MRI REPORT

SULFURIC ACID EMISSION TESTING OF A POWER PLANT

at

Shawnee Power Station
Paducah, Kentucky

EPA Project Report No. 74-SPP9

by

William H. Maxwell

Midwest Research Institute
EPA Contract No. 68-02-0228

MRI Project No. 3585-C, Task 41

For

Emission Measurements Branch
Office of Air Quality Planning and Standards
Environmental Protection Agency
Research Triangle Park, North Carolina 27711

Attn: Mr. Peter R. Westlin

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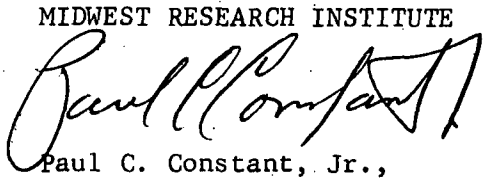
PREFACE

The work reported herein was conducted by Midwest Research Institute (MRI) under Environmental Protection Agency (EPA) Contract No. 68-02-0228, Task No. 37, Change No. 1.

The project was under the technical supervision of Mr. Paul C. Constant, Jr., Head, Environmental Measurements Section of the Physical Sciences Division. Mr. William Maxwell served as Crew Chief and was assisted by Messrs. Emile Baladi, George Cobb, Bruce DaRos, and John Kitko. Miss Christine Guenther was responsible for the data reduction and computer analysis. The analysis of the samples was done by Mr. Thurmon Oliver.

Approved for:

MIDWEST RESEARCH INSTITUTE



Paul C. Constant, Jr.,
Program Manager

21 May 1974

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I. INTRODUCTION

This report presents the results of source testing performed by Midwest Research Institute on a pilot-plant scale wet scrubber at the Shawnee Power Station, Paducah, Kentucky. Three tests each for H_2SO_4 mist and SO_2 were run on the inlet and outlet ducts to the scrubber.

The purpose of the testing was to determine the efficiency of a wet scrubber in removing H_2SO_4. The data were to be used in conjunction with comparison tests of in-stack and EPA Method 5 particulate sampling methods.

The scope of work for this project specified: three simultaneous tests on the inlet and outlet of the scrubber to be completed in accordance with the Federal Register, Vol, 36, No. 159, Part II, 17 August 1971. Sampling was completed with one test being run on 19 February 1974 and two tests on 20 February 1974.

The following sections of this report present: (1) the summary of results, (2) the process description, (3) the location of sampling ports, (4) sampling and analytical procedures, and (5) a discussion.

II. SUMMARY OF RESULTS

Table I contains a summary of results for this testing. A complete listing of the data and computer printout of the calculations is found in Appendix A. Sample calculations are found in Appendix B.

The O_2 data used in the determination of the stack-gas molecular weight were obtained from the plant process information by EPA. The CO_2 and CO data are representative of values obtained at other coal-fired power plants tested. Orsat analyses were not run during this testing.

The values listed on the computer printout for the amount of water collected are assumed values computed from moisture concentrations of 7% and 20% by volumes for the inlet and outlet ducts, respectively.

TABLE I

SUMMARY OF RESULTS

		Run Number					
		1-Inlet	1-Outlet	2-Inlet	2-Outlet	3-Inlet	3-Outlet
Concentration of H_2SO_4	- lb/dscf	0.00000082	0.00000043	0.00000352	0.00003170	0.00017006	0.00000825
	- mg/ncm	13.1	7.0	56.4	507.7	2,724.1	132.1
	- ppm	3.2	1.7	13.9	125.1	671.0	32.5
	- lb/hr	0.7	0.3	3.2	26.6	150.8	7.5
	- kg/hr	0.3	0.2	1.5	12.1	68.4	3.4
	- g/dscf	0.0057	0.0030	0.0247	0.2219	1.1904	0.0577
	- g/acf	0.0037	0.0024	0.0168	0.1764	0.8017	0.0457
Percent efficiency of removal[a/]		46.875		--		95.156	
Concentration of SO_2 (total)	- lb/dscf	0.00019421	0.00005993	0.00037156	0.00011591	0.00030421	0.00004210
	- mg/ncm	3,110.8	959.9	51.8	1,856.6	4,872.9	674.4
	- ppm	1,173.3	362.0	2,244.7	700.2	1,837.9	254.3
	- lb/hr	167.8	48.1	339.1	97.1	269.8	38.4
	- kg/hr	76.1	21.8	153.8	44.1	122.4	17.4
	- g/dscf	1.3594	0.4194	2.6010	0.8114	2.1295	0.2948
	- g/acf	0.8801	0.3287	1.7675	0.6451	1.4341	0.2332
Percent efficiency of removal[a/]		69.146		68.807		86.164	

a/ Obtained from ppm values

III. PROCESS DESCRIPTION

The Shawnee Power Station, operated by The Tennessee Valley Authority (TVA), is a coal-fired, steam-generation station, having 10 turbines, each served by a boiler and stack. A portion of the exhaust gases from one of these stacks is diverted for use with three pilot-plant scale wet scrubber systems. It was on one of these wet scrubber systems that the current testing was done. Figure 1 presents a flow diagram of the operation, showing the inlet and outlet sampling sites.

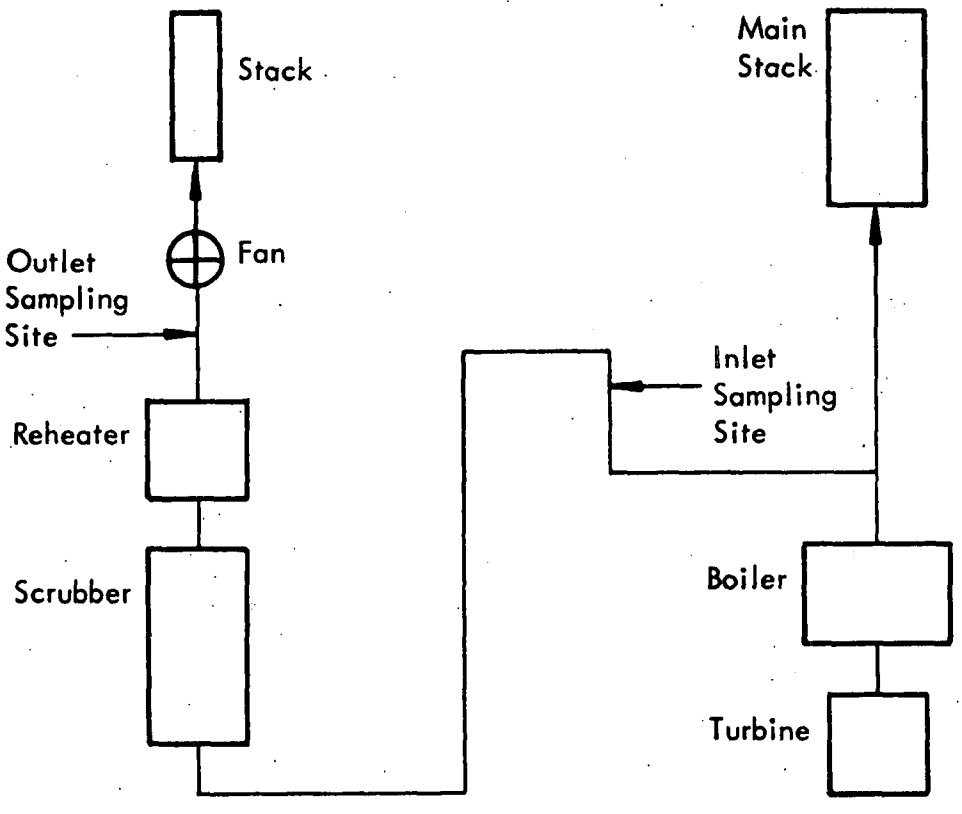


Figure 1 - Flow Diagram of Plant Operation

The scrubber tested was a Bechtel Turbulent contact absorber designed to handle approximately 30,000 cfm of exhaust gas. Water was the scrubbing medium flowing concurrently over plastic spheres in the scrubber main chamber. Downstream of the scrubber were a demister and a reheater.

IV. LOCATION OF SAMPLING PORTS

Both sampling locations were sited in enclosed sheds as protection against the weather. Existing 4 in. ID ports were utilized. Due to the proximity of the shed wall to one of the outlet ports, complete traversing on that port could not be accomplished. It was decided on-site by EPA and MRI personnel to run two traverses in the accessible port instead of only partially traversing in the blocked port. It was indicated that the sites had been selected to comply with EPA guidelines so the minimum number of points, 12, was used for the 2-hr tests. Figure 2 shows a schematic layout of the sampling sites and ports used.

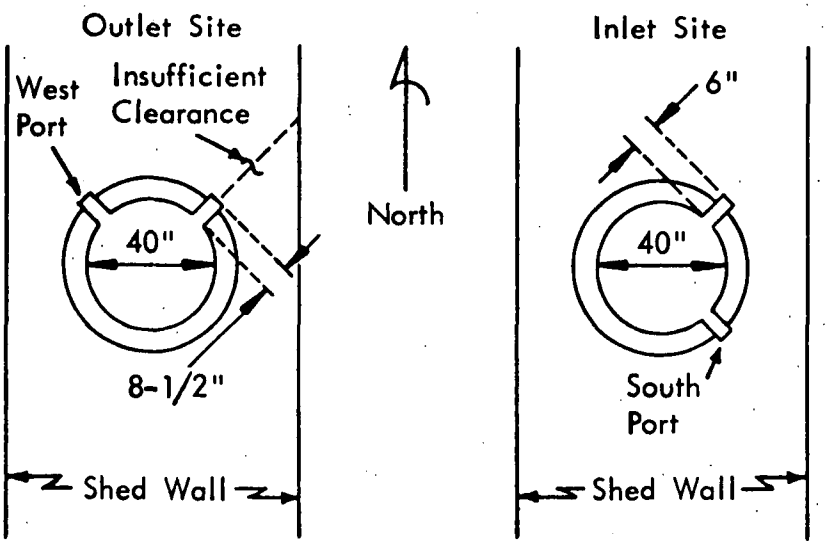


Figure 2 - Schematic of Sampling Sites

V. SAMPLING AND ANALYTICAL PROCEDURES

The samples were taken with Research Appliance Company (RAC) Model 2243 "Stacksamplr" equipment, as modified by MRI. Sampling train specifications were in accordance with the Federal Register, "Method 8 - Determination of Sulfuric Acid Mist and Sulfur Dioxide Emissions from Stationary Sources," Vol. 36, No. 159, 17 August 1971, with the following exceptions:

1. An additional Greenburg-Smith impinger containing 100 ml of 80% isopropanol was placed in front of the filter between the isopropanol and hydrogen peroxide. This gave a total of five impingers: two isopropanol, two hydrogen peroxide, and one silica gel.

2. Due to the ash content of the inlet duct, a cyclone and a filter were placed in front of the first isopropanol impinger. After the first run, this was also done for the outlet duct.

3. The system was purged for 30 min following each test. These exceptions were done upon the suggestion and approval of EPA.

Sample recovery was done in the field in accordance with the Federal Register except that the filters were not added to the isopropanol wash of the probe and cyclone or the contents of the first two impingers until they were returned to the lab at MRI.

The analytical procedures were those described in the Federal Register. Due to the presence of the fly-ash material, in addition to the filter material in the isopropanol solution, this solution was filtered prior to analysis to observe the end point more easily.

VI. DISCUSSION

Sampling was done simultaneously on both sites over a 2-hr period. There were two, six-point traverses per run, with each point sampled for 10 min. Data were recorded every 5 min. During the first run, it was discovered that a 4-min timer was being used on the outlet duct, resulting in 8-min points on the first traverse. As the second traverse consisted merely of a retracing of the first in the same port, the same timer was used but for 12-min points on the second traverse to get the 2-hr total sample time.

Large meter vacuum readings were encountered during the sampling periods on both ducts. This resulted partially from the high stack vacuum, reported as being 14 in. of water, the increased number of impingers and filters over that normally used for particulate sampling, and the high stack grain loading which tended to plug the first filters. At the higher vacuum readings, the silica gel, on occasion, tended to boil, i.e., be physically lifted by the gas flow in the impinger. Due to the higher vacuums, it became necessary to replace the first filter on the inlet train in order to maintain isokinetic sampling conditions. This was done once for runs 1 and 2 and twice on run 3.

Complete traversing could be effected on the inlet duct but the train could not be removed from the stack without first disconnecting the probe. Due to the high stack vacuum, this resulted in the loss of any sample contained in the probe. However, due to the large amount of mass collected by the cyclone and filter, the loss is believed to be negligible.

During run 3, on the inlet duct, it was observed that the hydrogen peroxide from the last impinger of the train was spilling over into the silica gel impinger due to the large amount of froth resulting from the bubbling action of the gas on the liquid. This did not cease even when the first filter was replaced. No determination could be made as to how much was lost but the resulting SO_2 data could be biased.

When the samples were opened at MRI, it was noticed that all of the hydrogen peroxide samples smelled of isopropanol indicating the perhaps some of the isopropanol was carried over through the filter to the hydrogen peroxide. This was not physically observed in the field.

At least one reference (Industrial Source Sampling, Brenchley, Turley, and Yarmac) states that Method 8 sampling should not be used on any source having a high particulate load which could cause interferences with the wet chemical analysis. It is not known how this particulate load would affect the sampling under study or if filtering the sample will remove the interferences.

APPENDIX A

RESULTS OF ANALYSIS - PRINTOUT OF COMPUTER CALCULATIONS

DATA AND CALCULATED VALUES

RUN- 1-I DATE- 02-19-74

ATMOS TEMP (DG.F)	ATMOS PRES (I.HG)	STACK VAC (I.H2O)	H2O COND (ML)	WT-PTL (MG)	WT-TTL (MG)	STACK AREA (FT2)	INIT VOL (DCF)	PERC O2 DRY	PERC CO2 DRY	PERC CO DRY	PITOT TUBE COEF
45.0	29.15	14.00	102.1			8.73	758.74	3.5	11.0	0.0	.850

PORT-POINT		SAMP TIME (MIN)	METER VOL (DCF)	DELTA P (I.H2O)	DELTA H (I.H2O)	TEMP IN (D.F)	TEMP OUT (D.F)	TRAIN VAC (I.HG)	STACK TEMP (D.F)	BOX TEMP (D.F)	PROBE T DIA (IN)	VEL (FPM)
S	1	5.00	761.36	.350	.910	60.0	47.0	8.0	310.0		.250	2502.2
S	1	5.00	763.93	.360	.930	70.0	48.0	8.0	309.0	60.0	.250	2536.1
S	2	5.00	766.67	.440	1.140	81.0	51.0	8.0	320.0		.250	2823.7
S	2	5.00	769.47	.450	1.160	86.0	53.0	9.0	316.0	65.0	.250	2848.3
S	3	5.00	772.26	.410	1.080	90.0	57.0	9.0	315.0		.250	2717.0
S	3	5.00	775.02	.410	1.080	92.0	59.0	9.5	314.0	75.0	.250	2715.3
S	4	5.00	777.84	.420	1.090	94.0	62.0	9.5	316.0		.250	2751.7
S	4	5.00	780.64	.420	1.090	95.0	63.0	9.5	315.0		.250	2750.0
S	5	5.00	783.47	.460	1.180	96.0	64.0	10.0	312.0		.250	2872.4
S	5	5.00	786.33	.450	1.150	97.0	66.0	10.0	314.0		.250	2844.6
S	6	5.00	789.29	.480	1.230	98.0	67.0	11.0	315.0		.250	2939.8
S	6	5.00	792.29	.470	1.210	99.0	68.0	11.0	315.0		.250	2909.0
S	6	5.00	795.05	.490	1.260	65.0	61.0	8.0	314.0	65.0	.250	2968.4
S	6	5.00	797.95	.490	1.260	78.0	61.0	9.5	311.0		.250	2962.6
S	5	5.00	800.82	.450	1.160	87.0	62.0	9.5	310.0		.250	2837.3
S	5	5.00	803.67	.450	1.160	91.0	63.0	9.5	312.0		.250	2841.0
S	4	5.00	806.52	.410	1.080	94.0	64.0	8.5	309.0		.250	2706.5
S	4	5.00	809.33	.410	1.080	95.0	65.0	8.5	305.0		.250	2699.4
S	3	5.00	812.02	.340	.890	96.0	66.0	8.0	301.0		.250	2451.8
S	3	5.00	814.71	.325	.840	95.0	67.0	9.0	300.0	75.0	.250	2395.5
S	2	5.00	817.55	.440	1.140	97.0	68.0	9.0	300.0		.250	2787.3
S	2	5.00	820.38	.440	1.140	98.0	68.0	9.0	299.0		.250	2785.5
S	1	5.00	823.12	.360	.930	98.0	69.0	8.5	295.0		.250	2512.9
S	1	5.00	825.80	.360	.930	98.0	70.0	8.0	295.0		.250	2512.9

DATA AND CALCULATED VALUES

RUN- 1-0 DATE- 02-19-74

ATMOS TEMP (DG.F)	ATMOS PRES (I.HG)	STACK VAC (I.H2O)	H2O COND (ML)	WT-PTL (MG)	WT-TTL (MG)	STACK AREA (FT2)	INIT VOL (DCF)	PERC O2 DRY	PERC CO2 DRY	PERC CO DRY	PITOT TUBE COEF
45.0	29.15	14.00	300.5			8.73	297.54	3.5	11.0	0.0	.850

PORT-POINT	SAMP TIME (MIN)	METER VOL (DCF)	DELTA P (I.H2O)	DELTA H (I.H2O)	TEMP IN (D.F)	TEMP OUT (D.F)	TRAIN VAC (I.HG)	STACK TEMP (D.F)	BOX TEMP (D.F)	PROBE T DIA (IN)	VEL (FPM)
E 1	4.00	299.69	.420	.850	45.0	45.0	11.0	150.0	50.0	.250	2507.6
E 1	4.00	301.69	.420	.850	60.0	50.0	11.0	150.0		.250	2507.6
E 2	4.00	303.78	.450	.940	76.0	54.0	11.0	160.0		.250	2616.8
E 2	4.00	305.81	.450	.940	80.0	57.0	12.0	160.0		.250	2616.8
E 3	4.00	307.93	.470	.950	84.0	59.0	13.0	170.0		.250	2695.8
E 3	4.00	310.17	.470	.950	87.0	60.0	13.0	170.0		.250	2695.8
E 4	4.00	312.36	.480	.960	90.0	61.0	13.0	170.0		.250	2724.3
E 4	4.00	314.57	.480	.960	92.0	62.0	13.0	170.0		.250	2724.3
E 5	4.00	316.77	.440	.880	94.0	64.0	13.0	170.0		.250	2608.3
E 5	4.00	318.96	.440	.880	94.0	64.0	12.5	170.0		.250	2608.3
E 6	4.00	321.01	.360	.730	94.0	65.0	12.0	200.0		.250	2414.8
E 6	4.00	322.96	.360	.730	94.0	65.0	12.0	200.0		.250	2414.8
E 6	4.00	324.89	.360	.730	94.0	65.0	12.0	200.0		.250	2414.8
E 6	4.00	326.59	.250	.530	93.0	62.0	12.0	200.0		.250	2012.4
E 6	4.00	328.43	.250	.530	91.0	60.0	12.0	200.0		.250	2012.4
E 5	4.00	330.20	.300	.610	90.0	58.0	11.0	180.0	75.0	.250	2170.8
E 5	4.00	331.92	.300	.610	90.0	58.0	11.0	180.0		.250	2170.8
E 5	4.00	333.66	.300	.610	89.0	59.0	11.0	180.0		.250	2170.8
E 4	4.00	335.40	.300	.610	88.0	59.0	11.0	180.0		.250	2170.8
E 4	4.00	337.15	.300	.610	88.0	62.0	11.0	180.0		.250	2170.8
E 4	4.00	338.85	.300	.610	87.0	61.0	11.0	180.0		.250	2170.8
E 3	4.00	340.90	.450	.930	87.0	62.0	17.0	175.0	80.0	.250	2648.2
E 3	4.00	343.00	.450	.930	89.0	64.0	20.0	175.0		.250	2648.2
E 3	4.00	345.07	.450	.930	91.0	66.0	21.0	175.0		.250	2648.2
E 2	4.00	347.11	.440	.890	92.0	67.0	23.0	180.0	80.0	.250	2628.9
E 2	4.00	349.13	.440	.890	93.0	68.0	23.0	180.0		.250	2628.9
E 2	4.00	351.10	.440	.890	93.0	69.0	23.0	180.0		.250	2628.9
E 1	4.00	352.95	.350	.710	94.0	70.0	23.0	160.0	75.0	.250	2307.8
E 1	4.00	354.72	.350	.710	95.0	70.0	23.0	160.0		.250	2307.8
E 1	4.00	356.47	.350	.710	95.0	71.0	23.0	160.0		.250	2307.8

DATA AND CALCULATED VALUES

RUN- 2-I DATE- 02-20-74

ATMOS TEMP (DG.F)	ATMOS PRES (I.HG)	STACK VAC (I.H2O)	H2O COND (ML)	WT-PTL (MG)	WT-TTL (MG)	STACK AREA (FT2)	INIT VOL (DCF)	PERC O2 DRY	PERC CO2 DRY	PERC CO DRY	PITOT TUBE COEF
40.0	29.84	14.00	102.7			8.73	839.55	3.5	11.0	0.0	.850

PORT-POINT	SAMP TIME (MIN)	METER VOL (DCF)	DELTA P (I.H2O)	DELTA H (I.H2O)	TEMP IN (D.F)	TEMP OUT (D.F)	TRAIN VAC (I.HG)	STACK TEMP (D.F)	BOX TEMP (D.F)	PROBE T DIA (IN)	VEL (FPM)
S 1	5.00	842.32	.370	.950	72.0	56.0	10.0	290.0	50.0	.250	2508.8
S 1	5.00	844.94	.370	.950	77.0	64.0	10.0	284.0		.250	2498.7
S 2	5.00	847.73	.450	1.180	88.0	66.0	7.0	290.0		.250	2766.7
S 2	5.00	850.51	.450	1.180	94.0	67.0	8.0	291.0		.250	2768.6
S 3	5.00	853.26	.410	1.080	97.0	68.0	8.5	291.0		.250	2642.7
S 3	5.00	856.02	.420	1.100	99.0	70.0	9.5	294.0		.250	2680.0
S 4	5.00	858.81	.430	1.130	100.0	71.0	11.5	291.0		.250	2706.3
S 4	5.00	861.57	.430	1.130	101.0	72.0	13.0	293.0		.250	2709.9
S 5	5.00	864.46	.480	1.230	102.0	74.0	17.0	293.0		.250	2863.2
S 5	5.00	867.27	.480	1.230	103.0	74.0	19.0	293.0		.250	2863.2
S 6	5.00	869.99	.500	1.000	102.0	76.0	23.0	290.0		.250	2916.4
S 6	5.00	872.57	.510	.970	102.0	76.0	24.0	291.0		.250	2947.4
S 6	5.00	875.49	.500	1.300	93.0	76.0	7.5	293.0	50.0	.250	2922.2
S 6	5.00	878.47	.500	1.300	102.0	76.0	7.5	295.0		.250	2926.1
S 5	5.00	881.40	.490	1.280	108.0	78.0	8.5	300.0		.250	2906.3
S 5	5.00	884.35	.490	1.280	109.0	79.0	9.5	291.0		.250	2889.0
S 4	5.00	887.18	.430	1.130	110.0	79.0	10.5	291.0		.250	2706.3
S 4	5.00	890.03	.440	1.140	110.0	80.0	12.0	294.0		.250	2743.1
S 3	5.00	892.83	.430	1.130	110.0	81.0	14.0	290.0		.250	2704.5
S 3	5.00	895.54	.440	1.140	110.0	81.0	16.0	290.0		.250	2735.8
S 2	5.00	898.37	.460	1.190	109.0	82.0	18.0	290.0		.250	2797.3
S 2	5.00	901.12	.460	1.190	108.0	82.0	20.0	291.0		.250	2799.2
S 1	5.00	903.78	.390	1.000	108.0	83.0	21.0	279.0		.250	2556.7
S 1	5.00	906.44	.390	1.000	108.0	83.0	23.0	285.0		.250	2567.1

DATA AND CALCULATED VALUES

RUN- 2-0 DATE- 02-20-74

ATMOS TEMP (DG.F)	ATMOS PRES (I.HG)	STACK VAC (I.H2O)	H2O COND (ML)	WT-PTL (MG)	WT-TTL (MG)	STACK AREA (FT2)	INIT VOL (DCF)	PERC O2 DRY	PERC CO2 DRY	PERC CO DRY	PITOT TUBE COEF
40.0	29.84	14.00	316.0			8.73	369.89	3.5	11.0	0.0	.850

PORT-POINT	SAMP TIME (MIN)	METER VOL (DCF)	DELTA P (I.H2O)	DELTA H (I.H2O)	TEMP IN (D.F)	TEMP OUT (D.F)	TRAIN VAC (I.HG)	STACK TEMP (D.F)	BOX TEMP (D.F)	PROBE T DIA (IN)	VEL (FPM)
E 1	5.00	372.70	.350	.720	54.0	48.0	7.0	175.0	55.0	.250	2307.4
E 1	5.00	375.09	.350	.720	68.0	51.0	7.5	175.0		.250	2307.4
E 2	5.00	377.90	.500	.990	82.0	54.0	8.0	180.0	60.0	.250	2768.7
E 2	5.00	380.59	.500	.990	87.0	57.0	8.0	180.0		.250	2768.7
E 3	5.00	383.23	.470	.950	92.0	60.0	8.0	190.0	75.0	.250	2705.3
E 3	5.00	385.86	.470	.950	95.0	63.0	9.0	190.0		.250	2705.3
E 4	5.00	388.58	.500	.990	98.0	66.0	10.0	180.0	75.0	.250	2768.7
E 4	5.00	391.34	.500	.990	100.0	68.0	10.5	180.0		.250	2768.7
E 5	5.00	393.99	.430	.870	102.0	70.0	11.0	180.0	75.0	.250	2567.6
E 5	5.00	396.57	.430	.870	103.0	72.0	10.5	180.0		.250	2567.6
E 6	5.00	398.92	.320	.660	104.0	74.0	10.0	180.0	75.0	.250	2215.0
E 6	5.00	401.20	.320	.660	104.0	75.0	10.0	180.0		.250	2215.0
E 6	5.00	403.39	.320	.660	90.0	72.0	10.0	180.0	75.0	.250	2215.0
E 6	5.00	405.63	.320	.660	92.0	73.0	11.0	180.0		.250	2215.0
E 5	5.00	408.07	.380	.760	94.0	74.0	12.0	180.0	75.0	.250	2413.7
E 5	5.00	410.50	.380	.760	97.0	74.0	13.0	180.0		.250	2413.7
E 4	5.00	413.01	.420	.850	100.0	75.0	14.0	180.0	75.0	.250	2537.6
E 4	5.00	415.68	.420	.850	102.0	77.0	14.5	180.0		.250	2537.6
E 3	5.00	418.35	.450	.900	104.0	78.0	15.0	190.0	80.0	.250	2647.1
E 3	5.00	421.01	.450	.900	105.0	78.0	16.0	190.0		.250	2647.1
E 2	5.00	423.65	.420	.850	106.0	79.0	17.0	190.0	80.0	.250	2557.3
E 2	5.00	426.28	.420	.850	107.0	79.0	17.0	190.0		.250	2557.3
E 1	5.00	428.83	.400	.810	108.0	80.0	17.0	175.0		.250	2466.7
E 1	5.00	431.32	.400	.810	108.0	80.0	17.0	175.0		.250	2466.7

DATA AND CALCULATED VALUES

RUN- 3-I DATE- 02-20-74

ATMOS TEMP (DG.F)	ATMOS PRES (I.HG)	STACK VAC (I.H2O)	H2O COND (ML)	WT-PTL (MG)	WT-TTL (MG)	STACK AREA (FT2)	INIT VOL (DCF)	PERC O2 DRY	PERC CO2 DRY	PERC CO DRY	PITOT TUBE COEF
50.0	29.90	14.00	101.3			8.73	918.80	3.5	11.0	0.0	.850

PORT-POINT		SAMP TIME (MIN)	METER VOL (DCF)	DELTA P (I.H2O)	DELTA H (I.H2O)	TEMP IN (D.F)	TEMP OUT (D.F)	TRAIN VAC (I.HG)	STACK TEMP (D.F)	BOX TEMP (D.F)	PROBE T DIA (IN)	VEL (FPM)
S	1	5.00	921.33	.340	.890	80.0	67.0	9.0	300.0	50.0	.250	2418.4
S	1	5.00	923.91	.350	.910	89.0	68.0	10.5	301.0		.250	2455.3
S	2	5.00	926.64	.440	1.130	98.0	71.0	11.0	304.0		.250	2758.4
S	2	5.00	929.36	.440	1.130	103.0	73.0	13.0	305.0		.250	2760.2
S	3	5.00	932.30	.400	1.030	90.0	78.0	11.0	301.0		.250	2624.8
S	3	5.00	935.08	.410	1.080	100.0	78.0	14.5	301.0		.250	2657.4
S	4	5.00	937.87	.440	1.130	107.0	80.0	19.0	301.0		.250	2753.0
S	4	5.00	940.56	.440	1.000	109.0	81.0	24.0	305.0		.250	2760.2
S	5	5.00	943.51	.470	1.210	105.0	83.0	15.0	300.0		.250	2843.4
S	5	5.00	946.43	.460	1.190	112.0	85.0	7.0	303.0		.250	2818.5
S	6	5.00	949.34	.480	1.230	115.0	85.0	8.5	300.0		.250	2873.5
S	6	5.00	952.28	.480	1.230	116.0	86.0	10.5	300.0		.250	2873.5
S	6	5.00	955.03	.390	1.005	117.0	87.0	12.5	295.0	65.0	.250	2581.6
S	6	5.00	957.94	.480	1.230	117.0	88.0	13.5	296.0		.250	2865.9
S	5	5.00	960.85	.460	1.190	116.0	89.0	15.5	297.0		.250	2807.4
S	5	5.00	963.79	.470	1.210	116.0	89.0	18.5	299.0		.250	2841.5
S	4	5.00	966.61	.410	1.080	116.0	90.0	19.5	299.0		.250	2654.0
S	4	5.00	969.30	.400	1.030	117.0	90.0	20.0	296.0		.250	2616.2
S	3	5.00	971.99	.420	1.090	104.0	88.0	6.0	297.0		.250	2682.6
S	3	5.00	974.73	.410	1.080	108.0	88.0	6.5	299.0		.250	2654.0
S	2	5.00	977.55	.450	1.170	115.0	88.0	8.5	295.0		.250	2773.1
S	2	5.00	980.37	.450	1.170	116.0	89.0	9.5	299.0		.250	2780.4
S	1	5.00	983.06	.370	.950	117.0	89.0	10.5	293.0		.250	2511.2
S	1	5.00	985.57	.370	.950	118.0	90.0	11.5	294.0		.250	2512.9

DATA AND CALCULATED VALUES

RUN- 3-0 DATE- 02-20-74

ATMOS TEMP (DG.F)	ATMOS PRES (I.HG)	STACK VAC (I.H2O)	H2O COND (ML)	WT-PTL (MG)	WT-TTL (MG)	STACK AREA (FT2)	INIT VOL (DCF)	PERC O2 DRY	PERC CO2 DRY	PERC CO DRY	PITOT TUBE COEF
50.0	29.90	14.00	341.2			8.73	443.44	3.5	11.0	0.0	.850

PORT-POINT	SAMP TIME (MIN)	METER VOL (DCF)	DELTA P (I.H2O)	DELTA H (I.H2O)	TEMP IN (D.F)	TEMP OUT (D.F)	TRAIN VAC (I.HG)	STACK TEMP (D.F)	BOX TEMP (D.F)	PROBE T DIA (IN)	VEL (FPM)
E 1	5.00	446.34	.470	.930	64.0	62.0	10.0	195.0	60.0	.250	2712.8
E 1	5.00	448.91	.470	.930	72.0	62.0	10.0	195.0		.250	2712.8
E 2	5.00	451.58	.520	1.020	80.0	63.0	10.0	195.0	75.0	.250	2853.5
E 2	5.00	454.25	.520	1.020	85.0	64.0	10.0	195.0		.250	2853.5
E 3	5.00	456.09	.470	.930	90.0	65.0	10.0	195.0	75.0	.250	2712.8
E 3	5.00	459.57	.470	.930	87.0	66.0	11.0	195.0		.250	2712.8
E 4	5.00	462.46	.500	1.020	84.0	68.0	12.0	195.0	75.0	.250	2798.1
E 4	5.00	465.55	.500	1.020	91.0	69.0	12.5	195.0		.250	2798.1
E 5	5.00	468.42	.520	1.050	99.0	70.0	13.0	180.0	75.0	.250	2820.6
E 5	5.00	471.30	.520	1.050	96.0	71.0	13.0	180.0		.250	2820.6
E 6	5.00	473.97	.450	.910	92.0	72.0	13.0	180.0	75.0	.250	2623.9
E 6	5.00	476.60	.450	.910	93.0	73.0	13.0	180.0		.250	2623.9
E 6	5.00	479.09	.400	.810	100.0	74.0	12.0	180.0	75.0	.250	2473.8
E 6	5.00	481.59	.400	.810	102.0	75.0	13.0	180.0		.250	2473.8
E 5	5.00	484.30	.510	1.010	104.0	77.0	14.0	185.0	75.0	.250	2804.2
E 5	5.00	487.14	.510	1.010	106.0	78.0	14.5	185.0		.250	2804.2
E 4	5.00	490.05	.570	1.140	108.0	79.0	15.0	185.0	75.0	.250	2964.6
E 4	5.00	493.97	.570	1.140	108.0	79.0	15.0	185.0		.250	2964.6
E 3	5.00	495.79	.510	1.010	108.0	78.0	15.0	185.0	80.0	.250	2804.2
E 3	5.00	498.74	.510	1.010	106.0	79.0	15.5	185.0		.250	2804.2
E 2	5.00	501.64	.520	1.050	105.0	80.0	16.0	180.0	80.0	.250	2820.6
E 2	5.00	504.46	.520	1.050	108.0	81.0	16.0	180.0		.250	2820.6
E 1	5.00	507.18	.450	.910	110.0	82.0	16.0	180.0	80.0	.250	2623.9
E 1	5.00	509.82	.450	.910	111.0	83.0	16.0	180.0		.250	2623.9

EMISSION DATA

NAME	DESCRIPTION	UNITS	1-I	1-O	2-I	2-O
	DATE OF RUN		02-19-74	02-19-74	02-20-74	02-20-74
DN	PROBE TIP DIAMETER	IN	.250	.250	.250	.250
TT	NET TIME OF RUN	MIN	120.0	120.0	120.0	120.0
PB	BAROMETRIC PRESSURE	IN.HG	29.15	29.15	29.84	29.84
PM	AVG ORIFICE PRES DROP	IN.H2O	1.088	.789	1.134	.834
VM	VOL DRY GAS-METER COND	DCF	67.06	58.93	66.89	61.43
TM	AVG GAS METER TEMP	DEG.F	75.8	74.8	87.8	82.9
VMSTD	VOL DRY GAS-STD COND	DSCF	64.80	57.01	64.72	59.93
VW	TOTAL H2O COLLECTED	ML	102.1	300.5	102.7	316.0
VWV	VOL H2O VAPOR-STD COND	SCF	4.84	14.24	4.87	14.98
PMOS	PERCENT MOISTURE BY VOL		6.949	19.989	6.995	19.995
MD	MOLE FRACTION DRY GAS		.931	.800	.930	.800
PCO2	PERCENT CO2 BY VOL, DRY		11.0	11.0	11.0	11.0
PO2	PERCENT O2 BY VOL, DRY		3.5	3.5	3.5	3.5
PCO	PERCENT CO BY VOL, DRY		0.0	0.0	0.0	0.0
PN2	PERCENT N2 BY VOL, DRY		85.5	85.5	85.5	85.5
MWD	MOLECULAR WT-DRY STK GAS		29.90	29.90	29.90	29.90
MW	MOLECULAR WT-STK GAS		29.07	27.52	29.07	27.52
CP	PITOT TUBE COEFFICIENT		.850	.850	.850	.850
DPS	AVG STK VELOCITY HEAD	IN.H2O	.420	.387	.447	.413
TS	AVG STACK TEMPERATURE	DEG.F	309.3	175.5	290.8	181.7
NP	NET SAMPLING POINTS		24	30	24	24
PST	STATIC PRES OF STACK	IN.HG	-1.03	-1.03	-1.03	-1.03
PS	STACK PRESSURE, ABSOLUTE	IN.HG	28.12	28.12	28.81	28.81
VS	AVG STACK GAS VELOCITY	FPM	2737	2446	2756	2515
AS	STACK AREA	IN2	1257	1257	1257	1257
QS	STK FLOWRATE, DRY,STD CN	DSCFM	14398	13391	15210	13971
QA	ACTUAL STACK FLOWRATE	ACFM	23895	21352	24060	21955
PERI	PERCENT ISOKINETIC		95.8	90.6	90.5	91.3
EA	PERCENT EXCESS AIR		18.4	18.4	18.4	18.4

EMISSION DATA

NAME	DESCRIPTION	UNITS	3-I	3-O
	DATE OF RUN		02-20-74	02-20-74
DN	PROBE TIP DIAMETER	IN	.250	.250
TT	NET TIME OF RUN	MIN	120.0	120.0
PB	BAROMETRIC PRESSURE	IN.HG	29.90	29.90
PM	AVG ORIFICE PRES DROP	IN.H2O	1.096	.982
VM	VOL DRY GAS-METER COND	DCF	66.77	66.38
TM	AVG GAS METER TEMP	DEG.F	95.9	84.6
VMSTD	VOL DRY GAS-STD COND	DSCF	63.79	64.72
VW	TOTAL H2O COLLECTED	ML	101.3	341.2
VWV	VOL H2O VAPOR-STD COND	SCF	4.80	16.17
PMOS	PERCENT MOISTURE BY VOL		7.000	19.994
MD	MOLE FRACTION DRY GAS		.930	.800
PCO2	PERCENT CO2 BY VOL, DRY		11.0	11.0
PO2	PERCENT O2 BY VOL, DRY		3.5	3.5
PCO	PERCENT CO BY VOL, DRY		0.0	0.0
PN2	PERCENT N2 BY VOL, DRY		85.5	85.5
MWD	MOLECULAR WT-DRY STK GAS		29.90	29.90
MW	MOLECULAR WT-STK GAS		29.07	27.52
CP	PITOT TUBE COEFFICIENT		.850	.850
DPS	AVG STK VELOCITY HEAD	IN.H2O	.426	.491
TS	AVG STACK TEMPERATURE	DEG.F	299.2	186.3
NP	NET SAMPLING POINTS		24	24
PST	STATIC PRES OF STACK	IN.HG	-1.03	-1.03
PS	STACK PRESSURE, ABSOLUTE	IN.HG	28.87	28.87
VS	AVG STACK GAS VELOCITY	FPM	2704	2752
AS	STACK AREA	IN2	1257	1257
QS	STK FLOWRATE, DRY,STD CN	DSCFM	14789	15211
QA	ACTUAL STACK FLOWRATE	ACFM	23606	24024
PERI	PERCENT ISOKINETIC		91.8	90.5
EA	PERCENT EXCESS AIR		18.4	18.4

EMISSION DATA
(METRIC RESULTS)

NAME	DESCRIPTION	UNITS	1-I	1-O	2-I	2-O
	DATE OF RUN		02-19-74	02-19-74	02-20-74	02-20-74
DN	PROBE TIP DIAMETER	IN	.250	.250	.250	.250
TT	NET TIME OF RUN	MIN	120.0	120.0	120.0	120.0
PB	BAROMETRIC PRESSURE	IN.HG	29.15	29.15	29.84	29.84
PM	AVG ORIFICE PRES DROP	IN.H2O	1.088	.789	1.134	.834
VM	VOL DRY GAS-METER COND	DCF	67.06	58.93	66.89	61.43
TM	AVG GAS METER TEMP	DEG.F	75.8	74.8	87.8	82.9
VMSTM	VOL DRY GAS-STD COND	NCM	1.84	1.61	1.83	1.70
VW	TOTAL H2O COLLECTED	ML	102.1	300.5	102.7	316.0
VWM	VOL H2O VAPOR-STD COND	NM3	.14	.40	.14	.42
PMOS	PERCENT MOISTURE BY VOL		6.949	19.989	6.995	19.995
MD	MOLE FRACTION DRY GAS		.931	.800	.930	.800
PCO2	PERCENT CO2 BY VOL, DRY		11.0	11.0	11.0	11.0
PO2	PERCENT O2 BY VOL, DRY		3.5	3.5	3.5	3.5
PCO	PERCENT CO BY VOL, DRY		0.0	0.0	0.0	0.0
PN2	PERCENT N2 BY VOL, DRY		85.5	85.5	85.5	85.5
MWD	MOLECULAR WT-DRY STK GAS		29.90	29.90	29.90	29.90
MW	MOLECULAR WT-STK GAS		29.07	27.52	29.07	27.52
CP	PITOT TUBE COEFFICIENT		.850	.850	.850	.850
DPS	AVG STK VELOCITY HEAD	IN.H2O	.420	.387	.447	.413
TSM	AVG STACK TEMPERATURE	DEG.C	154.0	79.7	143.8	83.1
NP	NET SAMPLING POINTS		24	30	24	24
PST	STATIC PRES OF STACK	IN.HG	-1.03	-1.03	-1.03	-1.03
PS	STACK PRESSURE, ABSOLUTE	IN.HG	28.12	28.12	28.81	28.81
VSM	AVG STACK GAS VELOCITY	M/MIN	834.4	745.6	840.1	766.6
AS	STACK AREA	IN2	1257	1257	1257	1257
QSM	STK FLOWRATE, DRY,STD CN	NM3/MIN	407.71	379.20	430.70	395.61
QAM	ACTUAL STACK FLOWRATE	M3/MIN	676.64	604.64	681.32	621.71
PERI	PERCENT ISOKINETIC		95.8	90.6	90.5	91.3

EMISSION DATA
(METRIC RESULTS)

NAME	DESCRIPTION	UNITS	3-I	3-O
	DATE OF RUN		02-20-74	02-20-74
DN	PROBE TIP DIAMETER	IN	.250	.250
TT	NET TIME OF RUN	MIN	120.0	120.0
PB	BAROMETRIC PRESSURE	IN.HG	29.90	29.90
PM	AVG ORIFICE PRES DROP	IN.H2O	1.096	.982
VM	VOL DRY GAS-METER COND	DCF	66.77	66.38
TM	AVG GAS METER TEMP	DEG.F	95.9	84.6
VMSTM	VOL DRY GAS-STD COND	NCM	1.81	1.83
VW	TOTAL H2O COLLECTED	ML	101.3	341.2
VWM	VOL H2O VAPOR-STD COND	NM3	.14	.46
PMOS	PERCENT MOISTURE BY VOL		7.000	19.994
MD	MOLE FRACTION DRY GAS		.930	.800
PCO2	PERCENT CO2 BY VOL, DRY		11.0	11.0
PO2	PERCENT O2 BY VOL, DRY		3.5	3.5
PCO	PERCENT CO BY VOL, DRY		0.0	0.0
PN2	PERCENT N2 BY VOL, DRY		85.5	85.5
MWD	MOLECULAR WT-DRY STK GAS		29.90	29.90
MW	MOLECULAR WT-STK GAS		29.07	27.52
CP	PITOT TUBE COEFFICIENT		.850	.850
DPS	AVG STK VELOCITY HEAD	IN.H2O	.426	.491
TSM	AVG STACK TEMPERATURE	DEG.C	148.4	85.7
NP	NET SAMPLING POINTS		24	24
PST	STATIC PRES OF STACK	IN.HG	-1.03	-1.03
PS	STACK PRESSURE, ABSOLUTE	IN.HG	28.87	28.87
VSM	AVG STACK GAS VELOCITY	M/MIN	824.3	838.9
AS	STACK AREA	IN2	1257	1257
QSM	STK FLOWRATE, DRY,STD CN	NM3/MIN	418.78	430.72
QAM	ACTUAL STACK FLOWRATE	M3/MIN	668.46	680.30
PERI	PERCENT ISOKINETIC		91.8	90.5

ANALYSIS DATA

NAME	DESCRIPTION	UNITS	1-I	1-I	1-I	1-O	1-O	1-O
	DATE		02-19-74	02-19-74	02-19-74	02-19-74	02-19-74	02-19-74
	PORT		S	S	S	W	W	W
	POINT SAMPLE		SO2 -1	SO2 -2	H2SO4	SO2 -1	SO2 -2	H2SO4
VM	VOL OF DRY GAS-METER CN	CU.FT	67.06	67.06	67.06	58.93	58.93	58.93
TM	AVG DRY GAS METER TEMP	DEG.R	535.80	535.80	535.80	534.80	534.80	534.80
PM	AVG ABS METER PRES	IN.HG	28.12	28.12	28.12	28.12	28.12	28.12
VMSTD	VOL OF DRY GAS-STD CN	CU.FT	64.80	64.80	64.80	57.01	57.01	57.01
QT	STK FLOWRATE, DRY,STD CN	DSCFM	14398.0	14398.0	14398.0	13391.0	13391.0	13391.0
VT	VOL OF TITRANT-SAMPLE	ML	283.00	26.10	.40	66.00	1.63	.35
VTB	VOL OF TITRANT-ABS BLANK	ML	.10	.10	.10	.10	.10	.10
N	NORMALITY OF TITRANT	G-EQ/L	.10050	.10050	.10050	.10050	.10050	.10050
VSOLN	TOTAL SOLUTION VOLUME	ML	230.0	230.0	650.0	290.0	115.0	365.0
VA	VOL SAMP ALIQUOT TITRD	ML	40.0	40.0	40.0	40.0	40.0	40.0
CSO2	CONC OF SAMPLE-STD CN	LB/DSCF	.00017786	.00001635	.00000082	.00005938	.00000055	.00000043
		PPM	1074.5	98.8	3.2	358.7	3.3	1.7
		LB/HR	153.7	14.1	.7	47.7	.4	.3
		GR/DSCF	1.2450	.1144	.0057	.4156	.0038	.0030
		GR/ACF	.8060	.0741	.0037	.3257	.0030	.0024
		MG/NM3	2849.0	261.8	13.1	951.1	8.8	7.0
		KG/HR	69.69	6.41	.32	21.64	.20	.16

ANALYSIS DATA

NAME	DESCRIPTION	UNITS	2-I	2-I	2-I	2-O	2-O	2-O
	DATE		02-20-74	02-20-74	02-20-74	02-20-74	02-20-74	02-20-74
	PORT		S	S	S	W	W	W
	POINT SAMPLE		SO2 -1	SO2 -2	H2SO4	SO2 -1	SO2 -2	H2SO4
VM	VOL OF DRY GAS-METER CN	CU.FT	66.89	66.89	66.89	61.43	61.43	61.43
TM	AVG DRY GAS METER TEMP	DEG.R	547.80	547.80	547.80	542.90	542.90	542.90
PM	AVG ABS METER PRES	IN.HG	28.81	28.81	28.81	28.81	28.81	28.81
VMSTD	VOL OF DRY GAS-STD CN	CU.FT	64.72	64.72	64.72	59.93	59.93	59.93
QT	STK FLOWRATE, DRY,STD CN	DSCFM	15210.0	15210.0	15210.0	13971.0	13971.0	13971.0
VT	VOL OF TITRANT-SAMPLE	ML	322.00	426.00	1.60	8.20	176.00	18.00
VTB	VOL OF TITRANT-ABS BLANK	ML	.05	.05	.10	.05	.05	.05
N	NORMALITY OF TITRANT	G-EQ/L	.10050	.10050	.10050	.10050	.10050	.10050
VSOLN	TOTAL SOLUTION VOLUME	ML	210.0	160.0	560.0	170.0	215.0	390.0
VA	VOL SAMP ALIQUOT TITRD	ML	40.0	40.0	40.0	40.0	40.0	40.0
CSO2	CONC OF SAMPLE-STD CN	LB/DSCF	.00018504	.00018652	.00000352	.00000410	.00011181	.00003170
		PPM	1117.9	1126.8	13.9	24.7	675.5	125.1
		LB/HR	168.9	170.2	3.2	3.4	93.7	26.6
		GR/DSCF	1.2953	1.3057	.0247	.0287	.7827	.2219
		GR/ACF	.8802	.8873	.0168	.0228	.6223	.1764
		MG/NM3	2964.0	2987.8	56.4	65.6	1791.0	507.7
		KG/HR	76.60	77.21	1.46	1.56	42.51	12.05

ANALYSIS DATA

NAME	DESCRIPTION	UNITS	3-I	3-I	3-I	3-O	3-O	3-O
	DATE		02-20-74	02-20-74	02-20-74	02-20-74	02-20-74	02-20-74
	PORT		S	S	S	W	W	W
	POINT SAMPLE		SO2 -1	SO2 -2	H2SO4	SO2 -1	SO2 -2	H2SO4
VM	VOL OF DRY GAS-METER CN	CU.FT	66.77	66.77	66.77	66.38	66.38	66.38
TM	AVG DRY GAS METER TEMP	DEG.R	555.90	555.90	555.90	544.60	544.60	544.60
PM	AVG ABS METER PRES	IN.HG	28.87	28.87	28.87	28.87	28.87	28.87
VMSTD	VOL OF DRY GAS-STD CN	CU.FT	63.79	63.79	63.79	64.72	64.72	64.72
QT	STK FLOWRATE, DRY,STD CN	DSCFM	14781.0	14781.0	14781.0	15211.0	15211.0	15211.0
VT	VOL OF TITRANT-SAMPLE	ML	380.00	31.00	90.90	70.00	7.00	6.00
VTB	VOL OF TITRANT-ABS BLANK	ML	.04	.04	.04	.04	.04	.04
N	NORMALITY OF TITRANT	G-EQ/L	.10050	.10050	.10050	.10050	.10050	.10050
VSOLN	TOTAL SOLUTION VOLUME	ML	270.0	225.0	440.0	200.0	200.0	330.0
VA	VOL SAMP ALIQUOT TITRD	ML	40.0	40.0	40.0	40.0	40.0	40.0
CSO2	CONC OF SAMPLE-STD CN	LB/DSCF	.00028487	.00001934	.00017006	.00003829	.00000381	.00000825
		PPM	1721.0	116.9	671.0	231.3	23.0	32.5
		LB/HR	252.6	17.2	150.8	34.9	3.5	7.5
		GR/DSCF	1.9941	.1354	1.1904	.2681	.0267	.0577
		GR/ACF	1.3429	.0912	.8017	.2121	.0211	.0457
		MG/NM3	4563.1	309.8	2724.1	613.4	61.0	132.1
		KG/HR	114.59	7.78	68.41	15.85	1.58	3.41

APPENDIX B

SAMPLE CALCULATIONS

EXAMPLE CALCULATIONS

1. VOLUME OF DRY GAS SAMPLED AT STANDARD CONDITIONS

$$VMSTD = \frac{17.71*VM*(PB + PM/13.6)}{TM+460.}$$

$$= \frac{17.71*\ 67.06*(29.15+\ 1.088/13.6)}{75.8+460.} = \quad 64.80 \text{ DSCF}$$

VMSTM = VMSTD*0.028317= 64.80*0.028317= 1.84 DNM3

2. VOLUME OF WATER VAPOR AT STANDARD CONDITIONS

VWV = 0.0474*VW = 0.0474* 102.1 = 4.84 SCF

VWM = VWV*0.028317 = 4.840*0.028317 = .1370 NM3

3. PERCENT MOISTURE IN STACK GAS

$$PMOS = \frac{100.*VWV}{VMSTD+VWV} = \frac{100.*\ 4.84}{64.80+\ 4.84} = 6.949 \text{ PERCENT}$$

4. MOLE FRACTION OF DRY STACK GAS

$$MD = \frac{100.-PMOS}{100.} = \frac{100.-\ 6.949}{100.} = .931$$

5. AVERAGE MOLECULAR WEIGHT OF DRY STACK GAS

MWD = (PCO2 * 44/100) + (PO2 * 32/100)
+(PN2+PCO * 28/100)

= (11.0 * 44/100) + (3.5 * 32/100)
+(85.5 * 28/100)

= 29.90

6. MOLECULAR WEIGHT OF STACK GAS

MW = MWD*MD + 18*(1-MD)

= 29.9* .931 + 18*(1- .931) = 29.07

7. STACK GAS VELOCITY AT STACK CONDITIONS

VS = 4360*AVG SQRT(DPS*(TS+460))*
SQRT(1/(PS*MW))

= 4360* 17.952
SQRT(1/(28.12 29.07)) = 2737 FPM

VSM = VS*0.3048 = 2737*0.3048 = 834 METERS/MIN

8. STACK GAS VOLUMETRIC FLOW AT STANDARD CONDITIONS, DRY BASIS

$$QS = \frac{0.123*VS*AS*MD*PS}{TS+460}$$

$$= \frac{0.123*\ 2737*\ 1257*\ .931*28.12}{309.3\ +460}$$

= 14398 DSCFM

QSM = QS*0.028317 = 14398*0.028317 = 407.71 NM3/MIN

9. STACK GAS VOLUMETRIC FLOW AT STACK CONDITIONS

$$QA = \frac{QS\ *\ (TS+460)}{17.71\ *\ PS\ *\ MD}$$

$$= \frac{14398*(\ 309.3+460)}{17.71*28.12*\ .931}$$

= 23895 ACFM

QAM = QA*0.028317 = 23895*0.028317 = 676.64 NM3/MIN

10. PERCENT ISOKINETIC

$$PERI = \frac{1032*(TS+460)*VMSTD}{VS*TT*PS*MD*(DN*DN)}$$

$$= \frac{1032*(\ 309.3+460)*\ \ 64.80}{2737*\ 120.0*28.12*\ .931*\ .250\ *\ .250}$$

= 95.8 PERCENT

11. PERCENT EXCESS AIR AT SAMPLING POINT

$$EA = \frac{100. * (PO2-0.5*PCO)}{0.264*PN2-PO2+0.5*PCO}$$

$$= \frac{100. *(3.5-0.5* 0.0)}{0.264*85.5- 3.5+0.5* 0.0} = 18.4 \text{ PERCENT}$$

1. Concentration of Sulfur Dioxide at Standard Conditions

$$CSO_2 = (0.0000705)\left[\frac{(VT-VTB)\ (N)\ (VSOLN/VA)}{VMSTD}\right]$$

$$= (0.0000705)\left[\frac{(26.10-0.10)\ (0.1005)\ \frac{230}{40}}{64.8}\right]$$

$$= 0.00001635 \text{ lb/dscf}$$

$$CPPM = \frac{(387)\ (CSO_2)\ (1,000,000)}{64.06}$$

$$= \frac{(387)\ (16.35)}{64.06}$$

$$= 98.8 \text{ ppm}$$

2. Concentration of H_2SO_4 Mist at Standard Conditions

$$CH_2SO_4 = (0.000108)\left[\frac{(VT-VTB)\ (N)\ (VSOLN/VA)}{VMSTD}\right]$$

$$= (0.000108)\left[\frac{(0.40-0.10)\ (0.1005)\ \frac{650}{40}}{64.8}\right]$$

$$= 0.00000082 \text{ lb/dscf}$$

$$CPPM = \frac{(387)\ (CH_2SO_4)\ (1,000,000)}{98.08}$$

$$= \frac{(387)\ (0.82)}{98.08}$$

$$= 3.2 \text{ ppm}$$

APPENDIX C

FIELD DATA SHEETS

MIDWEST RESEARCH INSTITUTE

RUN 1-inlet

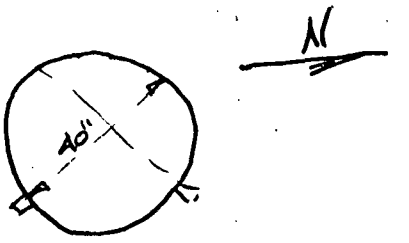
MRI Project Number 3585-C(A1) 1-I
Field Dates
Plant Shawnee Power Plant
Sampling Location Scrubber inlet
Sampling Date 19 Feb 74

FIELD CREW

Crew Chief		Maxwell
Testing Engineer	1	Maxwell
	2	
	3	
Engr. Technician	1	Maxwell
	2	
	3	
Lab Technician	1	Cobb
	2	Parks
	3	Kitko
Process Engineer	1	
	2	
Other	1	
	2	

TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

PLANT Shawnee Power
DATE 19 Feb 79
SAMPLING LOCATION Scrubber - inlet
INSIDE OF FAR WALL TO
OUTSIDE OF NIPPLE, (DISTANCE A)
INSIDE OF NEAR WALL TO
OUTSIDE OF NIPPLE, (DISTANCE B)
STACK I.D., (DISTANCE A - DISTANCE B) 40"
NEAREST UPSTREAM DISTURBANCE 8 dia
NEAREST DOWNSTREAM DISTURBANCE 2 dia
CALCULATOR Maxwell



SCHEMATIC OF SAMPLING LOCATION

TRAVERSE POINT NUMBER	FRACTION OF STACK I.D.	STACK I.D.	PRODUCT OF COLUMNS 2 AND 3 (TO NEAREST 1/8 INCH)	DISTANCE B	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (SUM OF COLUMNS 4 & 5)
1			1 3/4	~~2~~ 6	~~12 1/4~~ 7 3/4
2			5 3/4		~~14 1/4~~ 11 3/4
3			11 3/8		~~28 3/8~~ 17 3/8
4			29 1/4		~~56 3/4~~ 34 1/4
5			34 1/8		~~42 5/8~~ 40 1/8
6			38 1/4		~~46 3/4~~ 44 1/4

PRELIMINARY VELOCITY TRAVERSE

PLANT Shawnee Power
DATE 19 Feb 79
LOCATION Scrubber - inlet
STACK I.D. 40"
BAROMETRIC PRESSURE, in. Hg 29.15
STACK GAUGE PRESSURE, in. H_2O -14.0
OPERATORS MAXWELL, BALADI

SCHEMATIC OF TRAVERSE POINT LAYOUT

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), °F
S-1	.38	315
2	.39	322
3	.40	322
4	.42	323
5	.46	321
6	.46	321
	241	1924
	40	320
AVERAGE	.40	320

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), °F
AVERAGE		

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Run Number 1-I

Date 19 Feb 74

MIDWEST RESEARCH INSTITUTE
PRELIMINARY
MOISTURE DETERMINATION

Recorded by _____

Assisted by _____

NOTE: Same as Run No. _____

A. Condensor and/or Silica Gel Method

Barometric Pressure, P_B = _____ in. Hg

☐ Barometer Location _____

Reading Time _____ by _____

☐ Elevation _____

	Clock Time	Dry Gas Meter Reading(cf)	Flowmeter Setting	Dry Gas Meter Temp (°F)	Impinger Water Volume (ml)
Final					
Initial					
Difference		Vm =			Wc =

Tube No.	Weight (Grams)		
	Final	Initial	Difference
Total Moisture Adsorbed:			Wa =

Meter Pressure, $P_B \approx Pm$ = _____ in. Hg

Average Meter Temperature, Tm = _____ °F

Total Weight of Moisture Collected, Wc + Wa = Wm = _____ gm

$$\text{Moisture Content} = \frac{100}{1 + 375 \frac{Pm\,Vm}{(Tm+460)\,Wm}} = \text{_____ \% by Volume}$$

B. Wet/Dry Bulb Method

Dry Bulb Temperature = _____ °F

Wet Bulb Temperature = _____ °F

Moisture Content (from Ref. Table) = _____ % by Volume

C. Predetermined Value

% Moisture 7 Basis Assumed

MRI - Form P4 (10/72)

NOMOGRAPH DATA

PLANT Shawnee Power

DATE 19 Feb 74

SAMPLING LOCATION Scrubber inlet
SO_3

CALIBRATED PRESSURE DIFFERENTIAL ACROSS ORIFICE, in. H_2O	$\Delta H_@$	1.84
AVERAGE METER TEMPERATURE (AMBIENT + 20 °F), °F	$T_{m_{avg.}}$	70
PERCENT MOISTURE IN GAS STREAM BY VOLUME	B_{wo}	7 assumed
BAROMETRIC PRESSURE AT METER, in. Hg	P_m	29.15
STATIC PRESSURE IN STACK, in. Hg ($P_m \pm 0.073$ x STACK GAUGE PRESSURE in in. H_2O)	P_s	−14 in H_2O
RATIO OF STATIC PRESSURE TO METER PRESSURE	P_s/P_m	.965
AVERAGE STACK TEMPERATURE, °F	$T_{s_{avg.}}$	320
AVERAGE VELOCITY HEAD, in. H_2O	$\Delta p_{avg.}$	.40
MAXIMUM VELOCITY HEAD, in. H_2O	$\Delta p_{max.}$	.46
C FACTOR	.92	
CALCULATED NOZZLE DIAMETER, in.	.29	
ACTUAL NOZZLE DIAMETER, in.	.25	
REFERENCE Δp, in. H_2O	.72	

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DRY MOLECULAR WEIGHT DETERMINATION

PLANT Shawnee Power

DATE 19 Feb 74

SAMPLING TIME (24-hr CLOCK) _____

SAMPLING LOCATION _____

SAMPLE TYPE (BAG, INTEGRATED, CONTINUOUS) _____

ANALYTICAL METHOD _____

AMBIENT TEMPERATURE _____

OPERATOR _____

COMMENTS:

Obtained from EPA

GAS \ RUN	1		2		3		AVERAGE NET VOLUME	MULTIPLIER	MOLECULAR WEIGHT OF STACK GAS (DRY BASIS) M_d, lb/lb-mole
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET			
CO_2								44/100	
O_2 (NET IS ACTUAL O_2 READING MINUS ACTUAL CO_2 READING)							3.5	32/100	
CO (NET IS ACTUAL CO READING MINUS ACTUAL O_2 READING)								28/100	
N_2 (NET IS 100 MINUS ACTUAL CO READING)								28/100	
								TOTAL	

EPA (Dur) 230
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FIELD DATA

PLANT Shawnee Power
DATE 15 Feb 79
SAMPLING LOCATION Scrubber inlet
SAMPLE TYPE SO_3
RUN NUMBER 1-I
OPERATOR Maxwell
AMBIENT TEMPERATURE 45°
BAROMETRIC PRESSURE 29.15
STATIC PRESSURE, (P_s) −14.0
FILTER NUMBER (s)

PROBE LENGTH AND TYPE 5-ss glass
NOZZLE I.D. .125
ASSUMED MOISTURE, % 7
SAMPLE BOX NUMBER 11
METER BOX NUMBER 5
METER $\Delta H_@$ 1.89
C FACTOR .92
PROBE HEATER SETTING 40%
HEATER BOX SETTING 250
REFERENCE Δp .72

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F	Probe Temp
				DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F				
	10 / (339)	758.76										
S-1		761.36	.35	.91		310	60	47	8	230		300
1		763.93	.36	.93		309	70	48	8	261	60	
2		766.67	.44	1.14		320	81	51	8	257		
2		769.97	.45	1.16		316	86	53	9	234	65	260
3		772.26	.41	1.08		315	90	57	9	216		
3		775.02	.41	1.08		314	92	59	9.5	290	75	253
4		777.84	.42	1.09		316	94	62	9.5	214		
4		780.64	.42	1.09		315	95	63	9.5	230		257
5		783.47	.44	1.18		312	96	64	10	215		
5		786.33	.45	1.15		314	97	66	10	255		265
6		789.29	.48	1.23		315	98	67	11	281		
6	1430	792.29	.47	1.21		315	99	68	11	283		260

COMMENTS:

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE °F	Probe Temp
				DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F				
	10 / 1516	792.29 / 779.76										
9-6		795.05	.49	1.26		314	65	61	8	250	65	274
6		797.95	.49	1.26		311	78	61	9.5	294		
5		800.82	.45	1.16		310	87	62	9.5	290		260
5		803.67	.45	1.16		312	91	63	9.5	273		
4		806.52	.41	1.08		309	94	64	8.5	234		260
4		809.33	.41	1.08		305	95	65	8.5	277		
3		812.02	.34	.89		301	96	66	8	264		254
3		814.71	.25/A	.65	/1.03	300	95	67	9	276	75	
2		817.55	.44	1.14		300	97	68	9	265		240
2		820.38	.44	1.14		299	98	68	9	290		
1		823.12	.36	.93		295	98	69	8.5	270		255
1	1616	825.80	.36	.93		295	98	70	8	270	70	
	30 min purge	838.14		.5			90	70	3	240	65	

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4 72

MIDWEST RESEARCH INSTITUTE

RUN 1 - outlet
5 1-0

MRI Project Number 3585-C(41)
Field Dates
Plant Shawnee Power Plant, Paducah, Ky
Sampling Location Scrubber - inlet SO_3
Sampling Date 19 Feb 71

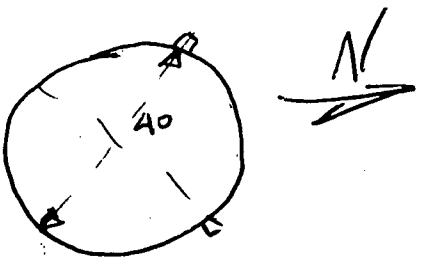
FIELD CREW

Crew Chief	Maxwell	
Testing Engineer	1	Baladi
	2	
	3	
Engr. Technician	1	Baladi
	2	
	3	
Lab Technician	1	Cobb
	2	DaRos
	3	Kitko
Process Engineer	1	
	2	
Other	1	
	2	

MRI - Form PO (10/72)

TRAVERSE POINT LOCATION FOR CIRCULAR DUCTS

PLANT Shawnee Power Plant, Paducah, Ky
DATE 19 Feb 1979
SAMPLING LOCATION Scrubber inlet
INSIDE OF FAR WALL TO
OUTSIDE OF NIPPLE, (DISTANCE A) _____
INSIDE OF NEAR WALL TO
OUTSIDE OF NIPPLE, (DISTANCE B) _____
STACK I.D., (DISTANCE A - DISTANCE B) 40"
NEAREST UPSTREAM DISTURBANCE 8 dia
NEAREST DOWNSTREAM DISTURBANCE 2 dia
CALCULATOR Maxwell



SCHEMATIC OF SAMPLING LOCATION

TRAVERSE POINT NUMBER	FRACTION OF STACK I.D.	STACK I.D.	PRODUCT OF COLUMNS 2 AND 3 (TO NEAREST 1/8 INCH)		DISTANCE B	TRAVERSE POINT LOCATION FROM OUTSIDE OF NIPPLE (SUM OF COLUMNS 4 & 5)
1	.044	40"	1.76	1 3/4	8 1/2	10 1/4
2	.147		5.88	5 3/4		14 1/4
3	.295		11.80	11 7/8		20 3/8
4	.705		28.20	28 1/4		36 3/4
5	.853		34.12	34 1/8		42 5/8
6	.956		38.24	38 1/4		46 3/4

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PRELIMINARY VELOCITY TRAVERSE

PLANT Shawnee
DATE 2/19/74
LOCATION Scrubber outlet
STACK I.D. 90"
BAROMETRIC PRESSURE, in. Hg 29.15
STACK GAUGE PRESSURE, in. H_2O -14.00
OPERATORS Baird:

SCHEMATIC OF TRAVERSE POINT LAYOUT

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), °F
1	.30	
2	.31	
3	.37	
4	.51	
5	.59	
6	.50	
AVERAGE	.43	232

TRAVERSE POINT NUMBER	VELOCITY HEAD (Δp_s), in. H_2O	STACK TEMPERATURE (T_s), °F
AVERAGE		

EPA (Dur) 233
4/72

Run Number 1-0 | MIDWEST RESEARCH INSTITUTE | Recorded by _____

Date 19 Feb 74 | PRELIMINARY MOISTURE DETERMINATION | Assisted by _____

NOTE: Same as Run No. _____

A. Condensor and/or Silica Gel Method

Barometric Pressure, P_B = _____ in. Hg

☐ Barometer Location _____

Reading Time _____ by _____

☐ Elevation _____

	Clock Time	Dry Gas Meter Reading(cf)	Flowmeter Setting	Dry Gas Meter Temp (°F)	Impinger Water Volume (ml)
Final					
Initial					
Difference		Vm =			Wc =

Tube No.	Weight (Grams)		
	Final	Initial	Difference
Total Moisture Adsorbed:			Wa =

Meter Pressure, $P_B \approx Pm$ = _____ in. Hg

Average Meter Temperature, Tm = _____ °F

Total Weight of Moisture Collected, Wc + Wa = Wm = _____ gm

$$\text{Moisture Content} = \frac{100}{1 + 375 \dfrac{Pm\,Vm}{(Tm+460)\,Wm}} = \text{_____ \% by Volume}$$

B. Wet/Dry Bulb Method

Dry Bulb Temperature = _____ °F

Wet Bulb Temperature = _____ °F

Moisture Content (from Ref. Table) = _____ % by Volume

C. Predetermined Value

% Moisture 20% Basis Assumed

MRI - Form P4 (10/72)

NOMOGRAPH DATA

PLANT Shawnee Power

DATE 19 Feb 74

SAMPLING LOCATION Scrubber outlet
SO_3

CALIBRATED PRESSURE DIFFERENTIAL ACROSS ORIFICE, in. H_2O	$\Delta H_@$	1.84
AVERAGE METER TEMPERATURE (AMBIENT + 20 °F), °F	$T_{m_{avg.}}$	70°
PERCENT MOISTURE IN GAS STREAM BY VOLUME	B_{wo}	20 %
BAROMETRIC PRESSURE AT METER, in. Hg	P_m	~~29.92~~ 29.15
STATIC PRESSURE IN STACK, in. Hg ($P_m \pm 0.073$ x STACK GAUGE PRESSURE in in. H_2O)	P_s	~~28.92~~ 28.15
RATIO OF STATIC PRESSURE TO METER PRESSURE	P_s/P_m	0.96
AVERAGE STACK TEMPERATURE, °F	$T_{s_{avg.}}$	232
AVERAGE VELOCITY HEAD, in. H_2O	$\Delta p_{avg.}$	0.43
MAXIMUM VELOCITY HEAD, in. H_2O	$\Delta p_{max.}$	0.59
C FACTOR		
CALCULATED NOZZLE DIAMETER, in.		0.24
ACTUAL NOZZLE DIAMETER, in.		0.29
REFERENCE Δp, in. H_2O		

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DRY MOLECULAR WEIGHT DETERMINATION

PLANT Shawnee Power

DATE 19 Feb 74

SAMPLING TIME (24-hr CLOCK) _____

SAMPLING LOCATION _____

SAMPLE TYPE (BAG, INTEGRATED, CONTINUOUS) _____

ANALYTICAL METHOD _____

AMBIENT TEMPERATURE _____

OPERATOR _____

COMMENTS:

Obtained from EPA

RUN / GAS	1		2		3		AVERAGE NET VOLUME	MULTIPLIER	MOLECULAR WEIGHT OF STACK GAS (DRY BASIS) M_d, lb/lb-mole
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET			
CO_2								44/100	
O_2 (NET IS ACTUAL O_2 READING MINUS ACTUAL CO_2 READING)							3.5	32/100	
CO (NET IS ACTUAL CO READING MINUS ACTUAL O_2 READING)							0.0	28/100	
N_2 (NET IS 100 MINUS ACTUAL CO READING)								28/100	
								TOTAL	

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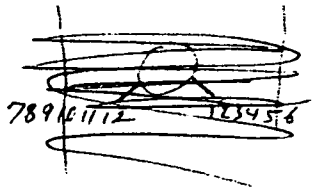

FIELD DATA

PLANT Shawnee
DATE 2/17/94
SAMPLING LOCATION 2-outlet
SAMPLE TYPE SO_3
RUN NUMBER 1-B
OPERATOR Balaki
AMBIENT TEMPERATURE 45
BAROMETRIC PRESSURE 29.15
STATIC PRESSURE, (P_s) −14.00 in H_2O
FILTER NUMBER (s)

PROBE LENGTH AND TYPE 5-glass
NOZZLE I.D. .25"
ASSUMED MOISTURE, % 20%
SAMPLE BOX NUMBER
METER BOX NUMBER
METER $\Delta H_@$ 1.89
C FACTOR
PROBE HEATER SETTING
HEATER BOX SETTING
REFERENCE Δp

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
				DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F			
	10	297.54									
1	~~4~~ 1:39	299.69	0.42	0.85		150	45	45	11	50	50
	4	301.69					60	50	11		
2	4	303.78	0.45	0.94		160	76	54	11	60	
	4	305.81	~~0.44~~				80	57	12		
3	4	307.93	0.47	0.45		170	84	59	13	70	
	4	310.17	~~0.48~~				87	60	13		
4	4	312.36	0.48	0.96		170	90	61	13	70	
	4	314.57					92	62	13		
5	4	316.77	0.44	0.88		170	94	64	13	75	
	4	318.96					94	64	12.5		
6	4	321.01	0.36	0.73		~~200~~	94	65	12	75	
	4 / 2:27	322.96					94	65	12		
6	4	324.89	0.36	0.73		200	94	65	12	75	
	4	326.54	0.25	0.53			93	62	12		
	4	328.43	~~0.23~~				91	60	12		
			0								
5	4	330.20	0.30	0.61		180	90	58	11	75	
	4	331.92					90	58	11		
	4	333.66					89	~~59~~	11		
4	4	335.40	0.30	0.61		180	88	59	11	75	
	4	337.15					88	62	11		

COMMENTS:

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE °F
				DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F			
	4	338.85					87	61	11		
3	4	340.90	0.45	0.93		175	87	62	17	80	
	4	343.00					89	64	20		
	4	345.07					91	66	21		
2	4	347.11	0.44	0.89		180	92	67	23	80	
	4	349.13					93	68	23		
	4	351.10					93	69	23		
1	4	352.95	0.35	0.71		160	94	70	23	75	
	4	354.72					95	70	23		
	4	356.47					95	71	23		

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4 72

MIDWEST RESEARCH INSTITUTE

RUN 2-I

MRI Project Number 3585-C41
Field Dates
Plant Shawnee Power
Sampling Location Scrubber inlet
Sampling Date 20 Feb 79

FIELD CREW

Crew Chief		Maxwell
Testing Engineer	1	Maxwell
	2	
	3	
Engr. Technician	1	Maxwell
	2	
	3	
Lab Technician	1	DaZoo
	2	Kilo
	3	Cobb
Process Engineer	1	
	2	
Other	1	
	2	

NOMOGRAPH DATA

PLANT Shawnee

DATE _____

SAMPLING LOCATION _____

Same as Run 1

CALIBRATED PRESSURE DIFFERENTIAL ACROSS ORIFICE, in. H_2O	$\Delta H_@$	
AVERAGE METER TEMPERATURE (AMBIENT + 20 °F), °F	$T_{m_{avg.}}$	
PERCENT MOISTURE IN GAS STREAM BY VOLUME	B_{wo}	
BAROMETRIC PRESSURE AT METER, in. Hg	P_m	
STATIC PRESSURE IN STACK, in. Hg ($P_m \pm 0.073$ x STACK GAUGE PRESSURE in in. H_2O)	P_s	
RATIO OF STATIC PRESSURE TO METER PRESSURE	P_s/P_m	
AVERAGE STACK TEMPERATURE, °F	$T_{s_{avg.}}$	
AVERAGE VELOCITY HEAD, in. H_2O	$\Delta p_{avg.}$	
MAXIMUM VELOCITY HEAD, in. H_2O	$\Delta p_{max.}$	
C FACTOR		
CALCULATED NOZZLE DIAMETER, in.		
ACTUAL NOZZLE DIAMETER, in.		
REFERENCE Δp, in. H_2O		

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DRY MOLECULAR WEIGHT DETERMINATION

PLANT Shawnee Power

DATE 20 Feb 74

SAMPLING TIME (24-hr CLOCK) _____

SAMPLING LOCATION _____

SAMPLE TYPE (BAG, INTEGRATED, CONTINUOUS) _____

ANALYTICAL METHOD _____

AMBIENT TEMPERATURE _____

OPERATOR _____

COMMENTS:

Obtained from EPA

RUN / GAS	1		2		3		AVERAGE NET VOLUME	MULTIPLIER	MOLECULAR WEIGHT OF STACK GAS (DRY BASIS) M_d, lb/lb-mole
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET			
CO_2								44/100	
O_2 (NET IS ACTUAL O_2 READING MINUS ACTUAL CO_2 READING)							3.5	32/100	
CO (NET IS ACTUAL CO READING MINUS ACTUAL O_2 READING)							0.0	28/100	
N_2 (NET IS 100 MINUS ACTUAL CO READING)								28/100	
								TOTAL	

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4/72

842.88 |
1 min

FIELD DATA

PLANT Shawnee Power
DATE 20 Feb 79
SAMPLING LOCATION Scrubber inlet
SAMPLE TYPE SO3
RUN NUMBER 2-I
OPERATOR Maxwell
AMBIENT TEMPERATURE 40
BAROMETRIC PRESSURE 29.84
STATIC PRESSURE, (P_s) -14.00
FILTER NUMBER (s)

PROBE LENGTH AND TYPE 5'-glass
NOZZLE I.D. .25
ASSUMED MOISTURE, % 7%
SAMPLE BOX NUMBER 12
METER BOX NUMBER 5
METER $\Delta H_@$ 1.89
C FACTOR .92
PROBE HEATER SETTING 90%
HEATER BOX SETTING 750
REFERENCE Δp .72

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F	Probe Temp
				DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F				
	10 / 0942	839.55										
S-1		842.32	.37	.95		290	72	56	10	310	50	290
1		844.91	.37	.95		284	77	64	10	224		222
2		847.73	.45	1.18		290	88	66	7	244		221
2		850.51	.45	1.18		291	94	67	8	240		223
3		853.26	.41	1.08		291	97	68	8.5	225		240
3		856.02	.42	1.1		294	99	70	9.5	221		247
4		858.81	.43	1.13		291	100	71	11.5	275		251
4		861.57	.43	1.13		293	101	72	13	295		255
5		864.46	.48	1.23		293	102	74	17	255		265
5		867.27	.48	1.23		293	103	74	19	257		257
6		869.99	.50	1.28	1.0	290	102	76	23	226		250
6		872.57	.51	1.30	.97	291	102	76	24	276		246

COMMENTS: Changed first filter after 1 hr

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4 72

Run 2-I
20 Feb 74
Shawnee Power-
503

Port / Point		Gas Meter Reading CFM	Δp	Δh	Stack Temp	Meter Temp in	Meter Temp out	Pump Vac.	Sample Box Temp	Impinger Temp	Probe Temp
	10 1115	872.57									
5-6		875.49	.50	1.30	293	93	76	7.5	216	50	237
6		878.97	.50	1.30	295	102	76	7.5	271		237
5		881.40	.49	1.28	300	108	78	8.5	265		238
5		884.35	.49	1.28	291	109	79	9.5	290		245
4		887.18	.43	1.13	291	110	79	10.5	267		250
4		890.03	.44	1.14	294	110	80	12	284		255
3		892.83	.43	1.13	290	110	81	14	229		260
3		895.54	.44	1.14	290	110	81	16	282		252
2		898.37	.46	1.19	290	109	82	18	270		248
2		901.12	.46	1.19	291	108	82	20	284		242
1		903.78	.39	1.0	279	108	83	21	237		242
1		906.44	.39	1.0	285	108	83	23	285		236
	30 min purge			.5		104	83	3	232	50	~~232~~

MIDWEST RESEARCH INSTITUTE

RUN 2 - Outlet

2-0

MRI Project Number 3585-C(41)
Field Dates 2/18/74
Plant Shawnee
Sampling Location Outlet
Sampling Date 2/20/74

FIELD CREW

Crew Chief		~~Baladi~~ Mayfield
Testing Engineer	1	Baladi
	2	
	3	
Engr. Technician	1	Baladi
	2	
	3	
Lab Technician	1	Cobb
	2	DeLos
	3	Kitko
Process Engineer	1	
	2	
Other	1	
	2	

NOMOGRAPH DATA

PLANT _____

DATE _____

SAMPLING LOCATION _____

Same as run 1

CALIBRATED PRESSURE DIFFERENTIAL ACROSS ORIFICE, in. H_2O	$\Delta H_@$	
AVERAGE METER TEMPERATURE (AMBIENT + 20 °F), °F	$T_{m_{avg.}}$	
PERCENT MOISTURE IN GAS STREAM BY VOLUME	B_{wo}	
BAROMETRIC PRESSURE AT METER, in. Hg	P_m	
STATIC PRESSURE IN STACK, in. Hg ($P_m \pm 0.073$ x STACK GAUGE PRESSURE in in. H_2O)	P_s	
RATIO OF STATIC PRESSURE TO METER PRESSURE	P_s/P_m	
AVERAGE STACK TEMPERATURE, °F	$T_{s_{avg.}}$	
AVERAGE VELOCITY HEAD, in. H_2O	$\Delta p_{avg.}$	
MAXIMUM VELOCITY HEAD, in. H_2O	$\Delta p_{max.}$	
C FACTOR		
CALCULATED NOZZLE DIAMETER, in.		
ACTUAL NOZZLE DIAMETER, in.		
REFERENCE Δp, in. H_2O		

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4/72

DRY MOLECULAR WEIGHT DETERMINATION

PLANT Skaunee

DATE

SAMPLING TIME (24-hr CLOCK)

SAMPLING LOCATION

SAMPLE TYPE (BAG, INTEGRATED, CONTINUOUS)

ANALYTICAL METHOD

AMBIENT TEMPERATURE

OPERATOR

COMMENTS:

Obtained from EPA

RUN / GAS	1		2		3		AVERAGE NET VOLUME	MULTIPLIER	MOLECULAR WEIGHT OF STACK GAS (DRY BASIS) M_d, lb/lb-mole
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET			
CO_2								44/100	
O_2 (NET IS ACTUAL O_2 READING MINUS ACTUAL CO_2 READING)							3.5	32/100	
CO (NET IS ACTUAL CO READING MINUS ACTUAL O_2 READING)								28/100	
N_2 (NET IS 100 MINUS ACTUAL CO READING)								28/100	
								TOTAL	

EPA (Dur) 230
4/72

FIELD DATA

PLANT Shawnee
DATE 2/20/74
SAMPLING LOCATION Outlet
SAMPLE TYPE 303
RUN NUMBER 2-0
OPERATOR Baladi
AMBIENT TEMPERATURE 40
BAROMETRIC PRESSURE 29.84
STATIC PRESSURE, (P_s) -14.0 in H-O
FILTER NUMBER (s)

PROBE LENGTH AND TYPE 5' glass
NOZZLE I.D. .25
ASSUMED MOISTURE, %
SAMPLE BOX NUMBER
METER BOX NUMBER
METER $\Delta H_@$
C FACTOR
PROBE HEATER SETTING
HEATER BOX SETTING
REFERENCE Δp

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
				DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F			
	10	369.89									
1	5 /10:04	372.70	0.35	0.72		175	54	48	7		55
	5	375.09				17	68	51	7.5		
2	5	377.90	0.50	0.99		180	82	54	8		60
	5	380.59					87	57	8		
3	5	383.23	0.47	0.95		190	92	60	8		75
	5	385.86					95	63	9		
4	5	388.58	0.50	0.99		180	98	66	10		75
	5	391.34					100	68	10.5		
5	5	393.99	0.43	0.87		180	102	70	11		75
	5	396.57					103	72	10.5		
6	5	398.92	0.32	0.66		180	104	74	10		75
	5 /11:04	401.20					104	75	10		
6	5 /11:14	403.39	0.32	0.66		180	90	72	10		75
	5	405.63					92	73	11		
5	5	408.07	0.38	0.76		180	94	74	12		75
	5	410.50					97	74	13		
4	5	413.01	0.42	0.85		180	100	75	14		75
	5	415.68					102	77	14.5		
3	5	418.35	0.45	0.90		190	104	78	15		80
	5	421.01					105	78	16		
2	5	423.65	0.42	0.85		190	106	79	17		80
	5	426.28					107	79	17		

COMMENTS:

↓

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
				DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F			
1	5	428.83	0.40	0.81		175	168	80	17		85
	5 / 12:14	431.32					168	80	17		

MIDWEST RESEARCH INSTITUTE

RUN 3-I

MRI Project Number 3585-(A1)
Field Dates
Plant Skaunee Power
Sampling Location scrubber inlet
Sampling Date 20 Feb 79

FIELD CREW

Crew Chief Maxwell

Testing Engineer 1 Maxwell
2
3

Engr. Technician 1 Maxwell
2
3

Lab Technician 1 DeRos
2 Cobb
3 Kitko

Process Engineer 1
2

Other 1
2

NOMOGRAPH DATA

PLANT Shawnee

DATE _____

SAMPLING LOCATION _____

Same as Run 1

CALIBRATED PRESSURE DIFFERENTIAL ACROSS ORIFICE, in. H_2O	$\Delta H_@$	
AVERAGE METER TEMPERATURE (AMBIENT + 20 °F), °F	$T_{m\,avg.}$	
PERCENT MOISTURE IN GAS STREAM BY VOLUME	B_{wo}	
BAROMETRIC PRESSURE AT METER, in. Hg	P_m	
STATIC PRESSURE IN STACK, in. Hg ($P_m \pm 0.073$ x STACK GAUGE PRESSURE in in. H_2O)	P_s	
RATIO OF STATIC PRESSURE TO METER PRESSURE	P_s/P_m	
AVERAGE STACK TEMPERATURE, °F	$T_{s\,avg.}$	
AVERAGE VELOCITY HEAD, in. H_2O	$\Delta p_{avg.}$	
MAXIMUM VELOCITY HEAD, in. H_2O	$\Delta p_{max.}$	
C FACTOR		
CALCULATED NOZZLE DIAMETER, in.		
ACTUAL NOZZLE DIAMETER, in.		
REFERENCE Δp, in. H_2O		

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DRY MOLECULAR WEIGHT DETERMINATION

PLANT Shawnee

DATE _____

SAMPLING TIME (24-hr CLOCK) _____

SAMPLING LOCATION _____

SAMPLE TYPE (BAG, INTEGRATED, CONTINUOUS) _____

ANALYTICAL METHOD _____

AMBIENT TEMPERATURE _____

OPERATOR _____

COMMENTS:

Obtained from EPA

RUN / GAS	1		2		3		AVERAGE NET VOLUME	MULTIPLIER	MOLECULAR WEIGHT OF STACK GAS (DRY BASIS) M_d, lb/lb-mole
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET			
CO_2								44/100	
O_2 (NET IS ACTUAL O_2 READING MINUS ACTUAL CO_2 READING)							3.5	32/100	
CO (NET IS ACTUAL CO READING MINUS ACTUAL O_2 READING)								28/100	
N_2 (NET IS 100 MINUS ACTUAL CO READING)								28/100	
								TOTAL	

EPA (Dur) 230
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FIELD DATA

PLANT Shawnee Power
DATE 20 Feb 74
SAMPLING LOCATION Scrubber inlet
SAMPLE TYPE 303
RUN NUMBER 3-1
OPERATOR Maxwell
AMBIENT TEMPERATURE 50
BAROMETRIC PRESSURE 29.90
STATIC PRESSURE, (P_s) -14.0 in H_2O
FILTER NUMBER (s)

PROBE LENGTH AND TYPE 5'-glass
NOZZLE I.D. .25
ASSUMED MOISTURE, % 7
SAMPLE BOX NUMBER 12
METER BOX NUMBER 5
METER $\Delta H_@$ 1.89
C FACTOR .93
PROBE HEATER SETTING ~~450~~ 506
HEATER BOX SETTING 225
REFERENCE Δp .72

SCHEMATIC OF TRAVERSE POINT LAYOUT

READ AND RECORD ALL DATA EVERY 5 MINUTES

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in. H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in. Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F	Probe
				DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F				
	0 / 1430	918.80										
S-1		921.33	.34	.89		300	80	67	9	257	50	356
1		923.91	.35	.91		301	84	68	10.5	286		319
2		926.64	.41	1.13		304	98	71	11	283		260
2		929.36	.44	1.13		305	103	73	13	277		245
* 3		932.90	.40	1.03		301	90	78	11	265		23
3		939.08	.41	1.08		301	100	78	14.5	270		234
4		937.87	.44	1.13		301	107	80	19	272		256
** 4		940.56	.44	1.13	1.0	305	109	81	24	274		240
5		943.51	.47	1.21		300	105	83	15	242		24?
5		946.43	.46	1.19		303	112	85	7	289		256
6		949.34	.48	1.23		300	115	85	8.5	256		256
6		952.28	.48	1.23		300	116	86	10.5	256		240

COMMENTS: * Stopped H_2O_2 from last impinger pulling into silica gel.
** Stopped to change first filter.

EPA (Dur) 235
4 72

Run 2

TRAVERSE POINT NUMBER	CLOCK TIME (24-hr CLOCK) / SAMPLING TIME, min	GAS METER READING (V_m), ft^3	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE °F	Probe
				DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F				
	10	952.78										
6		955.03	.48/.30	1.23	/.78	295	117	87	12.5	235	65	245
6		957.94	.48	1.23		296	117	88	13.5	225		243
5		960.85	.46	1.19		297	116	89	15.5	253		244
5		963.74	.47	1.21		299	116	89	18.5	264		247
4		966.61	.41	1.08		299	116	90	19.5	281		260
4		969.30	.40	1.03		296	117	90	20	260		266
* 3		971.99	.42	1.09		297	104	88	6	248		280
3		974.73	.41	1.08		299	108	88	6.5	282		274
2		977.55	.45	1.17		295	113	88	8.5	285		265
2		980.37	.45	1.17		299	116	89	9.5	283		266
1		983.06	.37	.95		293	117	89	10.5	237		260
1		985.57	.37	.95		294	118	90	11.5	250		260
	30 min purge		—	.5		—	110	90	6.5	280	55	—

EPA (Dur) 236 *
4-72

* Shut down to change first filter. Again H2O2 from 3rd impinger pulling into 4th

MIDWEST RESEARCH INSTITUTE

RUN 3-Outlet
3-O

MRI Project Number 3595-C(41)
Field Dates 2/20/74 C
Plant Shawnee
Sampling Location 2 Outlet
Sampling Date 20 Feb 74

FIELD CREW

Crew Chief Balaji Maxwell

Testing Engineer 1 Balaji
2
3

Engr. Technician 1 Balaji
2
3

Lab Technician 1 Kifko
2 Cobb
3 Palos

Process Engineer 1
2

Other 1
2

NOMOGRAPH DATA

PLANT Roanoke

DATE _____

SAMPLING LOCATION _____

Same as Run 1

CALIBRATED PRESSURE DIFFERENTIAL ACROSS ORIFICE, in. H_2O	$\Delta H_@$	
AVERAGE METER TEMPERATURE (AMBIENT + 20 °F), °F	$T_{m_{avg.}}$	
PERCENT MOISTURE IN GAS STREAM BY VOLUME	B_{wo}	
BAROMETRIC PRESSURE AT METER, in. Hg	P_m	
STATIC PRESSURE IN STACK, in. Hg ($P_m \pm 0.073$ x STACK GAUGE PRESSURE in in. H_2O)	P_s	
RATIO OF STATIC PRESSURE TO METER PRESSURE	P_s/P_m	
AVERAGE STACK TEMPERATURE, °F	$T_{s_{avg.}}$	
AVERAGE VELOCITY HEAD, in. H_2O	$\Delta p_{avg.}$	
MAXIMUM VELOCITY HEAD, in. H_2O	$\Delta p_{max.}$	
C FACTOR		
CALCULATED NOZZLE DIAMETER, in.		
ACTUAL NOZZLE DIAMETER, in.		
REFERENCE Δp, in. H_2O		

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DRY MOLECULAR WEIGHT DETERMINATION

PLANT Hanna

DATE _____

SAMPLING TIME (24-hr CLOCK) _____

SAMPLING LOCATION _____

SAMPLE TYPE (BAG, INTEGRATED, CONTINUOUS) _____

ANALYTICAL METHOD _____

AMBIENT TEMPERATURE _____

OPERATOR _____

COMMENTS:

Obtained from EPA

RUN / GAS	1		2		3		AVERAGE NET VOLUME	MULTIPLIER	MOLECULAR WEIGHT OF STACK GAS (DRY BASIS) M_d, lb/lb-mole
	ACTUAL READING	NET	ACTUAL READING	NET	ACTUAL READING	NET			
CO_2								44/100	
O_2 (NET IS ACTUAL O_2 READING MINUS ACTUAL CO_2 READING)							3.5	32/100	
CO (NET IS ACTUAL CO READING MINUS ACTUAL O_2 READING)								28/100	
N_2 (NET IS 100 MINUS ACTUAL CO READING)								28/100	
								TOTAL	

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E [redacted] 3 [redacted]

Baro. Pres. 29.90

Static. −16.0 in H₂O

TRAVERSE POINT NUMBER	SAMPLING TIME, min / CLOCK TIME (24-hr CLOCK)	GAS METER READING (V_m), ft³	VELOCITY HEAD (Δp_s), in. H_2O	ORIFICE PRESSURE DIFFERENTIAL (ΔH), in H_2O		STACK TEMPERATURE (T_s), °F	DRY GAS METER TEMPERATURE		PUMP VACUUM, in Hg	SAMPLE BOX TEMPERATURE, °F	IMPINGER TEMPERATURE, °F
				DESIRED	ACTUAL		INLET ($T_{m\,in}$), °F	OUTLET ($T_{m\,out}$), °F			
		443.44									
1	5 / 1:28	446.34	0.47	0.93		195	64	62	16		60
	5	448.91					72	62	10		
2	5	451.58	0.52	1.02		195	80	63	10		75
	5	454.25					85	64	10		
3	5	456.09	0.47	0.93		195	90	65	10		75
	5	459.57					97	66	11		
4	5	462.46	0.50	1.02		195	84	68	12		75
	5	465.55					91	69	12.5		
5	5	468.42	0.52	1.05		180	99	70	13		75
	5	471.30					96	71	13		
6	5	473.97	0.45	0.91		180	92	72	13		75
	5	476.60					93	73	+2.5	13	
6	5	479.09	0.40	0.81		180	100	74	12		75
	5	481.59					102	75	13		
5	5	484.30	0.51	1.01		185	104	77	14		75
	5	487.14					106	78	14.5		
4	5	490.05	0.57	1.14		185	108	79	15		75
	5	493.97					109	79	15		
3	5	495.79	0.51	1.01		185	108	78	15		80
	5	498.74					106	79	15.5		
2	5	501.64	0.52	1.05		180	105	80	16		80
	5	504.46					108	81	16		
1	5	507.18	0.45	0.91		180	110	82	16		80
	5	509.82					111	83	16		