RESEARCHREPORT
ENVIRONMENT

Title: Impact of Odor and Dust on Pig Performance - **NPB #00-065**

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I. Abstract

A research project to determine whether ozonation of air in a swine nursery has impact on dust, odor, and pig performance was undertaken at the Michigan State University swine research facility. One objective was to obtain baseline data for in-house dust, hydrogen sulfide, ammonia, and bacteria for a pull-plug system. A second objective was to compare these data with that of an untreated facility with regard to the level of gases, dust, and performance.

There was no significant difference in ammonia between the two treatments, and in both cases the measured concentrations were always less than 20 parts per million. Dust levels in both treatments were quite low and there was no difference. Hydrogen sulfide levels were significantly less in the ozonated treatment with levels generally about 100 parts per billion (ppb) whereas in the control the levels averaged about 400 ppb. The average daily gain and feed efficiency was better in the ozonated treatment than in the control, but there was inadequate replication to state that the differences were statistically significant.

II. Introduction

There have been and continue to be strong claims by manufacturers and vendors for the benefits of various schemes for odor suppression. One of the difficulties researchers have had in determining the efficacy of the systems is that there is no generally accepted protocol for sampling and analyzing odor. It is our expectation that this experiment will not only provide the baseline data for the system but will provide data for each of the treatments. Because of the extent of the instrumentation and control in this experiment, we will be able to define the results in both qualitative and quantitative terms. Several facets will come from this research and they include:

1. Quantification of emission rates for several key gases associated with odor.
2. Quantification of reduction emission (in the case of the oxygenation) or reduction of the concentration within the room as a result of a specific, commonly recommended system.

3. Quantification of the relative contribution of odor from dust or gases not attached to dust particles.

The results stated above will then provide the basis for baseline rates and relative efficacy of different odor suppression systems.

III. Objectives

1. Determine baseline data (control) for in-house gas, dust, piglet performance, and bacterial growth for a pull-plug nursery facility.
2. Compare three in-house air treatment systems to control (untreated) for effect on odor, specific gases, bacterial growth, and performance of nursery pigs.

IV. Procedures

This project involved four identical nursery rooms each with a capacity of 200 piglets at the new swine research facility at Michigan State University. Each room was equipped with a dust odor/treatment system. The waste handling system in the rooms is a pull-plug system in which the plugs are pulled once every two weeks. The system evaluated in this project was the air ozonation system designed by *Ozone Systems*. Each room was instrumented with identical instrument clusters of temperature, ammonia, relative humidity, carbon dioxide, oxygen, air pressure and air speed sensors. The data was sampled every five minutes and collected via a multiplexer in a single datalogger and downloaded to a personal computer. All sensors were calibrated before beginning the treatment (approximately every two weeks). In addition to the data taken on the datalogger, personnel entered the rooms daily at a prescribed time with a prescribed protocol. They were wearing masks equipped with activated carbon filters, and sampled the odor for a prescribed time upon entry. They then replaced the mask and took hydrogen sulfide samples with a precision total reduced sulfur sampler, and removed sampling tubes from the filtered and unfiltered air pumps for analysis on the Varian GC/MS cryogenic thermal desorption system.

During the experiment, the sensors for ammonia proved to be unreliable, and the procedure for analysis was changed to a wet chemistry method (NIOSH Method 6015, Issue 2, a wet chemistry and spectrophotometer method).

Bacteria culture media was exposed for a fixed length of time and the samples were further cultured for bacterial counts.

Feed consumption was monitored, and pigs were weighed upon entry into the rooms and upon exit. From the data average daily gain and feed efficiency were determined.

In addition to the aforementioned routine data collection, the Jerome meter was used to monitor hydrogen sulfide during several pull-plug events when the manure pits were emptied.

The ozone injection rate was between 0.01 and 0.02 parts per million in the ozone treatment test.

V. Results

A. Objective 1.

Some baseline was collected. Most of the data were collected during the warmer days of the summer and early fall at times when ventilation rates were relatively high, so it is not representative of cooler conditions when ventilation is minimal.

1) Ammonia data. Early attempts to measure ammonia with inexpensive electronic semiconductor type sensors proved to be very frustrating and unproductive. We changed to NIOSH Method 6015, Issue 2, a wet chemistry and spectrophotometer method. Ammonia concentrations in the control room and the ozonated room varied between 2 and 20 parts per million (ppm).

2) Hydrogen Sulfide data. Hydrogen sulfide was measured using a Jerome 631X. The minimum threshold for measuring H_2S is about 2 parts per billion (ppb). Typically we measured values less than 500 ppb (0.5 ppm), but immediately after pulling the plug of the pull-plug system we observed some values in excess of 2000 ppb (2 ppm). Ozone did affect H_2S, and that is addressed under objective 2.

3) Bacteria counts. Bacterial count data can only be used as relative data given the way it was taken. We did observe a difference in bacterial counts in areas where we could measure ozone, and that is addressed under objective 2.

4) Pig Performance. Pig performance data in both the control room and the ozonated room were collected. Average daily feed consumption for the control room was 1.295 lb./pig, average daily gain was 0.688 lb./pig, and feed efficiency was 1.883 lbs. feed per lb. gain. The ozonated treatment room average daily feed consumption was 1.181 lb/pig, average daily gain was 0.722 lb/pig, and feed efficiency was 1.637 lbs feed per lb. gain. The control room had 187 pigs with entering weight of 12.8 lbs and departure weight of 33.7 lbs, and the ozone room had 188 pigs with entering weight of 15.8 lbs and departure weight of 36.1 lbs.

5) Gas analysis. Data was analyzed using a Varian GC/MS. The expected peaks indicating the presence of indoles, skatoles, and several volatile fatty acids were noted. Comparisons are addressed in objective 2.

B. Objective 2. Comparison between ozonated and control.

1) Ammonia data. There were some differences in ammonia measured in the two settings, but the differences could not be attributed to ozonation, and were not consistent from one day to another. Typical values are shown in Figure 1.

2) Hydrogen Sulfide. Hydrogen sulfide is a very reactive gas, and the injection of ozone into the treatment room clearly affected the H_2S levels. Figure 2 shows H_2S averages for five locations with five replications of each measurement. The average H_2S level in the ozonated room was roughly one fourth of that in the control room. The levels in the ozonated room averaged about 100 ppb, and in the control room about 400 ppb. The amount of ozone injected would be adequate to react the H_2S to SO_2, so the results are predictable, but it was reassuring to be able to measure the predicted result.

3) Bacterial counts. The bacterial counts can only be looked at as relative numbers. Nonetheless, at locations in the

ozonated room where the ozone detection instrument noted detectable levels, bacterial counts were significantly lower.

4) Pig Performance. Pig performance data is shown in Table 1. The table shows that there was a difference in performance between the control and the treatment with ozone, but there is insufficient replication to address the significance of the difference.

5) Gas analysis. The gas analysis is at least as telling as the H_2S data. Figure 3 shows overlaid data for the indole and skatole peaks. The faint trace is the control data, and the dark trace is the ozonated room. The total amount of the gas is proportional to the area under the peak, and the superimposed trace shows substantially reduced levels of both compounds. It is logical that if the ozone reacted with the two compounds, some other compounds must have been produced, and that is shown in Figure 4. This is also an overlaid chromatogram plot, and it clearly shows substantially increased levels of more volatile compounds in the 18 to 24 minute range. Compounds that were decreased by ozonation were dimethyl disulfide, dimethyl trisulfide, indole, skatole, and 4-amino acetophenone. Stylene, xylene, and hexanal were all still present after ozonation and might actually have been increased.

6) Anecdotal evidence. Three laboratory assistants were trained to follow a specific protocol in collecting data and were asked to document their observations. In each case the assistants were wearing gas-scrubbing masks except for a period of time when the masks were removed to make observations. These are their comments: (Room 2 is control; Room 1 is ozonated).

a) There seem to be many more flies in the non-ozonated room.

b) There was a noticeable decrease in the number of bacteria on the plates at station #5. Station 5 was the first point I picked up ozone on the detector.

c) I can smell ozone in Room 1, but the detector does not indicate it.

d) Another observation in Room 1 that neither pigs nor ozone could be smelled.

e) Same day Room 2 smelled especially bad.

C. Other Observations

In the course of collecting the data reported above, two other observations were made. One common practice is to pull the plugs on the manure holding tank with the pigs in the building and without changing ventilation. Figure 5 shows H_2S concentrations for two locations on the same day after the plug has been pulled. In one case, the concentration was almost 10 ppm. Although the time the concentration was at that level was short, concentrations at that level merit attention.

A second common practice in facilities such as this one is to control temperature with ventilation. The result of that practice is that on some nights when the temperature is well below the desired temperature in the room but warm enough to not require supplemental heating, carbon dioxide levels get rather high. Figure 6 shows

CO_2 concentrations for a typical cycle in April, and on many nights the concentration was more than 2000 ppm.

Results of this research and that of others has led us to conclude that further research with adequate replication is necessary to document performance differences and gas/odor differences. A new project has been initiated at Michigan State University to investigate these differences in finisher pigs.

Table 1. Pig Performance

Treatment	No. Pigs	Wt. in	Wt. out	Ave daily feed	Ave daily gain	Feed Efficiency
Control	187	13.0	33.7	1.295	0.688	1.883
Ozonated	188	15.8	36.1	1.181	0.722	1.637

Figure 1

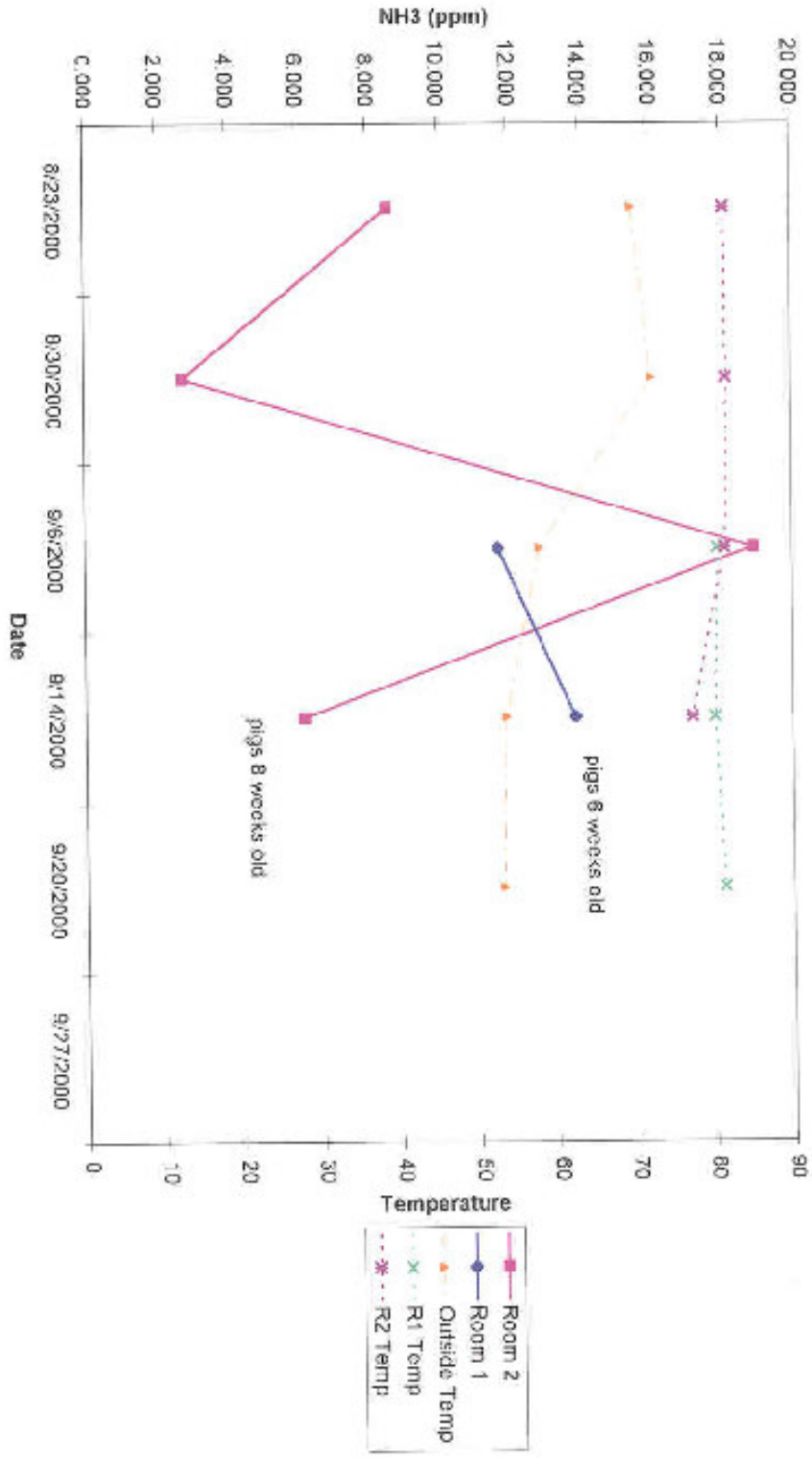

NH3 vs Temperature
NH3 (ppm)
20.000
18.000
16.000
14.000
12.000
10.000
8.000
6.000
4.000
2.000
0.000
8/23/2000
8/30/2000
9/6/2000
9/14/2000
9/20/2000
9/27/2000
Date
Temperature
90
80
70
60
50
40
30
20
10
0
pigs 6 weeks old
pigs 8 weeks old
Room 2
Room 1
Outside Temp
R1 Temp
R2 Temp

Figure 2

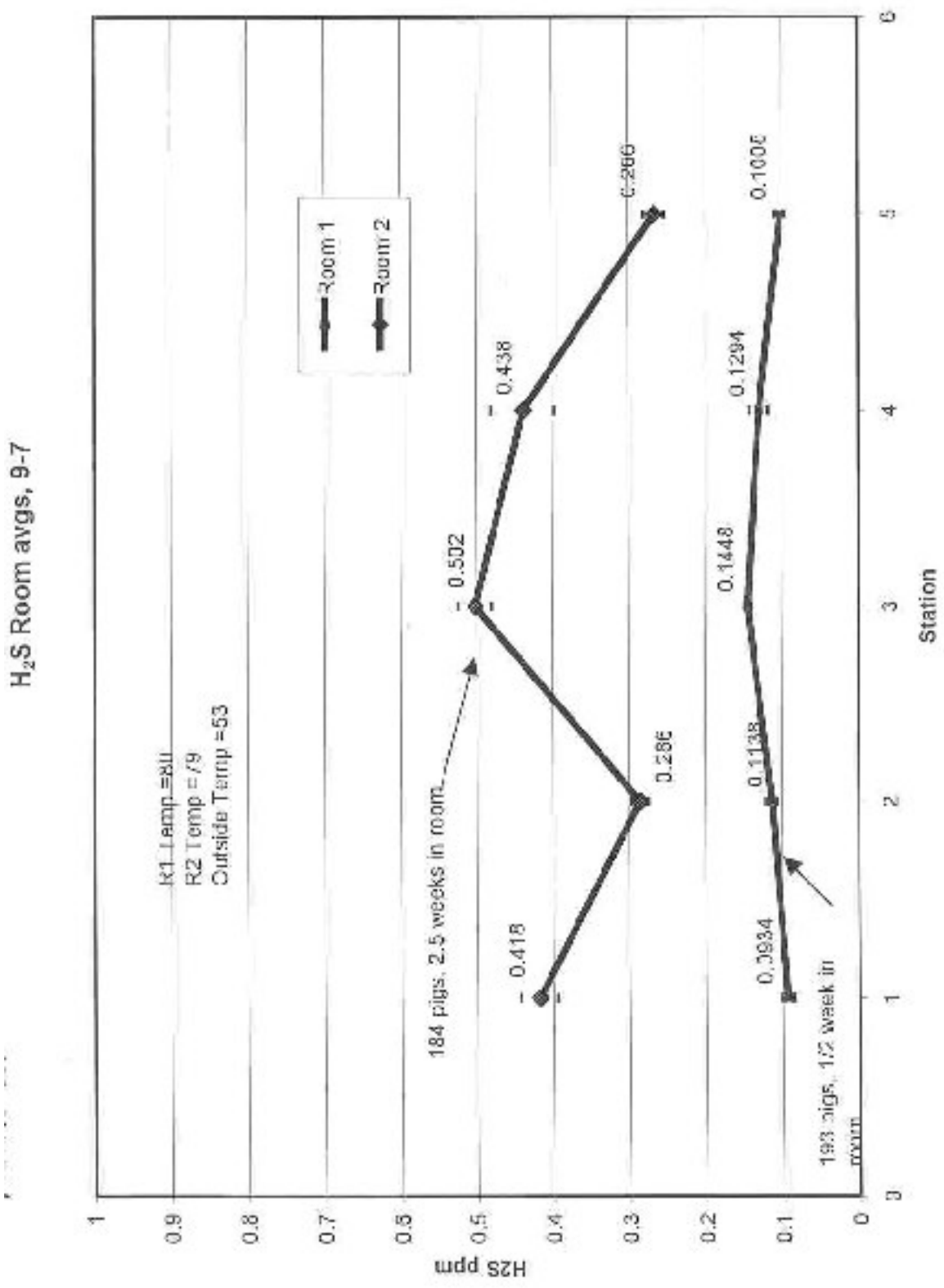

H2S Room avgs, 9-7
R1 Temp =80
R2 Temp = 79
Outside Temp =53
Room 1
Room 2
184 pigs, 2.5 weeks in room
193 pigs, 1/2 week in room
0.418
0.502
0.438
0.286
0.1448
0.1294
0.1138
0.0934
0.1005
H2S ppm
Station

Figure 3

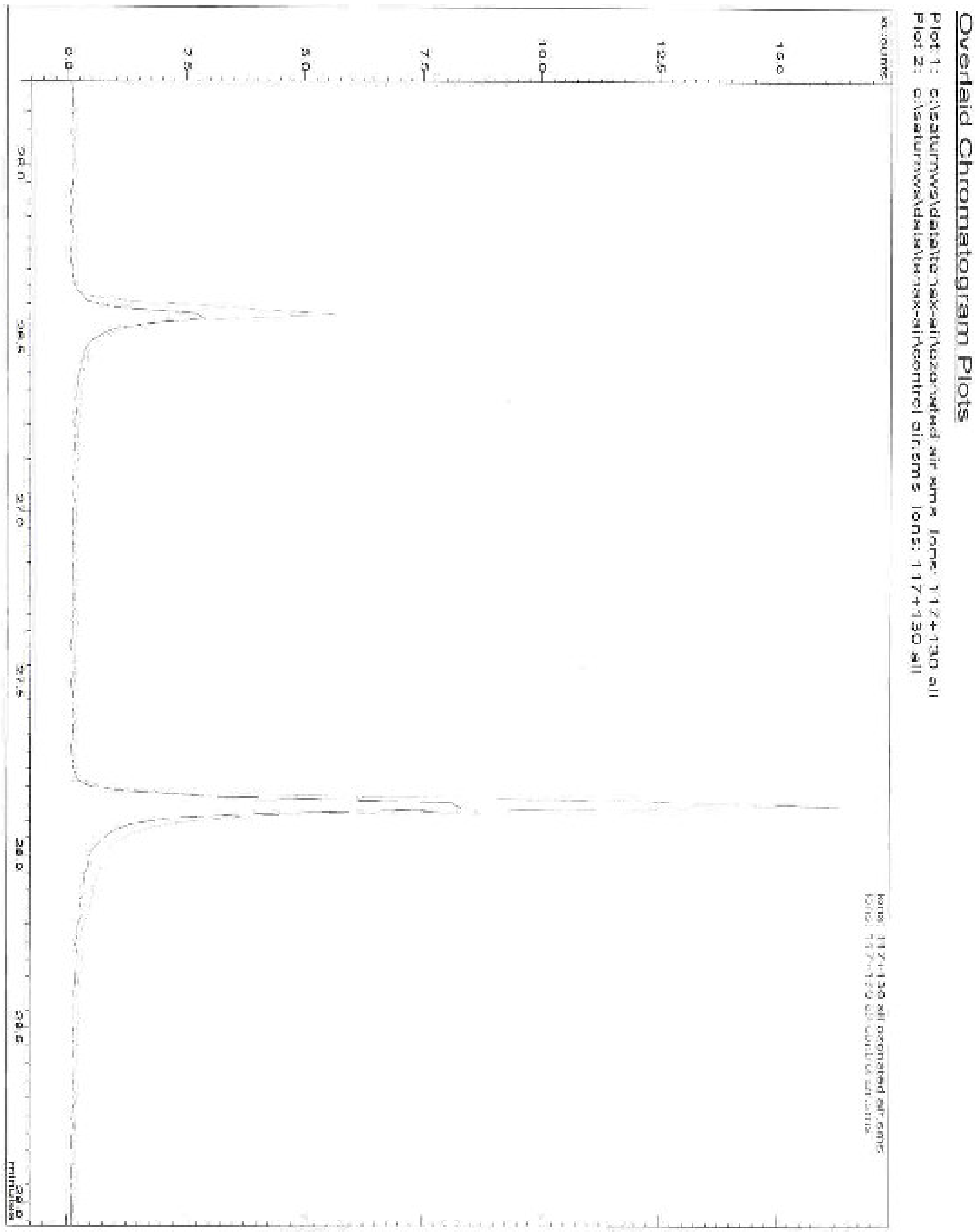

Overlaid Chromatogram Plots
kCounts
0.0
2.5
5.0
7.5
10.0
12.5
15.0
26.0
26.5
27.0
27.5
28.0
28.5
29.0
minutes

Figure 4

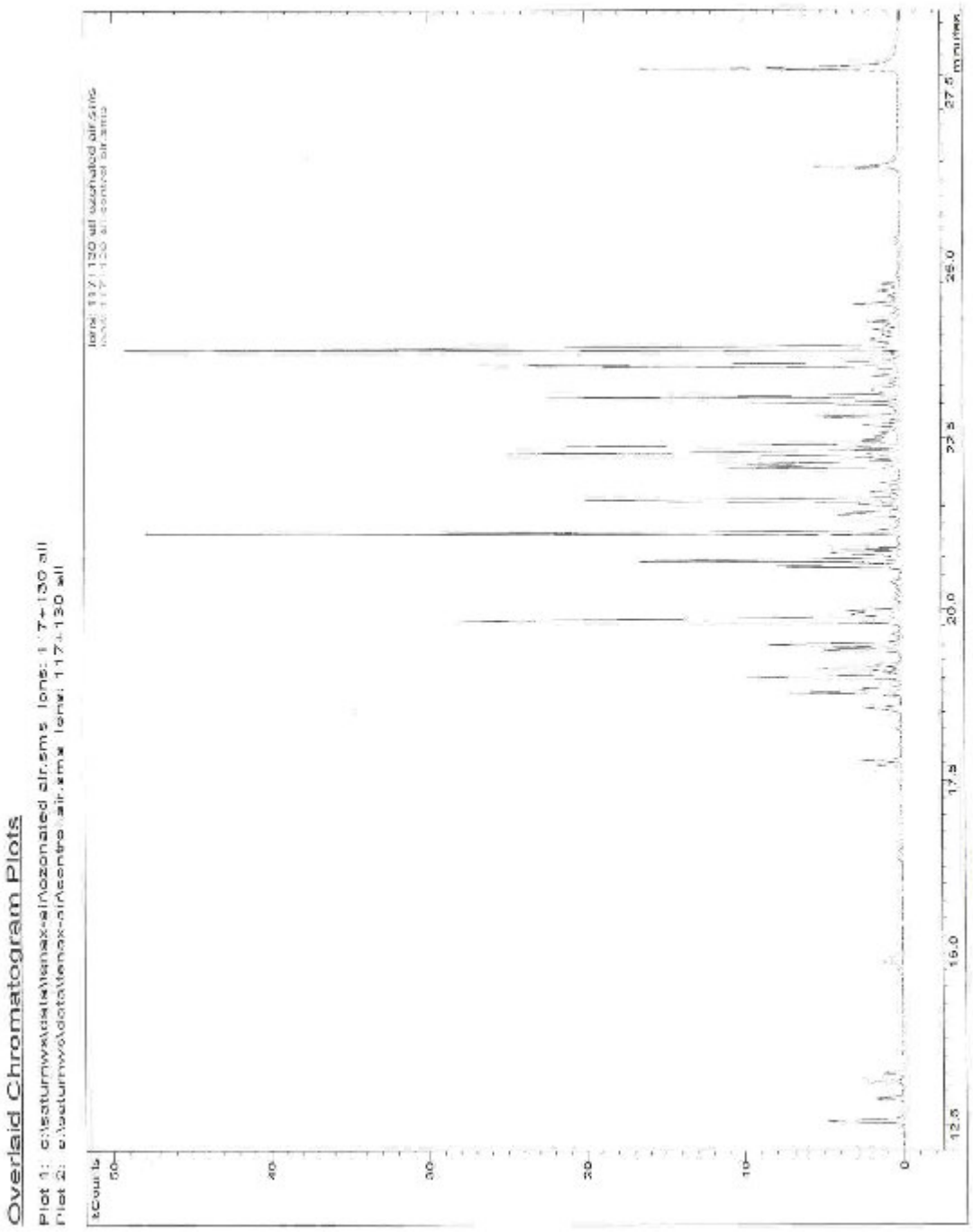
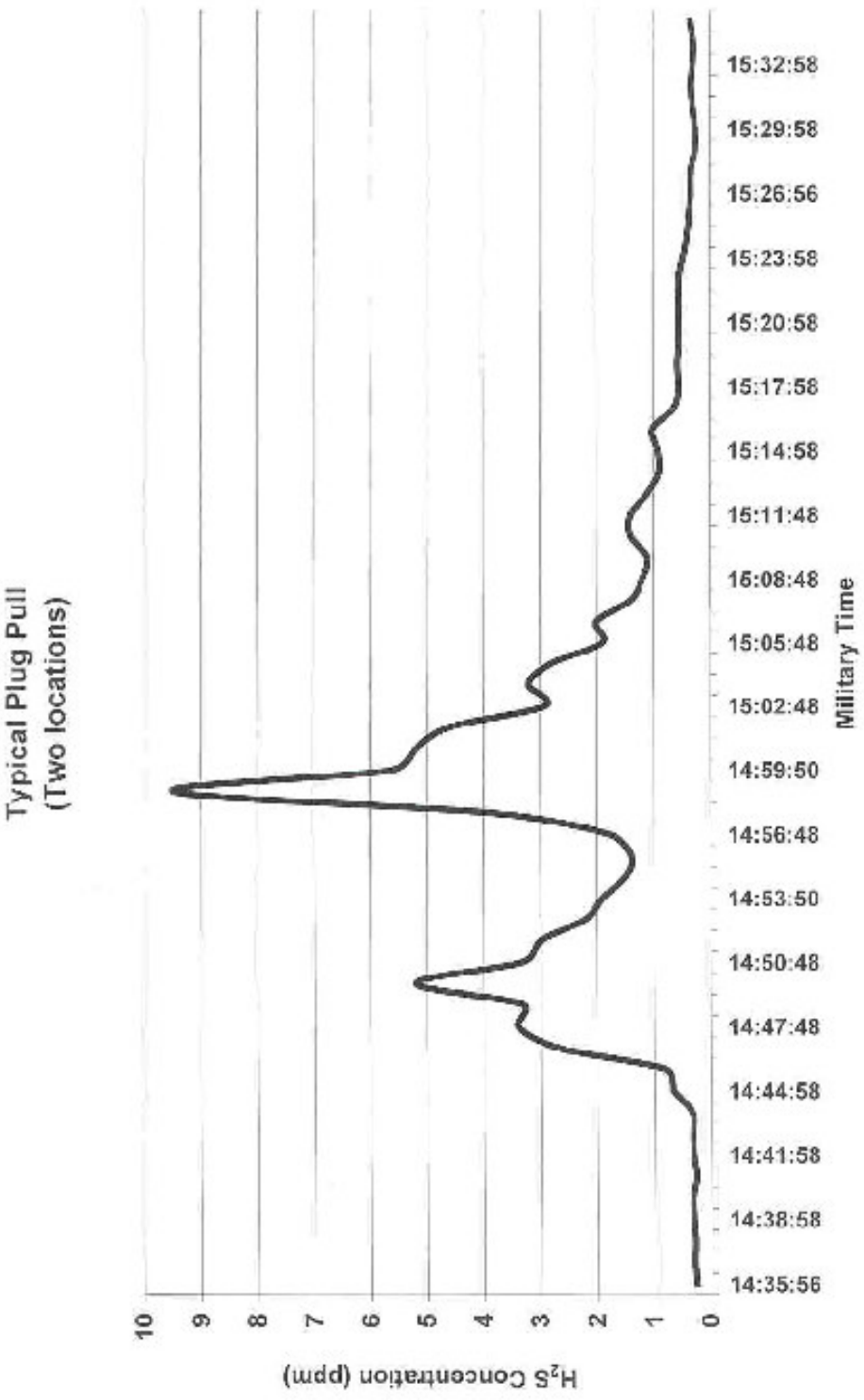

Overlaid Chromatogram Plots
Plot 1: c:\saturn\wsdata\ambax-air\ozonated air.sms Ions: 117+130 all
Plot 2: c:\saturn\wsdata\ambax-air\centre air.sms Ions: 117+130 all
Abundance
50
40
30
20
10
0
12.5
15.0
17.5
20.0
22.5
25.0
27.5
minutes

Figure 5


Typical Plug Pull
(Two locations)
H2S Concentration (ppm)
0
1
2
3
4
5
6
7
8
9
10
Military Time
15:32:58
15:29:58
15:26:56
15:23:58
15:20:58
15:17:58
15:14:58
15:11:48
15:08:48
15:05:48
15:02:48
14:59:50
14:56:48
14:53:50
14:50:48
14:47:48
14:44:58
14:41:58
14:38:58
14:35:56