

How can I Control Hydrogen Sulphide in my Barn?

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■ Introduction

Hydrogen sulphide (H₂S) is a life threatening gas produced by the anaerobic degradation of liquid manure. As most swine barns are equipped with gutters that accumulate manure for a period of time, H₂S can be released while performing common tasks that involve manure flow or mixing. In most cases, H₂S exposure may not result in death, but short and long-term effects can have impacts on the health and well being of the exposed person.

Saskatchewan Labour regulates H₂S exposure in the Occupational Health and Safety Regulation and stipulates that at no time should a person be exposed to an average of 10 ppm of H₂S for a period of 8-h (TWA: 8 hour time weighted average exposure limit) and an average of 15 ppm for a period of 15-min (STEL: 15-min time weighted average contamination limit). Saskatchewan Labour does not have a defined ceiling value for H₂S, but defines the level of H₂S that is immediately dangerous to life or health (IDLH) at 100 ppm, a level at which no one should even be exposed to.

Chénard et al. (2003) studied six pig farms to assess the exposure of the barn workers to H₂S while pulling pit plugs and power-washing production rooms. Results indicated that plug pulling generated high concentrations of H₂S reaching 1,000 ppm in some cases. All of the farms used in this study had plug

pulling events that exceeded limits defined by the Occupational and Safety Regulations of Saskatchewan. Also, the H₂S released when a plug was pulled did not follow a predictable pattern both over time, and within the room. Power washing generated lower H₂S concentrations than plug pulling but workers were exposed for a longer time period.

Based on the study by Chénard et al. (2003), swine barn workers may be exposed to H₂S concentrations that exceed acceptable limits when pulling pit plugs and power-washing rooms. The authors also concluded that further research is needed to improve the building design and manure management systems, and to develop practical engineering controls for preventing the H₂S exposure in swine buildings. This paper provides an update on the control technologies under development at PSC.

■ Objectives

The main goal for the current project is to develop low cost systems that will prevent or reduce worker exposure to high H₂S concentration during plug pulling events in swine buildings. The three specific objectives are presented under three different project modules:

Module 1

To design and develop a pit-plug pulling system that allows the plugs to be opened from a remote location, prevents backflow of manure or gases when the plugs are closed, and is adaptable to existing in-barn manure management systems.

Module 2

To determine reduction of H₂S gas when tap water is sprinkled, along with tap water with a buffer to increase pH, and tap water combined with hydrogen peroxide, essential oils or ferric sulphate. The water temperature and application rate are also investigated.

Module 3

To design and develop a pit scraper system to remove swine manure from the barn on a daily basis, and to evaluate the reduction of H₂S. The system will be developed and retrofitted in an existing barn with liquid manure handling systems.

Considering that Modules 1 and 2 have been completed and Module 3 is being initiated at the current time, this report focuses primarily on Modules 1 and 2 of the project.

■ Experimental Approach

Module 1 – Pit puller system

A pit plug was designed and a bench-scale prototype of the system was built. The extended cone plug was selected, as it met the design criteria of low cost, ease of installation, safety, plug popping control and formation of a consistent seal on the sewer pipe hole. This design also minimized the manure flow restriction to the hole. A cage was also designed to prevent the plug from coming too far out of the hole (**Figure 1**). With this cage in place, if the plug is pulled or if it pops due to a build-up of pressure in the lines, the funnel-shaped extension on the plug will remain in the hole and guide the plug back into the hole to reform the seal.

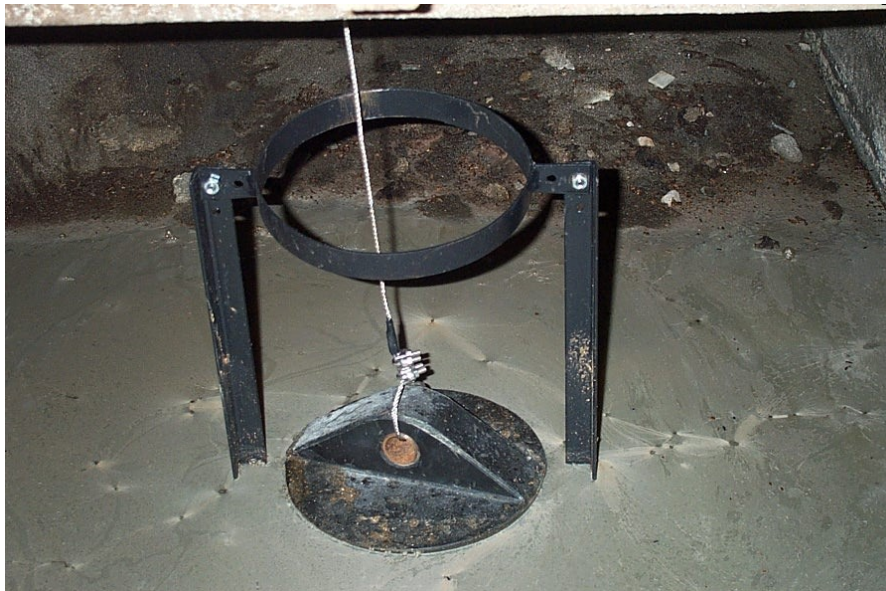


Figure 1. Plug pulling apparatus including cage underneath the slats.

The operating system for plug pulling was selected based on the following criteria: initial cost, operating cost and maintenance of the plug pulling system. The pulley system with optional winch was selected as the preferred method of mechanical plug pulling (**Figure 2**) amongst the following systems: an air pressure system, electric motor apparatus and pulley system.



Figure 2. Pit plug pulling winch system in alleyway. There are two winches operating two separate systems in two different rooms.

Module 2 - Bench Scale Experiments on Hydrogen Sulphide Abatement by Water-Based Liquid Spraying

A laboratory apparatus was designed (**Figures 3 and 4**) to simulate H₂S peak concentrations observed during plug pulling events in barns. This setup consisted of a 0.9 m high PVC tank in which H₂S gas at a concentration of 1000 ppm was injected. The head space of the tank was ventilated so by injecting a known amount of H₂S in the tank, it was possible to recreate an H₂S concentration pattern at the tank air exhaust similar to what was observed in barn conditions during Chénard et al. (2003) study. The tank was also equipped with a nozzle port to spray water solution while the H₂S was injected. Various additives could be added to the water in the open reservoir, and the treatments were sprayed at different flow rates.

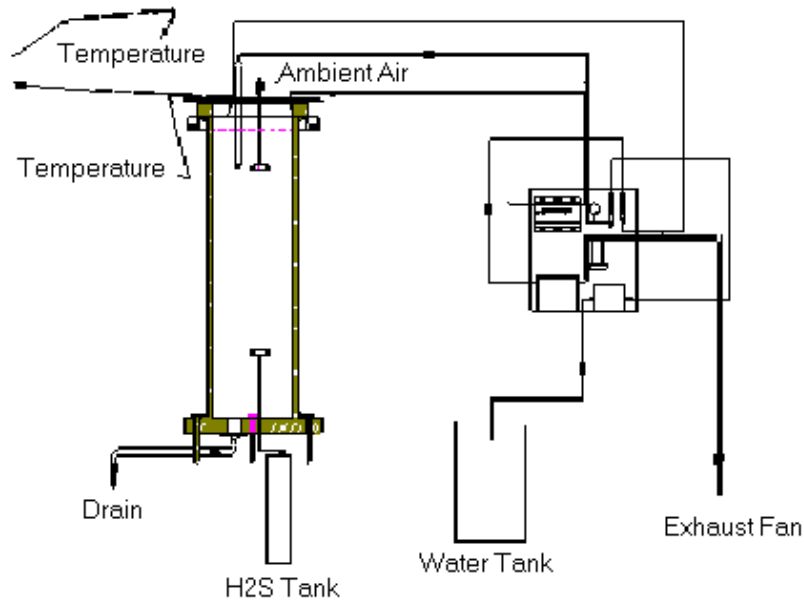


Figure 3. Overall schematic of hydrogen sulphide laboratory setup.

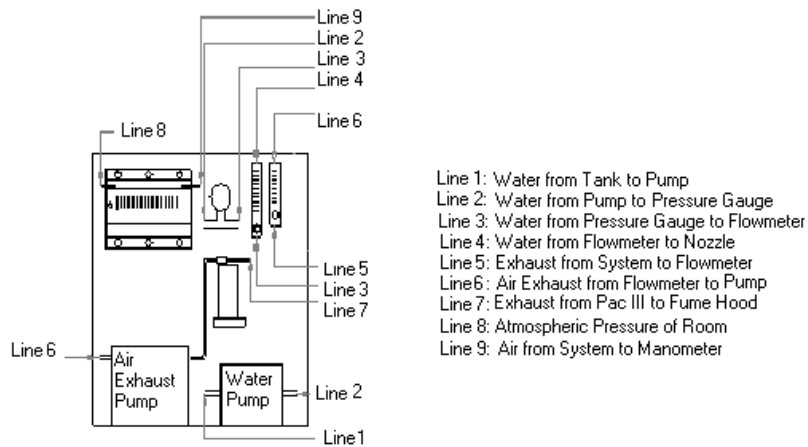


Figure 4. Diagram of hydrogen sulphide laboratory system operation.

■ Results to Date

Module 1 - Trial Results

A prototype of the plug system was installed in two full-scale grower-finisher rooms at PSC in the spring of 2003, and its operation is currently being tested and monitored. Nine pulling events have been recorded to date, with the H₂S concentration measured in both the room where the plug was pulled, and in the alleyway where the winch was located.

The maximum H₂S concentration from all the monitored events was 68 ppm, with corresponding concentrations in the alleyway near the winch at 0 ppm. This indicates the system has proven to be very effective in protecting the worker from being exposed to H₂S. The cost of implementing this design in a 4-plug room is estimated to be \$280, which includes the winch.

Module 2 – H₂S Abatement With Water-Based Liquid Spraying

Preliminary work was done to determine the injection rate and time needed for the H₂S gas to reach 180 ppm inside the pipe. This injection rate and time were then used to add H₂S to the pipe for the sprinkling study.

Based on preliminary results using the various treatments (three different nozzles, three operating pressures, and five water treatments), the final experiment used only the hollow and the initial full cone nozzles, with three operating pressures (10, 20, 30 psi) and three water treatments (tap water, tap water with an increased pH 9 and tap water with hydrogen peroxide). Three repetitions were made for each treatment.

The results from this trial are presented in **Figure 5**. There were no significant differences between the blocks ($p > 0.05$), and there were significant differences among both water type and nozzle type ($p < 0.05$). There was also a significant difference between the water*nozzle*pressure interaction ($p < 0.05$), which tells us that each treatment was significantly different from the others. The best reduction of H₂S occurred when the hollow cone nozzle was used at 30 psi using water at a pH of 9, resulting in a 79% reduction of the maximum H₂S. Use of a full cone nozzle at pressures 10, 20 and 30 psi resulted in high levels of H₂S reduction as well, but the water volume used was much higher than for the hollow cone (18 – 63% more water).

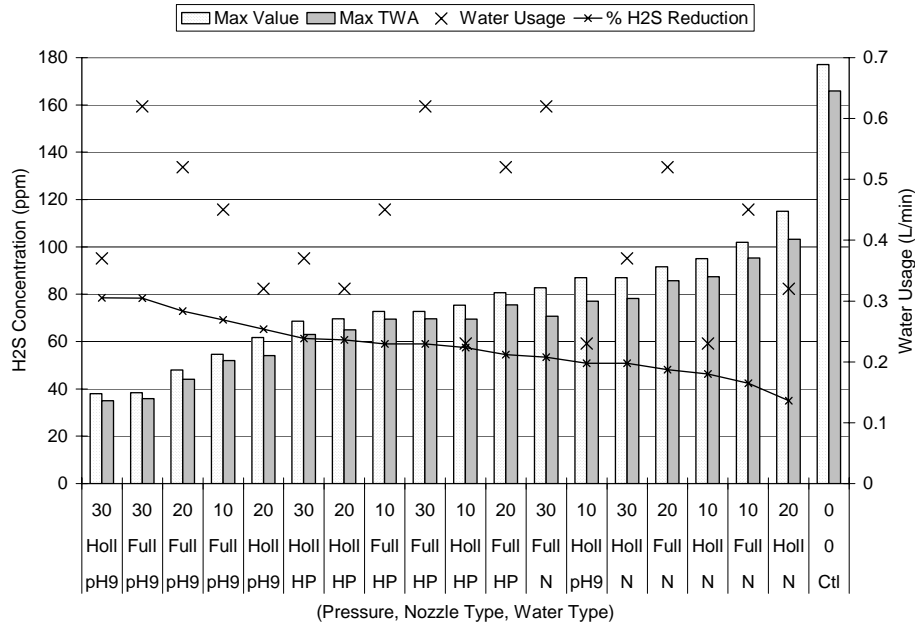


Figure 5. Summary of results (Pressures – 10, 20, 30 psi; Nozzle Types – hollow and full cone; Water Type – normal water, water at pH 9 and water with hydrogen peroxide added).

Calculations show that if the hollow cone nozzle was used in a grower-finisher swine manure pit to sprinkle water over the entire pit for 15 min. while the pit was draining, the total volume of water used would be in the range of 5 – 8% of the total manure pit volume (1.0 – 1.6 m³). However, it is likely that spraying would not have to be performed over the entire manure pit, and total sprinkling time could be shorter than 15 min., so the addition of water corresponding to 5-8% is likely a conservative estimate that could be reduced in the final design.

Further studies will be done using the top three optimum treatment combinations on reducing H₂S from agitated swine manure. Sixteen 45-gal barrels will be used for this study, and manure will be used from a grower-finisher room. Since the hollow cone nozzle saw a good reduction of H₂S (51 – 79% reduction) with tap water at a pH of 9 and used much less water than the full cone nozzle, the subsequent study using manure as a source of H₂S will investigate the use of hollow cone nozzles with tap water at a pH 9 at 10, 20 and 30 psi.

■ Summary

Swine workers may be at risk of being exposed to high H₂S concentrations when pulling pit plugs in barns. Three engineering controls are being studied at PSCI:

- a remote plug puller system
- a water based sprinkling system
- an adapted manure scraper

At this time, both the remote puller and the sprinkling systems look promising to control the H₂S exposure of workers at a low cost. Further experiments will be completed with the water spraying system and the manure scraper concept will be implemented at PSCI over the winter of 2004.

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■ References

Chénard, L., S.P. Lemay and C. Laguë. (2003) Hydrogen sulfide assessment in shallow-pit swine housing and outside manure storage. *Journal of Agricultural Safety and Health* **9**(4): 285-302.