

# Engineering Controls Reduce Hydrogen Sulphide Exposure in Swine Barns

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## Summary

Three engineering control measures were developed and tested for effectiveness in protecting swine barn workers from exposure to hydrogen sulfide (H<sub>2</sub>S) gas during manure handling events. A remote manure pit plug pulling system allowed the worker to pull the manure pit plug from outside the room. A water sprinkling apparatus was also devised, which resulted in 79% reduction of H<sub>2</sub>S gas concentration under optimal laboratory conditions. A manure scraper system was installed to remove manure daily from the manure pit of a grower-finisher room. Preliminary measurements showed that H<sub>2</sub>S levels were 80 to 96% lower in the scraper room than in a similar room with a conventional pull-plug system.

## Introduction

High levels of H<sub>2</sub>S can have detrimental effects on both workers and swine. Previous research by the Prairie Swine Centre Inc. (PSCI) indicated that workers are at risk of exposure to potentially hazardous H<sub>2</sub>S levels when performing manure management tasks, such as pulling manure pit plugs. The main goal of this project is to develop practical measures that can prevent or reduce worker exposure to high H<sub>2</sub>S concentration in swine buildings. Three different systems were investigated in separate modules.

### Module 1 – Improved Design for Pit Plugs

In this module, an improved pit plug concept that allowed for pulling the plugs from a remote location was designed and evaluated (Fig. 1). The system was installed in two grower-finisher rooms at PSCI and tested by measuring H<sub>2</sub>S concentrations using a H<sub>2</sub>S monitor (Draeger Pac III monitor with a H<sub>2</sub>S sensor, Draeger, Lübeck, Germany) during the plug-pulling operations.

After examining several plug designs, the extended cone plug was selected and installed. Monitoring of H<sub>2</sub>S



Figure 1. Improved pit-plug design showing the (a) extended cone plug, (b) with cable attached and plug-height stop, and (c) the cable-winch system for remotely pulling the plug from outside the room.

levels during nine plug-pulling events showed that the maximum H<sub>2</sub>S concentration in the room over the plug area was 68 ppm, while corresponding concentrations at the alleyway near the winch was 0 ppm. Hence, the system was very effective in protecting the worker from being exposed to H<sub>2</sub>S by allowing the worker to perform the task away from the plug area.

### Module 2 – H<sub>2</sub>S Abatement by Water-based Liquid Spray

Because H<sub>2</sub>S is water soluble, it was hypothesized that spraying a water-based liquid over agitated manure would reduce emissions into the air. A laboratory spray chamber was set up to determine the impact of a water-based spray on H<sub>2</sub>S levels in the chamber (Fig. 2). Preliminary tests were done to investigate the reduction in H<sub>2</sub>S levels as affected by various parameters such as type of spray nozzle, water pressure, temperature and pH, as well as the use of various chemical additives.

Laboratory tests with various combinations of test parameters consistently reduced the concentration of pure H<sub>2</sub>S gas released into the chamber. Using a hollow cone nozzle at 200 kPa with water at pH = 9 resulted in a 79% reduction of the peak H<sub>2</sub>S levels. The treatment was applied to a set of barrels filled with swine manure. In four control barrels where no spray was applied, manure agitation produced an average of 148 ppm, with a

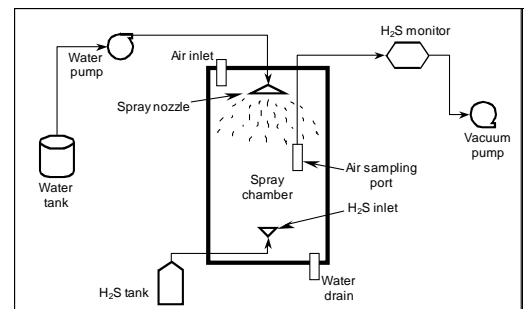


Figure 2. Schematic diagram of laboratory set-up used to determine the effect of water-based spray on H<sub>2</sub>S levels in the chamber.

peak reading of 520 ppm measured from the exhaust air. However, application of the water-spray treatment increased the average and maximum H<sub>2</sub>S concentrations to 273 and 690 ppm, respectively. Because these were not consistent with the observations in the laboratory study, it was suspected that other gases generated in the manure barrel affected the Draeger Pac III monitor. Additional tests are on-going to investigate the water-spray treatment further.

*“A water sprinkling apparatus resulted in 79% reduction of H<sub>2</sub>S gas concentration under optimal conditions.”*



Figure 3. Scraper blade used for daily removal of manure from the pit. The manure pit has drains at both ends, through which the scraped manure was emptied to the sewer line.

**Module 3 – Manure Scraper System to Reduce H<sub>2</sub>S Levels**

In this module, a manure pit scraper system (Fig. 3) was installed in a grower-finisher room to remove swine manure on a daily basis. Its effectiveness was evaluated by comparing the air quality in the scraper room and a similar room (Control) with conventional manure pit-plug system.

Table 1 summarizes the maximum H<sub>2</sub>S concentrations measured at two locations in the rooms. Compared to the control room, the maximum H<sub>2</sub>S concentrations were lower in the scraper room by an average of 80% over the plug area and by an average of 96% over the middle pen. Additionally, the maximum H<sub>2</sub>S levels in the control room exceeded the 15-ppm ceiling occupational exposure limit (OEL) value on three occasions during the two trials, while no peak H<sub>2</sub>S readings were higher than this limit value in the scraper room. The ceiling OEL is the maximum concentration of a biological or chemical agent to which a worker may be exposed, i.e., no worker should be exposed to any levels above this limit at any time.

During the two trials, significant levels of ammonia were measured in the incoming inlet air for both rooms, possibly due to recirculation of air exhausted from the fans into the supply air as well as from possible back draft of ammonia from adjacent rooms into the barn attic. The weekly average ammonia concentrations measured at the exhaust was significantly ( $p < 0.05$ ) higher in the scraper room (11.3 ppm, SD = 2.3 ppm) than in the control room (9.8 ppm, SD = 2.1 ppm), although the mean difference was smaller than the indicated accuracy of the ammonia analyzer. The calculated ammonia emissions were about 44% higher in the scraper room, which was attributed to the formation of a film of excreta on the pit bottom surface after scraping; this has been

Table 1. Summary of maximum H<sub>2</sub>S concentration (ppm) measured in the scraper and control rooms.

	Date	Control		Scraper	
		Over plug	Middle pen	Over plug	Middle pen
Trial 1	10-Mar-04	4.0	2.0	0.0	0.0
	24-Mar-04	0.0	0.0	0.0	0.0
	7-Apr-04	9.0	0.0	11.0	7.0
	21-Apr-04	12.0	4.0	0.0	0.0
Trial 2	30-Jun-04	12.0	2.0	0.0	0.0
	21-Jul-04	95.0	N/A	6.0	N/A
	11-Aug-04	40.0	30.0	2.0	0.0
	25-Aug-04	30.0	10.0	1.0	2.0
	Average	25.3	6.9	2.5	1.3
	SD	31.2	10.8	4.0	2.6

N/A – data not available, instrument malfunction

previously reported as possibly causing increased ammonia emissions in scraper systems. However, the observed ammonia levels were still lower than the 25-ppm OEL for ammonia, despite the presence of ammonia in the incoming air. Additional tests are on-going to determine the effectiveness of maintaining a layer of standing water at the bottom of the manure channel to control ammonia emissions.

**Conclusions**

A remote manure plug pulling system was successfully developed. Results showed that the system was effective in preventing worker exposure to H<sub>2</sub>S by allowing the pulling of the plugs from the alleyway. A water-spray treatment showed consistent reduction in H<sub>2</sub>S levels in a laboratory study. However, application of the treatment on agitated manure showed opposite effect on H<sub>2</sub>S. A manure scraper system used for daily manure removal from a swine room was effective in reducing H<sub>2</sub>S to levels below the maximum exposure limit for worker's safety. The system generated higher ammonia levels, although peak readings did not exceed the ammonia exposure limit value. Additional tests are being conducted to further investigate both the scraper and the water-spray systems.

**Acknowledgements**

Strategic funding provided by Sask Pork, Alberta Pork, Manitoba Pork, and Saskatchewan Agriculture and Food Development Fund. Project funding provided by Sask Pork, Agriculture Development Fund, and PIC Canada.

*“Preliminary measurements showed that H<sub>2</sub>S levels were 80 to 96% lower in the scraper room.”*