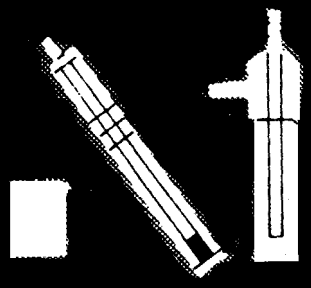
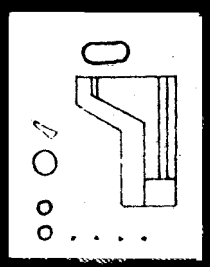
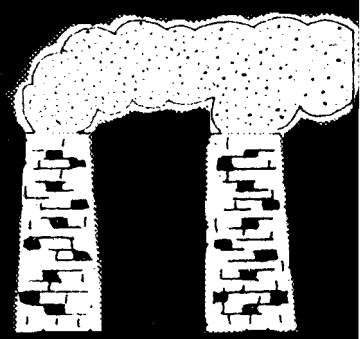
REPORT NO. 77-BAT-5







AIR POLLUTION EMISSION TEST

ESB, INCORPORATED

ALLENTOWN, PENNSYLVANIA

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Waste Management
Office of Air Quality Planning and Standards
Emission Measurement Branch
Research Triangle Park, North Carolina

Environmental Consultants

TEST REPORT

SULFURIC ACID EMISSIONS

from

ESB Battery Plant-Forming Room
Allentown, PA

by

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York Research Corporation
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Contract No. 68-02-1401, Task 34
Project No. 77-BAT-5
YRC Job No. 4-8479-34

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July 27, 1977

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FIGURES

SUMMARY OF TEST RESULTS

Tables S-1 through S-12 summarize the results of the sulfuric acid mist emission test program conducted on the Plate Forming Room at ESB, Incorporated in Allentown, Pennsylvania. Sulfuric acid mist, sulfur trioxide, and sulfur dioxide concentrations were measured at the inlet and outlet of a scrubber through which the fumes from the plate forming were vented. Tests were conducted during the forming cycle (1:00 PM to 5:00 AM); with and without a soapy foam covering the vats to reduce emissions.

The values designated as SO_3 represent sulfuric acid mist plus sulfur trioxide and the values presented as SO_2 represent only sulfur dioxide. Figures S-2 and S-3 summarize the with foam and without foam test data. The data points on all the graphs are the SO_3 concentration levels plotted at the time representing the midpoint of that particular test. The plots are the best fit lines derived by linear regression analysis. Figures S-4 through S-6 present the data from each day separately. Tables S-2 through S-6 present the data from each test day. The various problems encountered during the testing of this process are discussed in the text. Additional test data are provided in the computer data printouts in Appendix A.

TABLE S-1

TEST LOG

	INLET TEST NO./TIME	OUTLET TEST NO./TIME
Test Day 1	1/1930-2305	1/1930-2320
4/18, 19/77	2/0005-0505	2/0100-0427
With Foam		
Test Day 2	3/2119-2313	3/2105-2255
4/20/77	4/0100-0315	4/0055-0240
With Foam	5/0420-0522	5/0405-0450
Test Day 3	6/1311-1506	6/1325-1550
4/20,21/77	7/1615-1804	
Without Foam	8/1839-2023	7/1800-2125
	9/2100-2244	
	10/2310-0110	8/2230-0155
	11/0150-0445	9/0230-0500
Test Day 4	12/0130-0450	10/0170-0455
4/22/77		
With Foam		

FIGURE S-1

SO_3 REMOVAL EFFICIENCY vs TIME

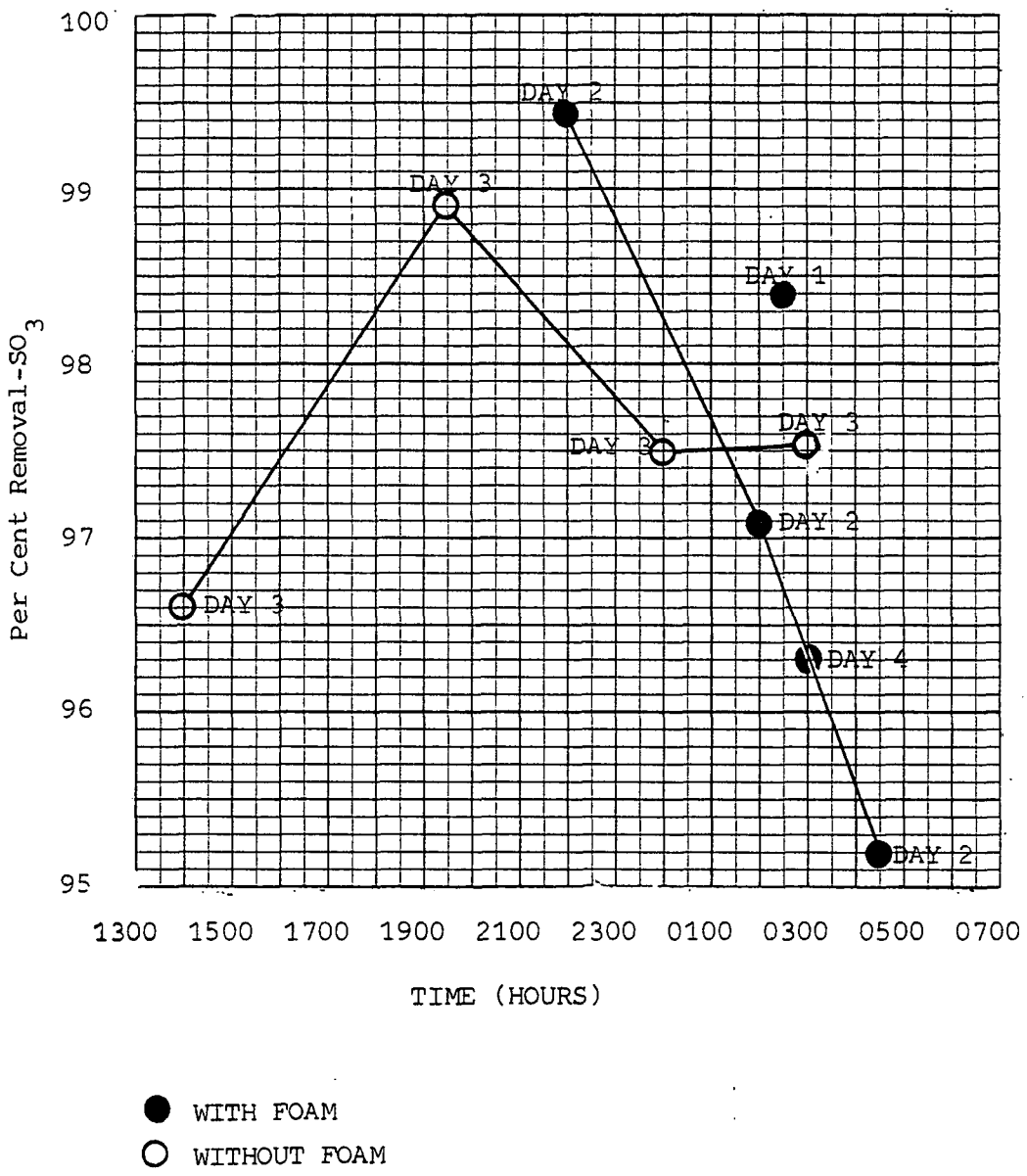


FIGURE S-2

WITH FOAM

Days 1, 2 and 4
□ - Inlet
○ - Outlet

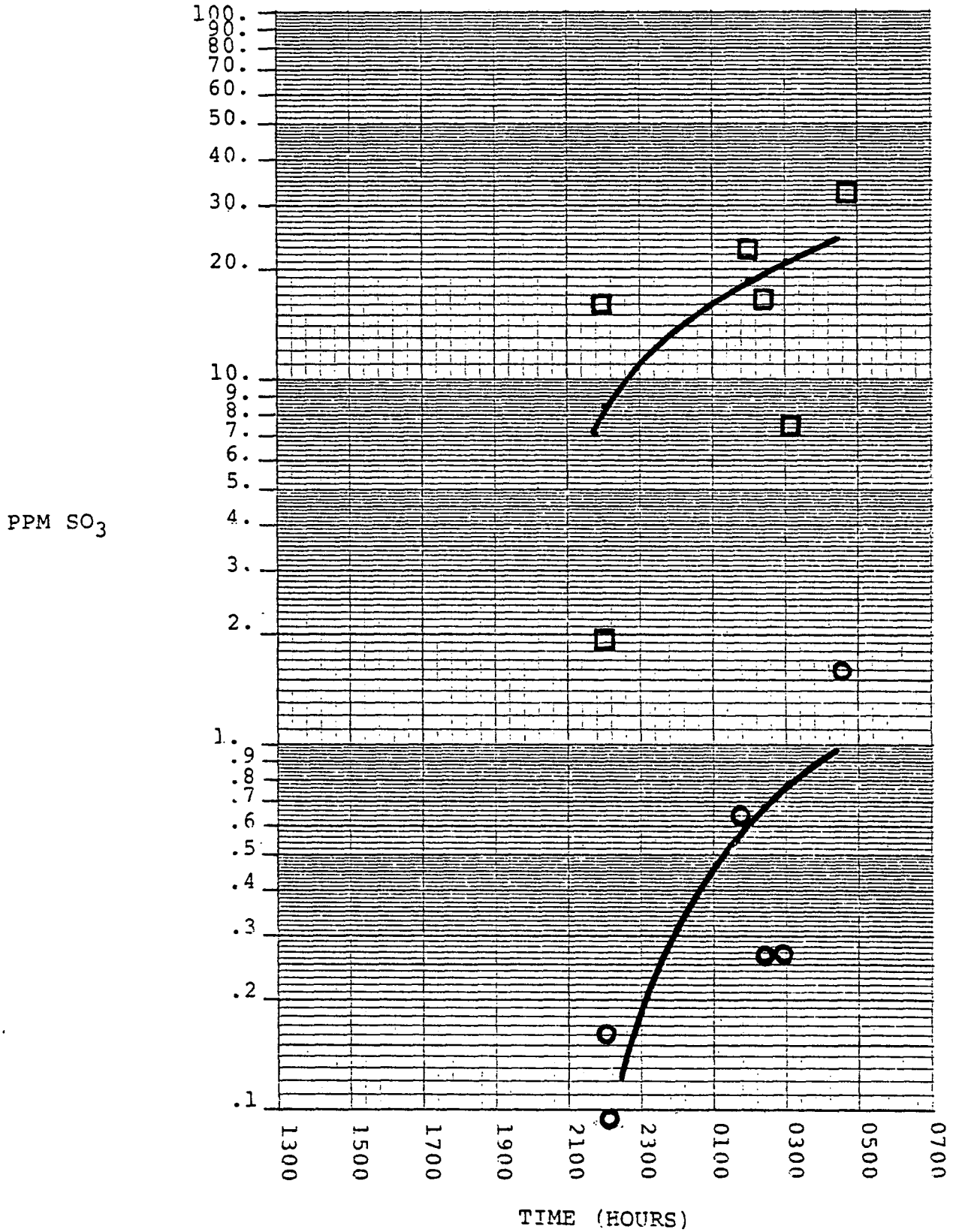


FIGURE S-3

WITHOUT FOAM

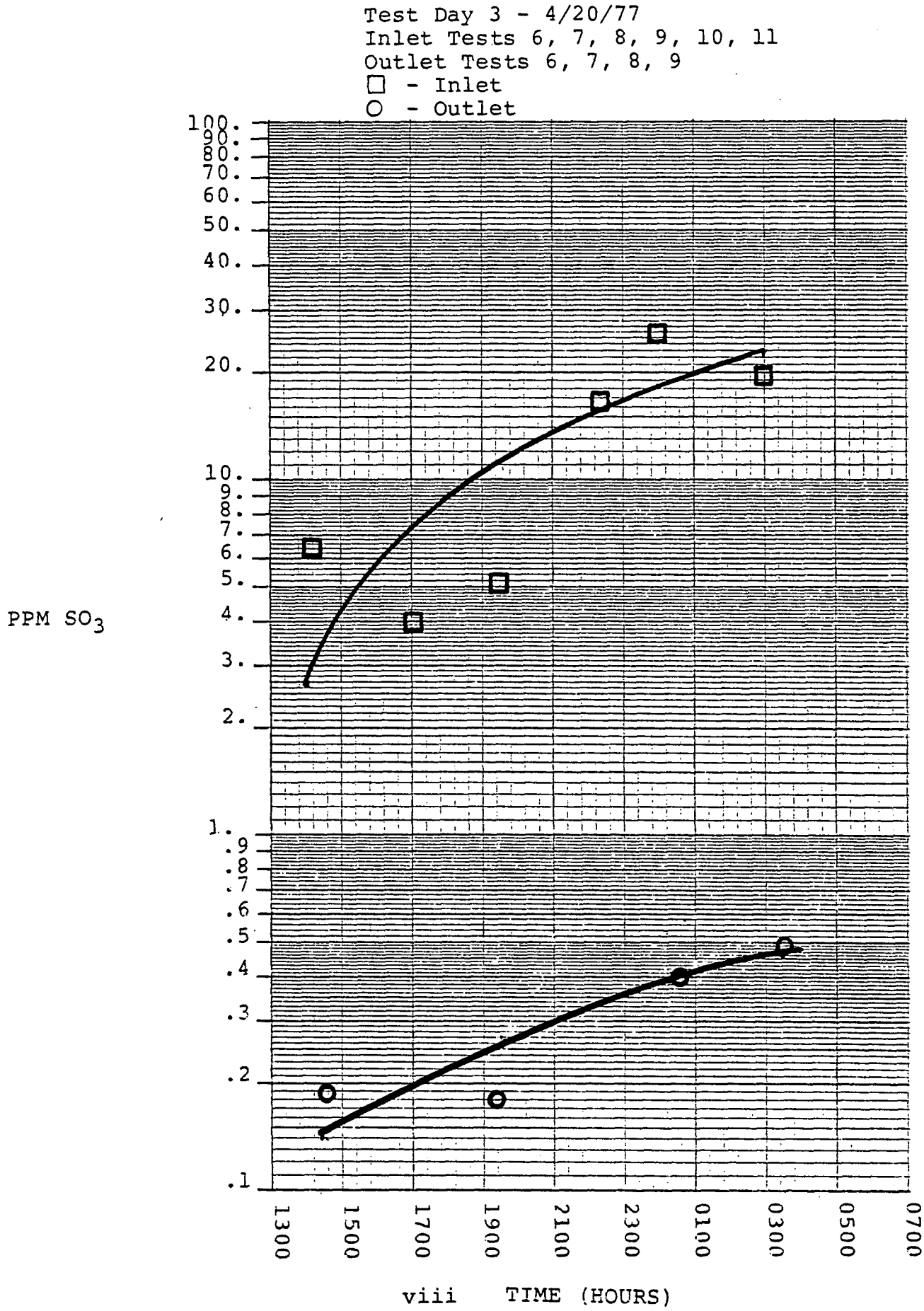


FIGURE S-4

WITH FOAM

Test Day 1 - 4/18,19/76
Tests 1, 2
□ - Inlet
○ - Outlet

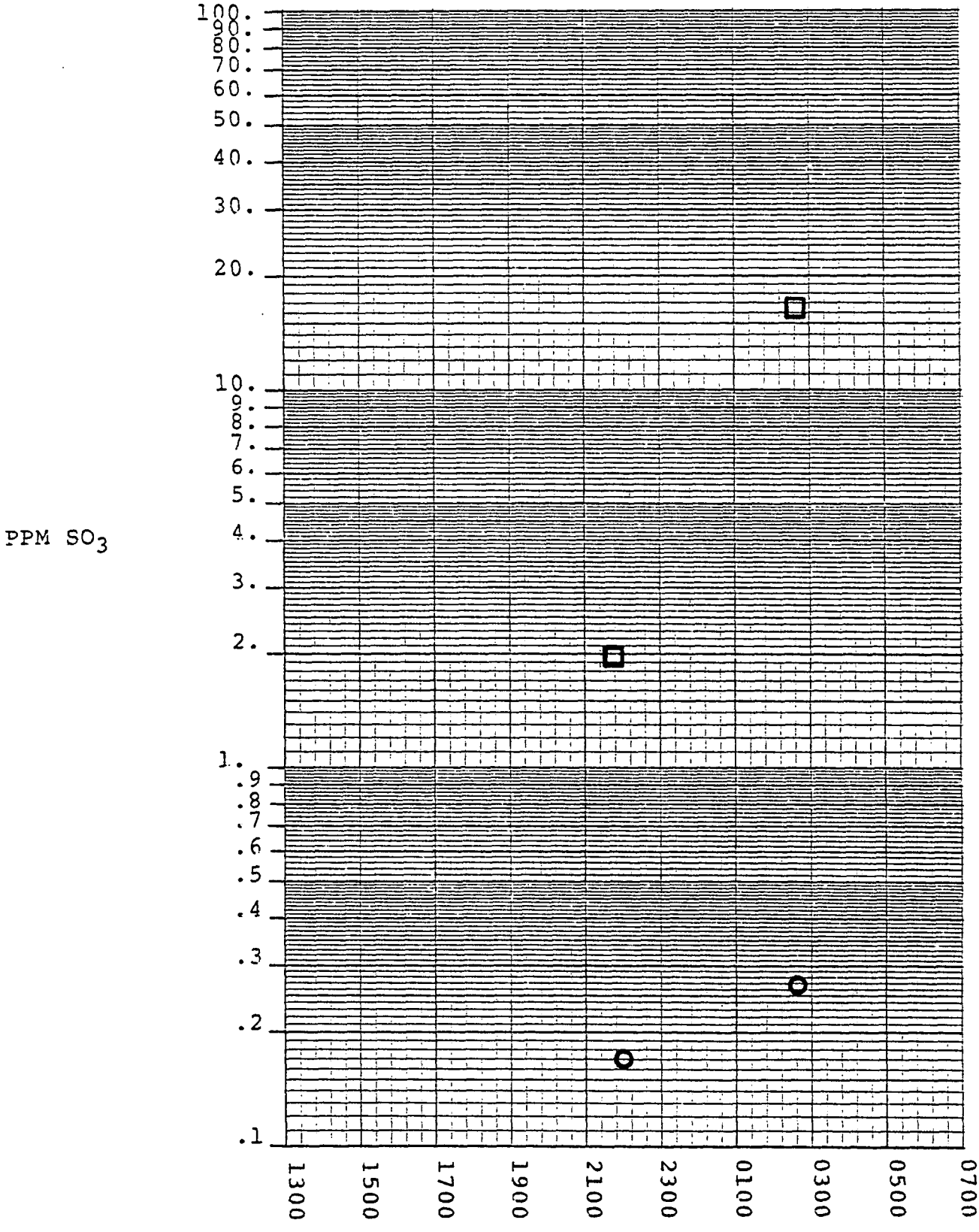


FIGURE S-5

WITH FOAM

Test Day 2 - 4/20/77
Tests 3, 4, 5
□ - Inlet
○ - Outlet

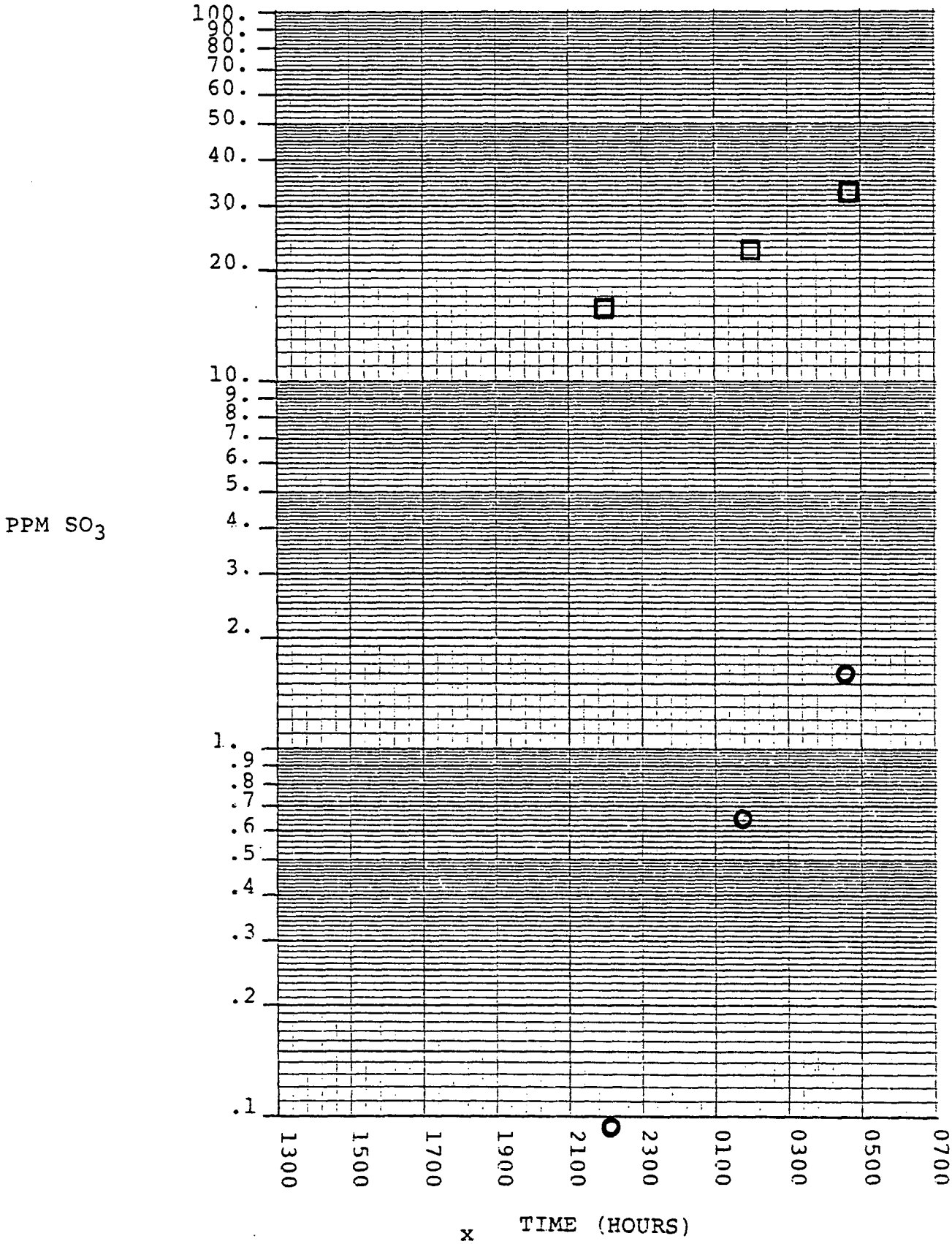


FIGURE S-6

WITH FOAM

Day 4 - 4/22/77
Inlet Test 12
Outlet Test 10
□ - Inlet
○ - Outlet

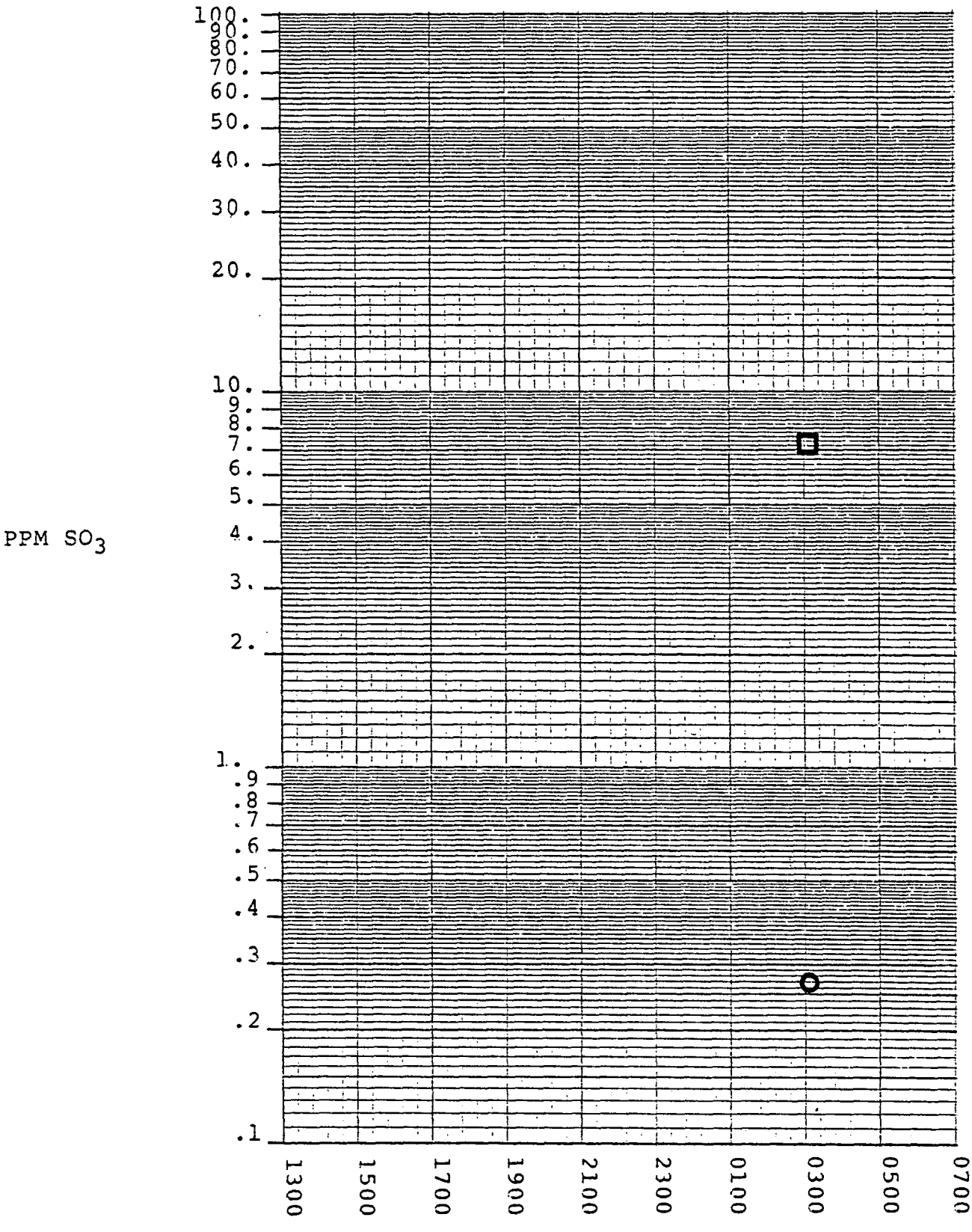


TABLE S-2. DAY 1 - WITH FOAM

INLET		
Test No.	1*	2
Time	1930-2305	0005-0505
ACFM	3094.0	2996.0
ACMM	87.56	84.79
SCFMD	2883.0	2775.0
DNCMM	81.59	78.53
SO_3 ppm	1.97	16.57
SO_3 lb/hr	0.070	0.57
SO_3 mg/cu.m	6.56	55.21
SO_2 ppm	0.12	0.066
SO_2 mg/cu.m	0.32	0.18

OUTLET		
Test No.	1*	2
Time	1930-2320	0100-0427
ACFM	4014.0	3418.0
ACMM	113.60	96.73
SCFMD	3794.0	3269.0
DNCMM	107.37	92.51
SO_3 ppm	0.17	0.26
SO_3 lb/hr	0.0080	0.011
SO_3 mg/cu.m	0.57	0.87
SO_2 ppm	0.010	0.0
SO_2 mg/cu.m	0.026	0.0

* Questionable results

TABLE S-3. DAY 2 - WITH FOAM

INLET

Test No.	3	4	5
Time	2119-2313	0100-0315	0420-0522
ACFM	3250.0	3078.0	3293.0
ACMM	91.98	87.11	93.19
SCFMD	2938.0	2784.0	2969.0
DNCMM	83.15	78.79	84.02
SO_3 ppm	16.01	22.86	32.86
SO_3 lb/hr	0.58	0.79	1.21
SO_3 mg/cu.m	53.34	76.17	109.49
SO_2 ppm	0.0	0.49	0.55
SO_2 mg/cu.m	0.0	1.31	1.47

OUTLET

Test No.	3	4	5
Time	2105-2255	0055-0240	0405-0450
ACFM	3290.0	3409.0	3521.0
ACMM	93.11	96.47	99.64
SCFMD	3079.0	3241.0	3338.0
DNCMM	87.14	91.72	94.47
SO_3 ppm	0.09	0.66	1.57
SO_3 lb/hr	0.0034	0.027	0.065
SO_3 mg/cu.m	0.30	2.20	5.23
SO_2 ppm	0.0	0.0	0.0
SO_2 mg/cu.m	0.0	0.0	0.0

TABLE S-4. DAY 3 - WITHOUT FOAM

INLET

Test No.	6	7	8
Time	1311-1506	1615-1804	1839-2023
ACFM	3273.0	2885.0	3126.0
ACMM	92.63	81.65	88.47
SCFMD	3005.0	2641.0	2861.0
DNCMM	85.04	74.74	80.97
SO_3 ppm	6.55	4.03	16.4
SO_3 lb/hr	0.24	0.13	0.58
SO_3 mg/cu.m	21.82	13.43	54.64
SO_2 ppm	0.54	0.17	0.034
SO_2 mg/cu.m	1.44	0.45	0.091

OUTLET

Test No.	6	7
Time	1325-1550	1800-2125
ACFM	3585.0	3800.0
ACMM	101.46	107.54
SCFMD	3390.0	3595.0
DNCMM	95.94	101.74
SO_3 ppm	0.19	0.18
SO_3 lb/hr	0.0080	0.0080
SO_3 mg/cu.m	0.63	0.60
SO_2 ppm	0.073	0.050
SO_2 mg/cu.m	0.19	0.13

TABLE S-5. DAY 3 - WITHOUT FOAM (CONT.)

INLET

Test No.	9	10	11
Time	2100-2244	2310-0110	0150-0445
ACFM	3032.0	3105.0	2957.0
ACMM	85.81	87.87	83.68
SCFMD	2775.0	2837.0	2697.0
DNCMM	78.53	80.29	76.33
SO_3 ppm	16.4	26.1	19.57
SO_3 lb/hr	0.56	0.92	0.66
SO_3 mg/cu.m	54.64	86.96	65.21
SO_2 ppm	0.0	0.0	0.0
SO_2 mg/cu.m	0.0	0.0	0.0

OUTLET

Test No.	8	9
Time	2230-0155	0230-0500
ACFM	3468.0	3342.0
ACMM	98.14	94.58
SCFMD	3286.0	3158.0
DNCMM	92.99	89.37
SO_3 ppm	0.41	0.48
SO_3 lb/hr	0.017	0.19
SO_3 mg/cu.m	1.37	1.60
SO_2 ppm	0.0	0.0
SO_2 mg/cu.m	0.0	0.0

TABLE S-6. DAY 4 - WITH FOAM

INLET	
Test No.	12
Time	0130-0450
ACFM	3067.0
ACMM	86.80
SCFMD	2744.0
DNCMM	77.66
SO_3 ppm	7.33
SO_3 lb/hr	0.25
SO_3 mg/cu.m	24.42
SO_2 ppm	0.0
SO_2 mg/cu.m	0.0
OUTLET	
Test No.	10
Time	0120-0455
ACFM	3114.0
ACMM	88.13
SCFMD	2905.0
DNCMM	82.21
SO_3 ppm	0.27
SO_3 lb/hr	0.0097
SO_3 mg/cu.m	0.90
SO_2 ppm	0.0
SO_2 mg/cu.m	0.0

1.0 INTRODUCTION

York Research Corporation was contracted by the Emissions Measurement Branch of the Environmental Protection Agency to perform a source emission survey on a lead acid battery plate forming room at ESB, Incorporated, located in Allentown, Pennsylvania. The objective of the test program was to measure the concentrations of H_2SO_4 mist vented to the atmosphere from the forming room.

The forming room operates between approximately 1300 hours and 0500 hours on a five day per week schedule. The battery plates are immersed in a sulfuric acid solution and an electrical current is applied. The process releases hydrogen bubbles through the solution, causing the emission of H_2SO_4 mist.

Emissions are controlled by two techniques:

- Covering the vats with a soapy foam to contain the mist.
- Venting the room through a scrubber to the atmosphere.

Tests were conducted during the week of April 18, 1977. The inlet and outlet of the scrubber were tested simultaneously during the forming cycle (with and without foam applied).

Those present during the test program were:

Lee Beck	U.S. EPA Emissions Standards and Engineering Division
Daniel Bivins	U.S. EPA Emissions Standards and Engineering Division
Jonathan Gardner	York Research Corporation
John Gale	York Research Corporation
Richard Keith	York Research Corporation
William Cesareo	York Research Corporation
Louis Millspaugh	York Research Corporation
Michael Ziskin	York Research Corporation
James Cassermere	York Research Corporation
Stephen Wahlig	York Research Corporation
Stephen Creaturo	York Research Corporation

2.0 TECHNICAL APPROACH

2.1 Test Locations

The inlet sampling ports were located in a horizontal section of ductwork connecting the forming room to the scrubber (Figure 2-1). Two ports (90° apart) were installed approximately 2 diameters upstream from the scrubber. The inside diameter of this duct measured 20¼ inches. Ten points were sampled per port resulting in a total of 20 separate points. The sampling time for each point varied as the test duration was changed.

The outlet sampling ports were located in the stack (ID 20½ inches) approximately two diameters from the exit. The two ports were 90° apart. Ten points were sampled per port simultaneously with the inlet test location.

2.2 EPA Method 8

Sulfuric acid mist, sulfur trioxide and sulfur dioxide concentrations were measured in accordance with EPA Method 8[1]. This method requires isokinetic sampling of the gas stream in order to collect a representative sample of sulfuric acid mist.

The sampling train consisted of a glass-lined heated probe, four Greenburg Smith impingers immersed in an ice bath, and a Pyrex glass filter holder. An umbilical cord connected the probe and impingers to the control console. The control console contained a vacuum pump, dry gas meter, calibrated orifice, and dual manometers. A Type "S" pitot tube and thermocouple were attached to the probe to provide gas stream pressure differential and temperatures at each point. Velocity pressure (Δ P) and the pressure drop across the orifice (Δ H) were observed from the dual manometer as inches of water.

Isokinetic sampling was maintained by the use of a nomograph which correlated velocity pressure (Δ P), and orifice pressure drop (Δ H).

The front half of the train (probe, first impinger, and filter) removed sulfuric acid mist and sulfur trioxide from the gas sample. The first impinger (which was a Greenburg-Smith design) contained 100 ml of 80% isopropanol. Mist which was not collected in the isopropanol was trapped by the filter. At completion of the test, the isopropanol (with filter and wash of the front half) was placed in a glass sample jar for subsequent analysis. This sample was designated as the SO_3 sample.

The back half of the train consisted of the second and third impingers. Each contained 100 ml of 3% H_2O_2 to absorb sulfur dioxide from the gas sample. The contents of the two impingers, plus washes, were designated as the SO_2 sample.

The samples were analyzed at the test location titrametrically utilizing barium perchlorate. The percent moisture content in the sampled stream was determined by means of a separate moisture train because Method 8 proved unsuitable for measurement of moisture content.

Two moisture tests were performed at each location, and the results averaged.

[1] Federal Register, Voo. 40; 36 FR 24876, Dec. 23, 1971

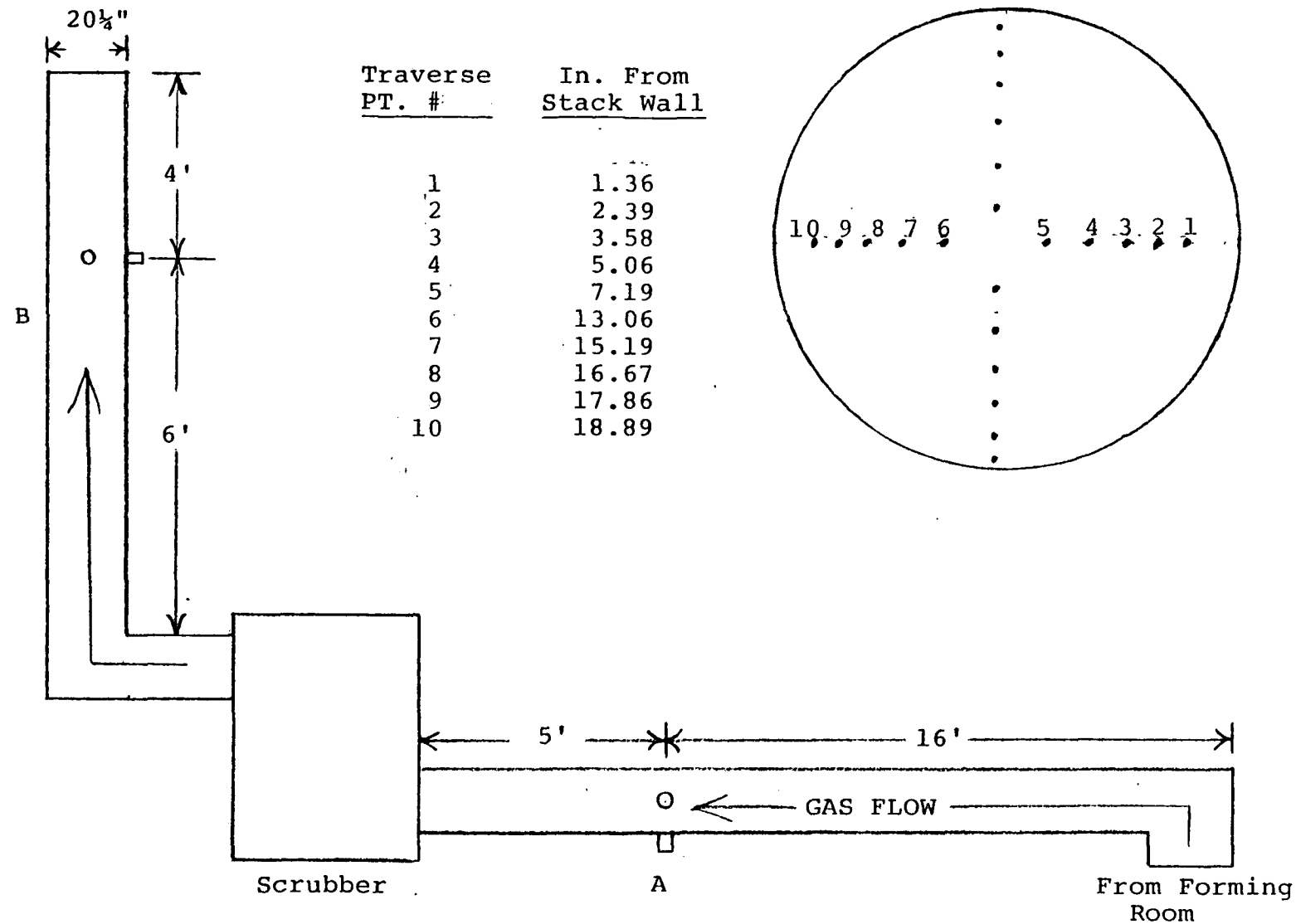
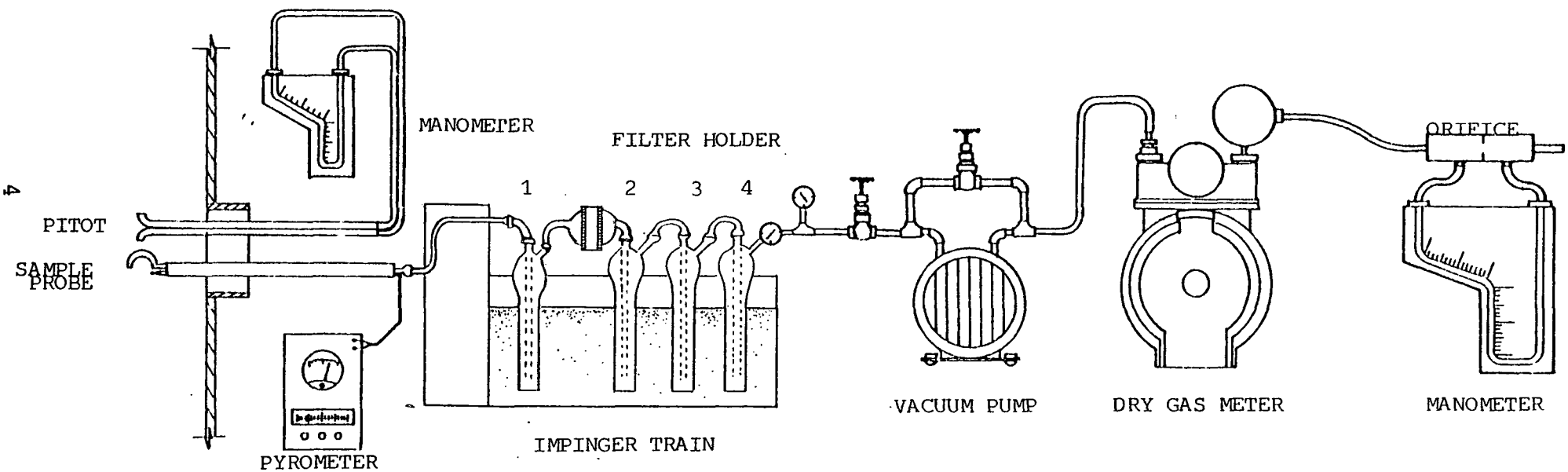


FIGURE 2-1 - H_2SO_4 SCRUBBER SAMPLING POINTS A & B



EPA METHOD 8

SAMPLING TRAIN

FIGURE 2-2

Gas analysis was determined in accordance with EPA Method 3. An integrated gas sample was collected in a flexible Tedlar bag and analyzed with an Orsat Analyzer. The gas composition was found to be characteristic of ambient air.

3.0 DISCUSSION OF RESULTS

Various problems were encountered during the testing; some of which may affect the test results.

Upon completion of the first test run, it was apparent that most of the isopropanol had evaporated from the first impinger; leaving only 10-20 ml. A similar problem had been observed in previous testing, however to a lesser degree (only 10-20 ml had been lost). It was decided that the increased amount of isopropanol loss was due to the abnormally long test duration of four hours as compared with the usual one or two hour tests. The response to the evaporation difficulties was to add isopropanol whenever the level was in danger of exposing the impinger tip. Considering this circumstance, the results from Test No. 1 should be viewed with suspicion.

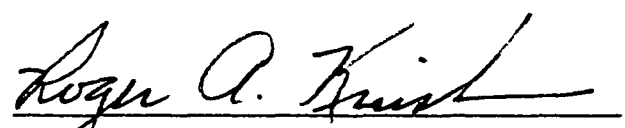
Another testing difficulty which resulted in a deviation from the prescribed method was related to the ambient concentrations of sulfuric acid mist. The forming rooms at ESB are located inside the general plant building. Acid mist leaking out of the various cracks and holes in the room under test, and out of the two other forming rooms in the building resulted in high ambient concentrations of acid mist which caused discomfort to the test engineers even when respirators were worn. When three test engineers on the first night shift (when the ambient concentrations were the worst) produced disturbing medical symptoms, it was decided to modify the inlet test procedure so that the test engineers would not have to remain in the high ambient concentrations of sulfuric acid mist. To accomplish this, the sample train was placed at a point of average velocity and operated for the designated test time, recording test data only at the beginning and end of the test. This allowed the engineers to stay in an uncontaminated area during the test period. The even gas flow conditions at the inlet permitted representative samples to be obtained with this modification, although the volumetric flow rates from these tests (8-12) should not be considered as accurate as those measured with a full traverse.

The concentrations of SO_3 measured, ranged from a maximum of 33 ppm at the inlet to a minimum of 0.1 ppm at the outlet. Method 8 was designed to measure higher concentrations, therefore, by extending the test duration (4 hours on the outlet) to obtain a larger sample volume, it was possible to measure very low SO_3 concentrations with this method.

Prepared by:

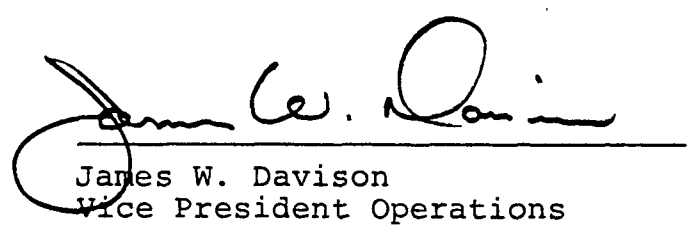
Jonathan B. Gardner
Project Director

Reviewed by:



Roger A. Kniskern
Manager Emissions Measurement

Approved by:



James W. Davison
Vice President Operations