – March 31, 2006

I. Project Title: Partitioning between pit and wall emission streams of Hydrogen sulfide, ammonia, particulate matter, and odor from deep-pit pig finishing facilities for decision support in selecting emission control technologies

NPB project identification number: 05-113

Principle Investigator: Larry D. Jacobson
Institution: University of Minnesota

Project Objectives:

1. Monitor quasi-continuous emissions of H_2S, NH_3, CO_2, and PM_{10} plus intermittent sampling of odor from the barn's pit and wall exhaust streams over an approximate 180-day period that would include both warm and cold ambient temperatures.
2. Monitor the indoor air quality of the barn over this same period of time by quasi-continuously measuring concentrations of H_2S, NH_3, CO_2, and PM_{10} from several separate locations inside the barn.

II. Progress toward meeting objectives:

After locating a cooperator in southern Minnesota with a deep-pit, fan ventilated, 2400 head pig finishing barn ("double wide" barn with two 1200 head side by side rooms), the project was begun last October (2005). An instrument trailer that contained the data acquisition computer, gas analyzers and sampling system, and particulate monitors was placed outside of the southwest corner of the finishing barn (figure 1). The western 1200-head room of the double-wide barn was instrumented to collect environmental data and gas samples from several different barn locations as indicated in figure 2.

The four 24" diameter pit fans (approximate airflow of 6000 cfm/fan) for the west room were temporarily turned to bypass the biofilters on the barns and were controlled and sequenced with timers in order to obtain two-hour operating periods with 0, 4, 10, and 20 cfm/pig ventilation rates (0, 1, 2, and 4 operating pit fans) through the pit. The wall fans were calibrated using a Fan Assessment Numeration System (FANS) unit in order to get accurate in-place airflow measurements. Particulate matter under 10 microns in diameter (PM_{10}) was continuously measured at the wall fan and the southwest pit fan locations using Tapered Element Oscillating Microbalances (TEOM) instruments. To facilitate the TEOM equipment in the pit exhaust air stream, a shelter was constructed with an expanded metal floor and placed over the pump out area as shown from the outside in figure 1. A 36" diameter blade fan, approximate airflow of 10,000 cfm and from a previous project, was then attached to the side of the shelter and

replaced one of the existing pit fans. A donut shaped wooden baffle was placed on the suction side of this fan so it would restrict the airflow capacity (measured with FANS unit) down to the level of the previous and other pit fans (6000 cfm) on the barn.

III. Status of project in regards to stated timeline:

The project is currently in the data collection and analysis phase. Collection of data from last fall (2005) was quite limited as the barn was nearing the end of a pig growth cycle (pigs enter at 50 lbs and leave at market weight or 250 lbs which takes about 4 months) since 3 to 4 weeks before the barn is completely emptied the heavier pigs are removed or "topped off" on a weekly basis. Thus very limited data was collected with a full barn in October. Data collection began for the winter period in January 2006 and continued through the first week of March. Data collection will begin again in April and will run until this batch of pigs is marketed (July).

IV. Modifications of project from original proposal:

As indicated above, collection of data was not begun until the first part of November of 2005, which limited the days of data with a full barn since heavy pigs were already being removed from the barn and sent to market in early November. The original plan was to begin data collection in September or October but funds were not transferred to the University until Oct 1 and it took several weeks to set up the collection lines, instrument trailer, and measure airflow from the exhaust fans plus make sure all systems worked properly

Figure 1. View of pumpout shelter for particulate sampler along with instrument trailer.

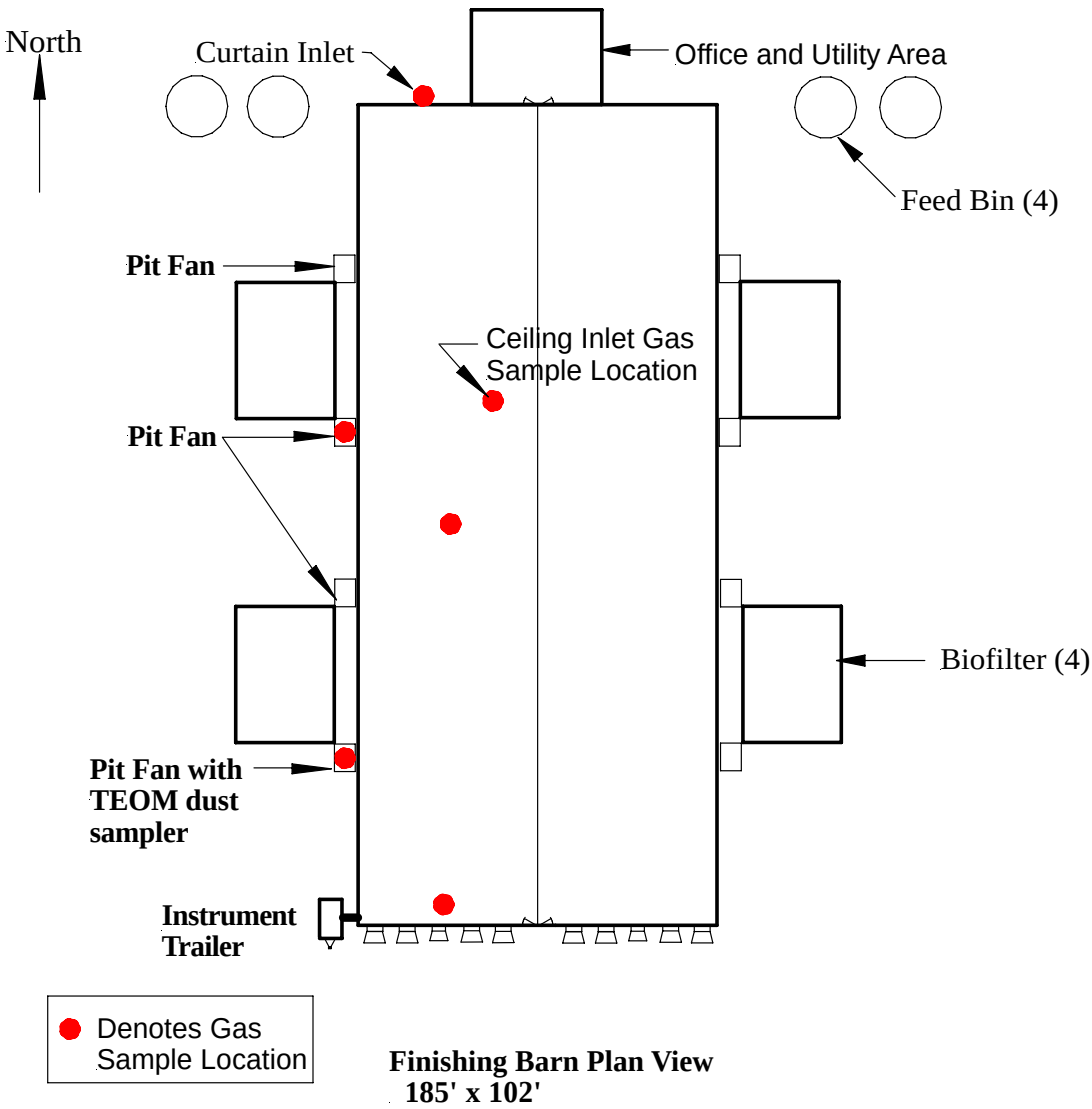

Figure 2. Site layout

V. Preliminary results:

The 4 pit fans of this mechanically-ventilated barn are controlled by individual timers that are sequenced into 2-hour periods of 0, 1, 2, and 4 operating pit fans. A 36” diameter wall fan was set to operate continuously, but restricted to an airflow rate of 4000 cfm. The other 50” diameter wall fans were allowed to operate as needed by the room’s ventilation controller (temperature dependent).

There was one gas sampling location in the middle of barn that was only used for monitoring indoor air quality. A second indoor location was at the fan end of the barn and was used for wall emission calculations. The indoor air quality results are shown in figures 3 and 4 for NH_3 and H_2S, respectively. The small variations in the indoor ammonia and hydrogen sulfide concentrations between the different

pit ventilation rates indicate that the operation of pit fans have little impact on indoor air quality. When there was reduced or no pit ventilation, the temperature controlled wall fans were activated and effectively kept the barn's total air exchange rate relatively constant over the four ventilation treatments. This is evident by the relative constant CO_2 concentrations shown in figure 5. It is interesting to note that the highest indoor H_2S concentration occurred when the pit airflow rate was the highest (figure 4).

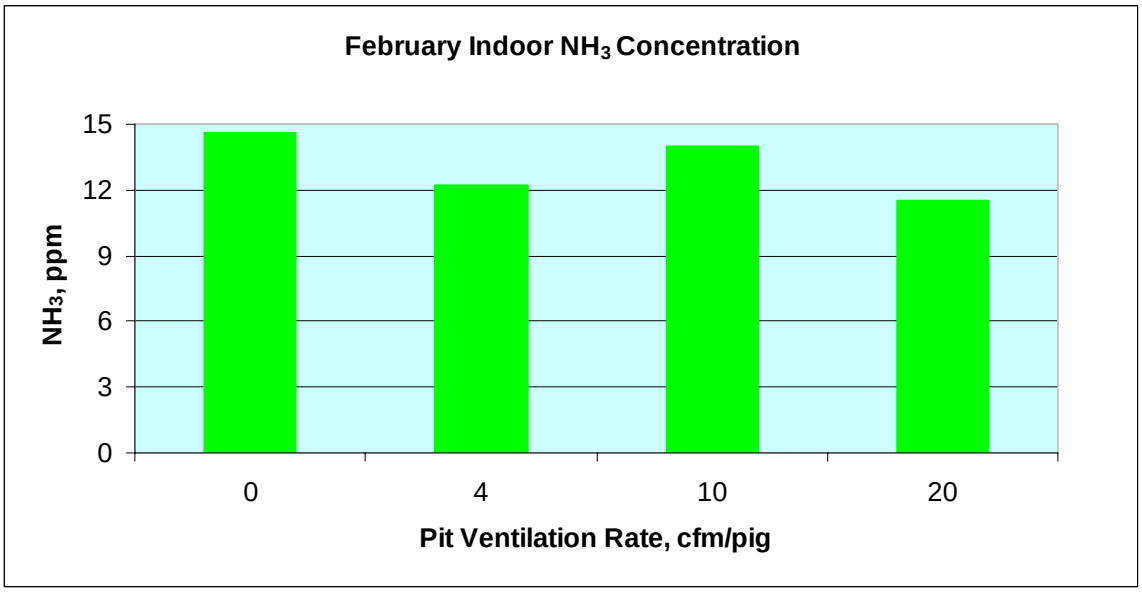

Figure 3. Cold weather ammonia indoor concentration.

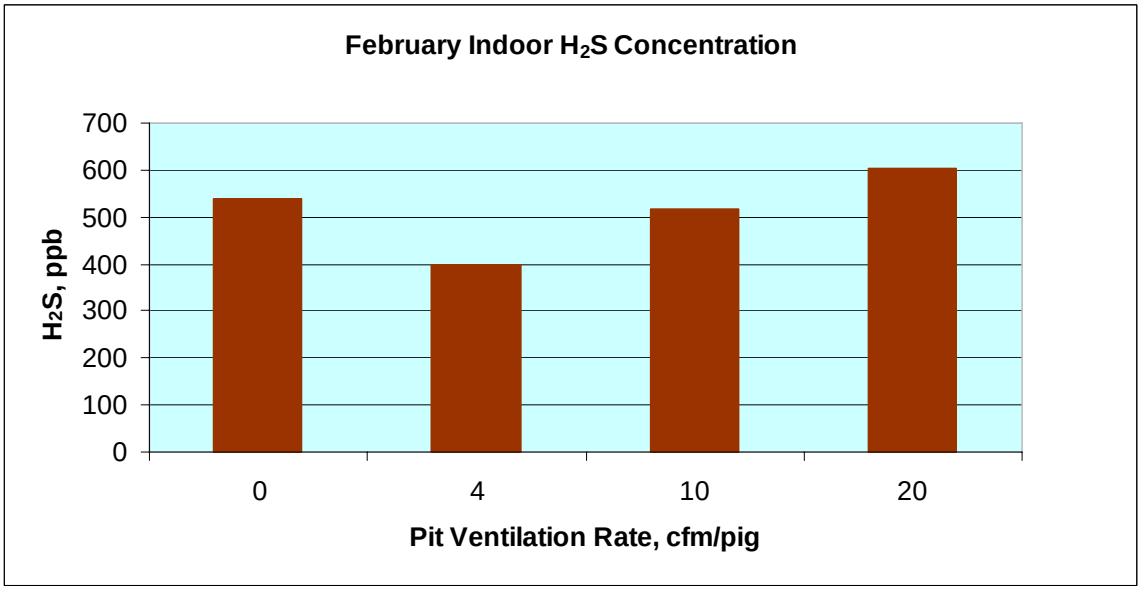

Figure 4. Cold weather indoor hydrogen sulfide concentration.

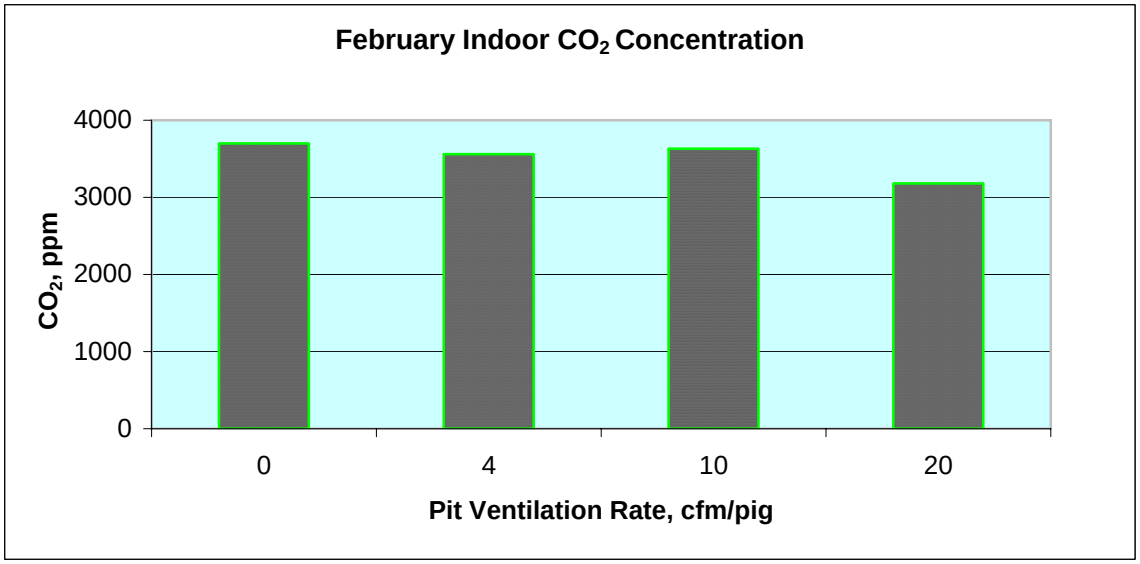

Figure 5. Cold weather indoor carbon dioxide concentration.

Emission rates for NH_3 and H_2S are summarized in figures 6 and 7. In both cases, the lowest total building emission occurred when there was no pit ventilation and consistently increased as additional pit ventilation was added. For ammonia this ranged from 10 (no pit fans) to 12.5 (4 pit fans) kg (NH_3)/day and for hydrogen sulfide from 0.5 (no pit fans) to almost 0.8 (4 pits fans) kg (H_2S)/day. The increased emission is more pronounced with H_2S which is likely due to the pit being the source of H_2S generation.

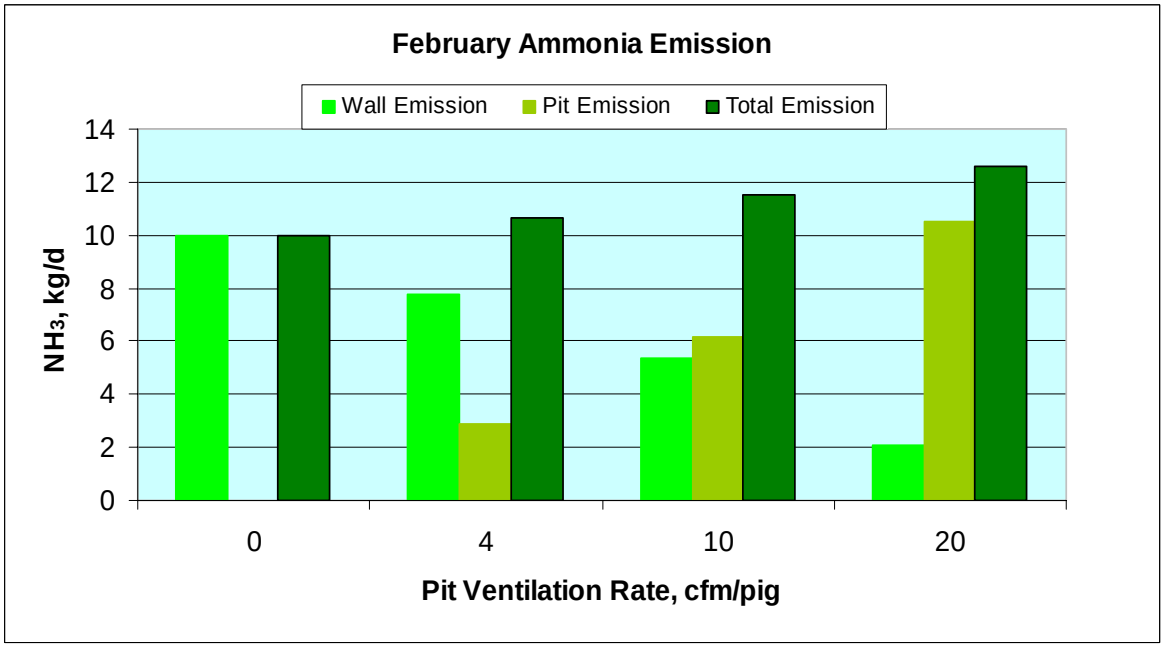

Figure 6. Cold weather ammonia emission.

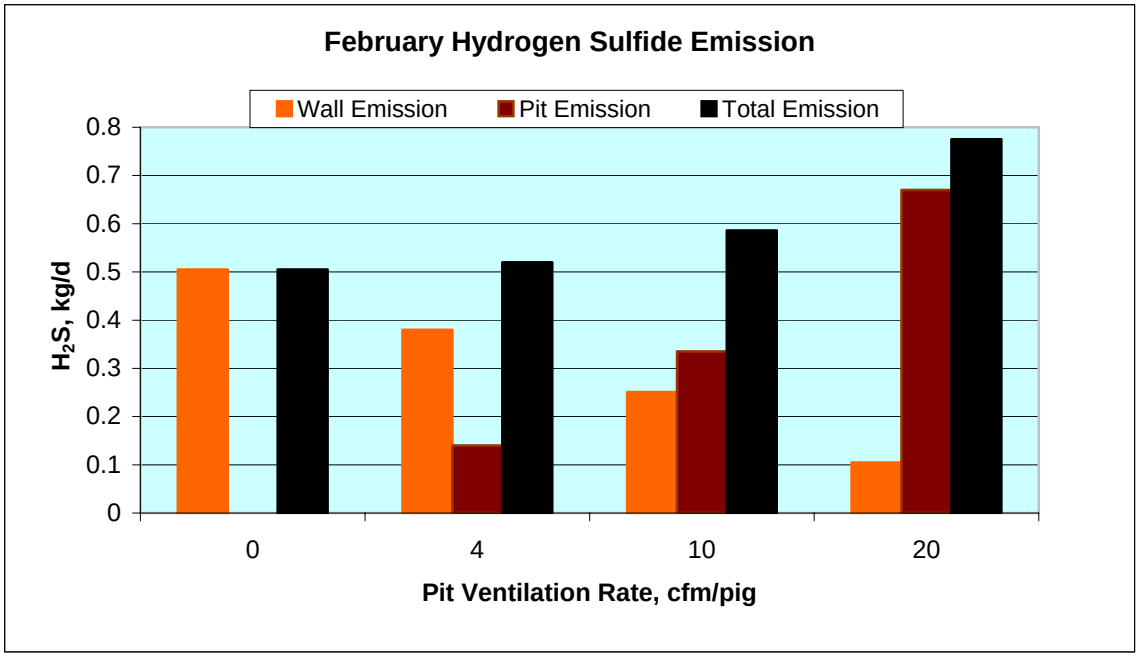

Figure 7. Cold weather hydrogen sulfide emission.

Figure 8 reveals the PM_{10} emissions from both the wall and pit airstreams for the "winter" period. The results clearly indicate that there was much less PM_{10} emitted from pit fans than there was from wall fans. The lower pit emission could be due to the particles being captured on the slats and the manure surface in the pit. A number of previous emission projects have only measured PM_{10} concentrations above the slats and then assumed that the concentration was the same through both pit and wall airstreams.

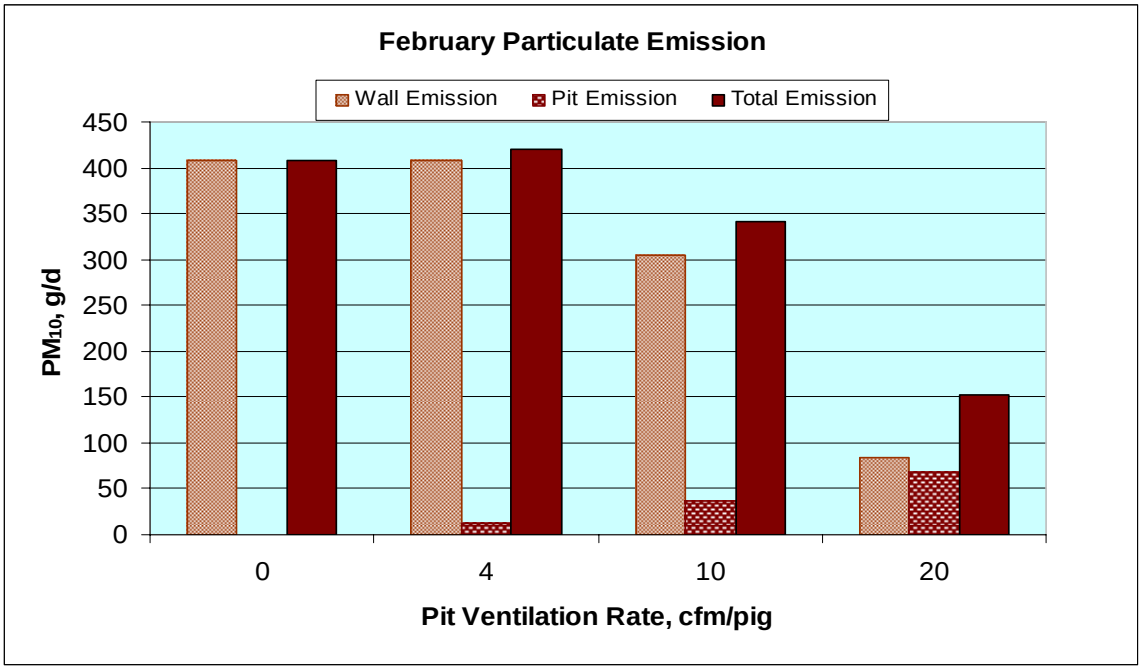

Figure 8. Cold weather particulate (PM_{10}) emission.

Finally, Figure 9 gives the odor emission data that was collected on two separate days during the winter period. The data suggest that the total odor emission is similar for the 0 and 10 cfm/pig pit ventilation rates. For a 20 cfm/pig pit ventilation rate, the odor emission is lower; however this highest pit ventilation rate only had one set of odor samples while the other rates had at least two samples. The plan is to collect and analyze odor samples at least three separate times during the next pig cycle and compared them with these results.

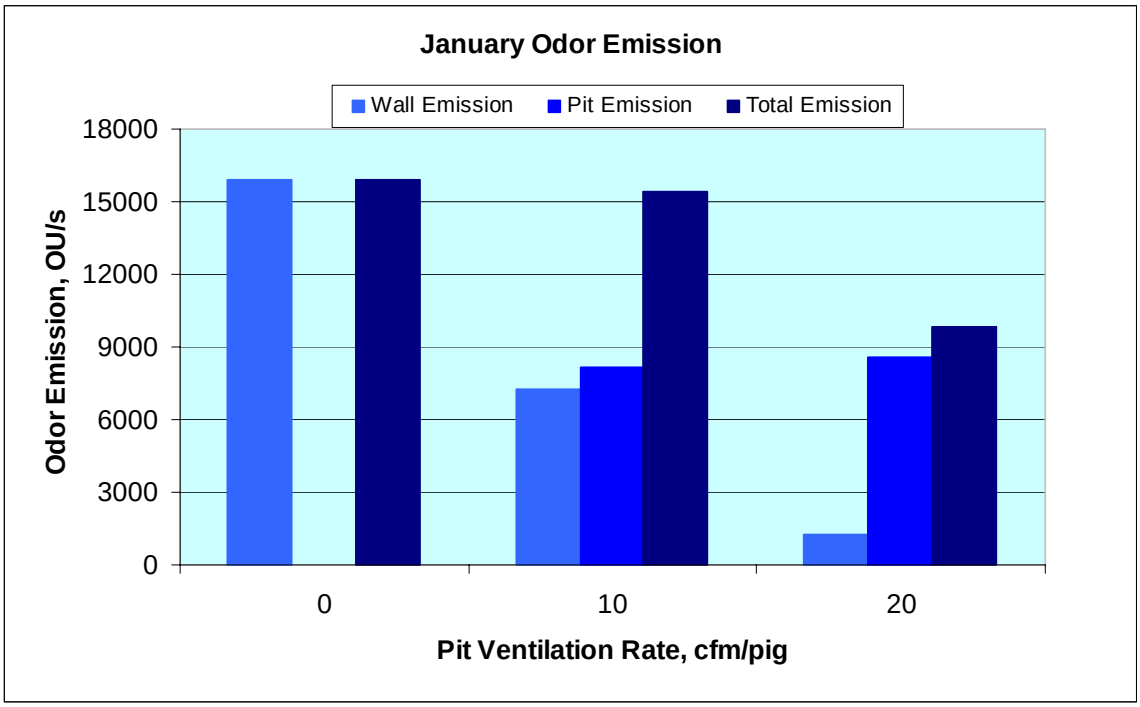

Figure 9. Cold weather odor emission.